The Application Of Game Theory In Mobile Games: How Game Companies Choose Their Optimal Strategies Based On Gacha-Monetization.

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1 Background

In recent years, the mobile game market continues to grow, and people can see the powerful position of smartphones in the era of Internet. Nowadays, people cannot live without mobile phones, and mobile games are also very popular. The advantages of convenient play and strong social attributes make mobile games become a fever. "*Genshin Impact* made $1.4 billion dollars in 2021 and according to Sensor Tower's list of top grossing games of 2021, Genshin placed third with fellow gacha games PUBG mobile and Honors of Kings placing first and second each grossing $2.8 billion respectively. These top 3 mobile games of 2021 are all Gacha games" (2022). Compared with other types of games, almost free mobile games can achieve nearly 100 billion in revenue. According to Newzoo's data (Figure 1.), revenue from mobile games accounted for 52% of the entire global games market in 2021.

The earliest card drawing mechanism is Gacha in Japan. This mechanism first came from the Gacha (ガチャ lottery draw) system invented by Japanese games. The etymology of Gacha is the capsule toy "Gashapon" (ガシャポン) refers to a game method in which people only need to insert coins and then twist the knob to get a random toy from the capsule. "Gacha game is a special opaque selling strategy, where the seller is selling gacha pulls to the buyer. Each gacha pull provides a certain probability for the buyer to win the gacha game, similar to a lottery ticket" (Chen & Fang, 2023). It works in the same way as a vending machine: you get a reward after putting in coins, but the reward is random. In English-speaking countries, the mechanism for randomly obtaining prizes similar to Gacha is called the "loot box". " The "loot box", a now-ubiquitous monetisation feature allowing players to buy a package of random power-ups" (2023). The earliest use of this mechanism was TSR's Dungeons and Dragons and Magic: The Gathering (1993) released by Wizards of the Coast. Players can buy a physical card pack they do not know what cards it contains, but each physical card pack might match their desired set of cards. Therefore, many players exchange the purchased card packs with each other for the physical cards they want, which is the origin of the trading card game. However, after the birth of computer games, this approach was changed from transactions between players to transactions between players and game developers. Players will have a mixed mood of excitement and anxiety after purchasing a

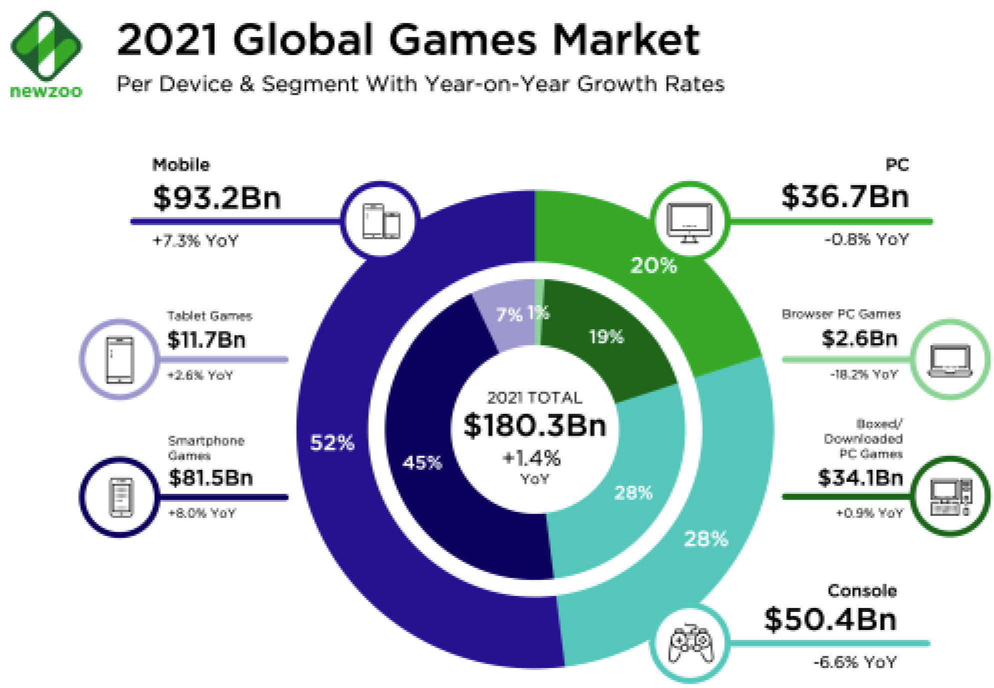


Figure 1: Total revenue of $180.3Bn in 2021 Global Games Market. Source from Newzoo.

virtual card pack. If players could not get the rewards they want when open the pack, it is easy for people to imply that they will definitely get the cards they want next time. This is the essence of the Gacha system - allowing players always hopeful and addicted to spend a lot of time and money for card drawing in the game since they cannot trade.

The gambler psychology created by the Gacha mechanism is very effective. "Similar to the findings of early gambling researchers regarding slot machines-which are essentially an antiquated rendition of loot boxes -game developers utilize operant conditioning to induce an addictive gambling-like behavior from gamers" (Liu, 2019). Game manufacturers definitely want to let players voluntarily press the recharge button more diligently. "In most gacha games nowadays, players will most likely be pulling for characters that they will be able to play in these games or just for collection purposes. Some games may also allow players to pull weapons or items for their characters, further expanding the pool of items that is available" (Jėčius & Frestadius, 2022). Therefore, besides various rewards (good-looking characters and game items, etc.), there are various methods to stick players based on this mechanism, such as virtual currency exchange, reward level design, floating probability, and rare rewards within the event date. For example, the game *Genshin Impact* (MiHoYo released in 2020) pushes a player's desire to pull seven of one specific character to unlock his/her full potential with a chance of 0.06% to get a five-star (top level) character and the game developer dilutes the pool with weapons (other game items) to ensure the odds of actually getting characters are quite low. Also, *Genshin Impact* offers vitural currency exchange system and almost all five-star characters only appear into the pool within limited event dates. Subsequently, the development of the smartphone industry in the 21st century gives more people the opportunity to download games for free as their daily entertainment just through mobile phones. Then, the Gacha mechanism provides inspiration for mobile game developers and quickly apply it to almost all mobile games in the market. The Gacha system adds a unique payment mechanism to mobile games and creates a continuous attraction for players with updating reward in the pack.

As more and more mobile games introduce the Gacha mechanism, the game strategies among game manufacturers are also particularly important. “From games with a popular following, like Nintendo’s Fire Emblem Heroes (Nintendo, 2017), to popular mobile games like Puzzle and Dragons (GungHo Online Entertainment, 2012), Sword Art Online: Memory Defrag (BANDAI NAMCO Entertainment, 2016) and Fate/Grand Order (Aniplex Inc., 2017), the gacha mechanic builds casino excitement into the daily grind of mobile play” (Spiker, 2017). Most times, a group of players of one game will also be players of another game because of the social nature of mobile games. Besides the downloadable content of “rewards” and updated “products” launched by the game itself, the game strategies based on the Gacha mechanism is a key consideration. These strategies help game manufacturers gain an advantage in the competition for winning more consumers from the same player group. This article will mainly use the Gacha mechanism to build models and then simulate the competitive game strategies among game developers and choose the optimal solution for game manufacturers.

2 Model and Analysis

2.1 Modeling Method

The models focus on the competitive relationship from the perspective of game companies. To simplify the model, we suppose a **duopoly** market where only two companies choose to release their Gacha games. Both companies will design their Gacha game configuration including the probability of winning the reward in multiple draws. Every game has two monetization methods by attracting more players based on the Gacha mechanism: direct payments from players and investments from sponsors.

I. **Notations**:

- Game Companies: G_i, where $i \in \mathbb{N}$
- Odds/Probabilities of winning: p_i in the ith draws in a game, where $0 \leq p_i \leq 1$
- Expected rewards obtained by gamers with n draws: $\sum_{i=1}^{n} i \times p_i$
- Pure strategies for G_i: s_i represents A_i, B_i, C_i, etc $\forall i \in \mathbb{N}$.
- A strategy profile assigns one strategy choice (outcome) for G_i: $S_i = (s_i, s_{-i})$
- Number of gamers in total: k_g
- Number of sponsors in total: k_s
- Gamers in the market: m_i represents the ith gamers who pay within the game.
- Sponsors in the market: n_i represents the ith sponsors who invest the game.
- A gamer’s payment value: V_{P_i} represents the value of ith gamer’s payment.
- A sponsor’s investment: V_{I_i} represents the value of ith sponsor’s investment.

- Payoff function (Utility) for G_i: $U_i = \sum_{i=1}^{k_g} m_i(V_{P_i}) + \sum_{i=1}^{k_s} n_i(V_{I_i})$
- Belief of G_i on other companies: θ_{-i}
- Best response to some belief for G_i: $BR_i(s_i, \theta_{-i})$

II. **Gacha Game Categories Based on Probability** (Chen & Fang, 2023):

Fixed Probability ($p_i \equiv p =$ such a number $\in [0,1]\ \forall i \in \mathbb{N}$): The fixed probability game ensures the probability of wining the reward remains the same during the drawing process.

Changed Probability ($p_i \neq p_j\ \forall i \neq j,\ i, j \in \mathbb{N}$): The changed probability game allows the probability of wining the reward is different at each draw.

III. **Basic Assumptions**:

- Only G_1 and G_2 since doupoly.
- Both game companies are rational;
- Both game companies have no more than 26 pure strategies each;
- All game players and sponsors are rational;
- Game companies' and gamers' rationality is common knowledge;
- Rules of the game (strategies, payoff values, number of gamers and sponsors) are common knowledge.

2.2 Static Situation

The base model includes two companies who are releasing their mobile games (identical games) at the same time. Both of them adopt the Gacha-mechanism. Also, both companies applying the same Fixed Probability for their Gacha games. Thus, the probability (p) for getting rewards from the pool is no differences between two games and suppose $p = 0.5$.

There are $k_g = 10$ gamers are asked to play both games and each of them have $V_{P_i} = \$10$, so they need to adjust how to spend their 10 dollars into two games. Each company has the same 3 strategies ($A_1 = A_2$, $B_1 = B_2$, $C_1 = C_2$) to attract and earn revenue from those gamers through the Gacha-mechanism as the following:

(1) Charge (A_i): asking player spend \$10 buying 10 draws

(2) Coin (B_i): players can pay \$10 to get 100 game coins (the virtual currency used in the game) which is valued 100 draws.

(3) Free (C_i): Open the channel for players to obtain virtual currency by finishing daily duties, so no cost here except time.

Then, The expected number of rewards that each game company's strategy brings to gamers is:

A_i : \$10 $= 10 \times 0.5 = 5$ rewards.

B_i : $\$10 = 100 \times 0.5 = 50$ rewards.

C_i : $\sum_{i=1}^{\infty} i \times 0.5 = \infty$ rewards. Completely depends on how many draws a gamer want to play.

Thus, it is obvious that most rational gamers will definitely prefer and choose the game company who plays strategy C_i since $5 < 50 < \infty$.

2.2.1 Model 1

Model 1 Additional Assumptions:

- No sponsors under this case ($k_s = 0$) thus $\sum_{i=1}^{0} n_i(V_{I_i}) = 0$;
- Gamers can choose to play both games;
- One gamer can only pay \$10 for one game and no cost for a free one;
- When two companies choose the same strategy ($s_1 = s_2$), each game will have 5 gamers' payment but not C_i since the game will be free;
- If one company chooses A_i and the other one chooses B_i, 7 gamers will pay \$10 for A_i game and the rest 3 gamers pay \$10 for B_i game;
- If one company chooses C_i, and then the other one chooses either A_i or B_i will win 10 gamers' payments.

Game companies' payoffs represented by player's payments merely. The payoff equation is:

$$U_i = \sum_{i=1}^{k_g} m_i \times (\$10), \qquad \text{where} \quad 0 \leq k_g \leq 10$$

Model 1		G_2		
		A_2	B_2	C_2
G_1	A_1	50 , 50	30 , 70	100 , 0
	B_1	70 , 30	50 , 50	100 , 0
	C_1	0 , 100	0 , 100	0 , 0

In this **model 1** matrix, we assume the 2 games are theoretically identical, and then it is easy to see the second strategy (coin) will encourage more players to pay \$10 since they will get more opportunities to draw their rewards. Through the rationalibility, strategies C_i is not considerable because we suppose that the 10 gamers will play both games in this model. Obviously, players will choose to spend their money on a charging game. Then $BR_1(B_2) = B_1$ and $BR_2(B_1) = B_2$, which indicates that the Nash Equilibrium of B_1B_2. Therefore, B_i is the optimal strategy for both companies with $(U_1, U_2) = (\$50,\$50)$ under the given case.

2.2.2 Model 2

However, if we think about the reality at the consumers' view, a channel opened to obtain in-game-currency will attract more customers because they do not have to pay for the Gacha-mechanism. We then can try to use the number of gamers as payoffs of a company. That means, one more gamer plays this game, the company will get an extra value of $V_{I_i} = \$5$ revenue, even the game is free. There are still $k_g = 10$ gamers, but if a player choose to play one game, the other is not on his/her list. If no gamers play the game, no investment in this game.

Model 2 Additional Assumptions:

- No gamers' payments as payoffs under this case ($V_{P_i} = 0$) thus $\sum_{i=1}^{10} m_i(0) = 0$;
- Gamers can only choose to one game.
- k_s is defined by how many gamers choose to play the game. If the game attract no gamers, and then no sponsors will invest in this game ($0 \leq k_s \leq 10$).
- When two companies choose the same strategy ($s_1 = s_2$), each game will have 5 gamers choose to play and $k_s = 5$ for both companies.
- If one company chooses A_i and the other one chooses B_i, 3 sponsors will pay \$5 for A_i game and the rest 7 sponsors pay \$5 for B_i game (idea from Model 1).
- If one company chooses C_i, and then this company will win 10 sponsors' investments (idea from Model 1).

The payoff equation is represented by sponsors' investments:

$$U_i = \sum_{i=1}^{k_s} n_i(\$5), \qquad \text{where} \quad 0 \leq k_s \leq 10$$

Model 2		G_2		
		A_2	B_2	C_2
G_1	A_1	25 , 25	15 , 35	0 , 50
	B_1	35 , 15	25 , 25	0 , 50
	C_1	50 , 0	50 , 0	25 , 25

A cheaper or a free Gacha game will attract more players. Now, the dominant strategy for both companies will be C_i, which indicates the $NE = C_1C_2$. While, no companies will get money from gamers so that the utility values for those companies at the Nash Equilibrium is $(U_1, U_2) = (\$25, \$25)$ with the focus on sponsors' perspectives.

2.2.3 Model 3: General Solution

Recall the rule of this static game. We then can combine the two situations discussed above, two Gacha games are theoretically identical but one gamer only choose to play one game.

Model 3 Additional Assumptions:

- One gamer can only choose to play and pay for one game, and how many gamers choose the game, there will be the same number of sponsors who invest in this game.
- Whatever the strategy chosen by a game company (G_i), $0 \leq k_s = k_g \leq 10$.
- When two companies choose the same strategy ($s_1 = s_2$), $k_s = k_g = 5$ evenly for G_1 and G_2, but only sponsors' investments for C_i equilibrium with no gamers' payments (idea from previous models).
- If one company chooses A_i and the other one chooses B_i, $k_s = k_g = 3$ for A_i game and the rest $k_s = k_g = 7$ for B_i game (idea from previous models).
- If one company chooses C_i, and then this company win $k_s = k_g = 10$ but only win payoffs from sponsors' investments (idea from previous models).

Thus, the model will be changed, and the payoff equation will be fully presented by:

$$U_i = \sum_{i=1}^{k_g} m_i(\$10) + \sum_{i=1}^{k_s} n_i(\$5) \qquad \text{where} \quad k_s \equiv k_g \; \forall i \in [1, 10]$$

Model 3		G_2		
		A_2	B_2	C_2
G_1	A_1	75 , 75	45 , 105	0 , 50
	B_1	105 , 45	75 , 75	0 , 50
	C_1	50 , 0	50 , 0	25 , 25

From the **Model 3**, we can see that a Gacha game can earn revenue from both direct gamers' payments and sponsors' investments. However, under the given situations, it is hard for each company to decide which pure strategy is the best.

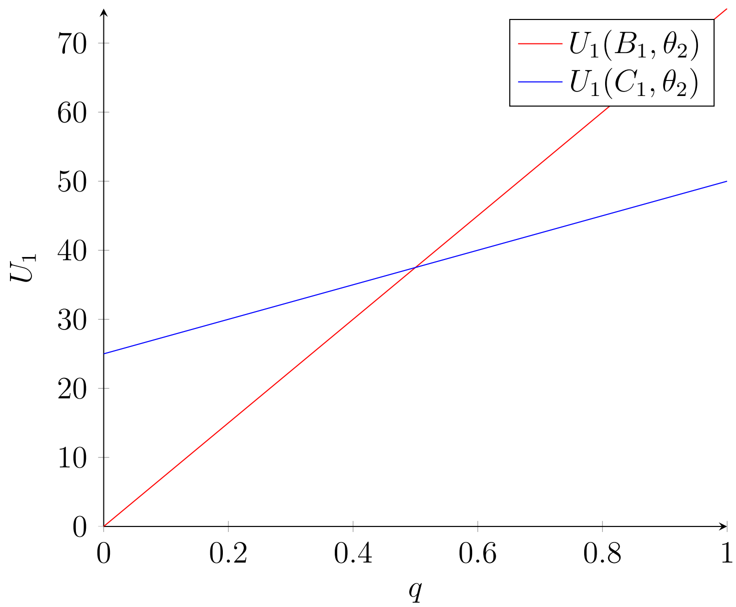
$BR_i(s_{-1})$	
$BR_1(A_2) = B_1$	$BR_2(A_1) = B_2$
$BR_1(B_2) = B_1$	$BR_2(B_1) = B_2$
$BR_1(C_2) = C_1$	$BR_2(C_1) = C_2$

After finding the best responses for each company, there is no dominant strategy based on the **Model 3** matrix. While, for G_i, B_i and C_i are two undominated strategies. The best response for G_i indicates that B_i and C_i are those two game companies' rationalizable strategies and bring two Equilibriums with different payoff values. Thus, both companies might play their strategies depends on their beliefs.

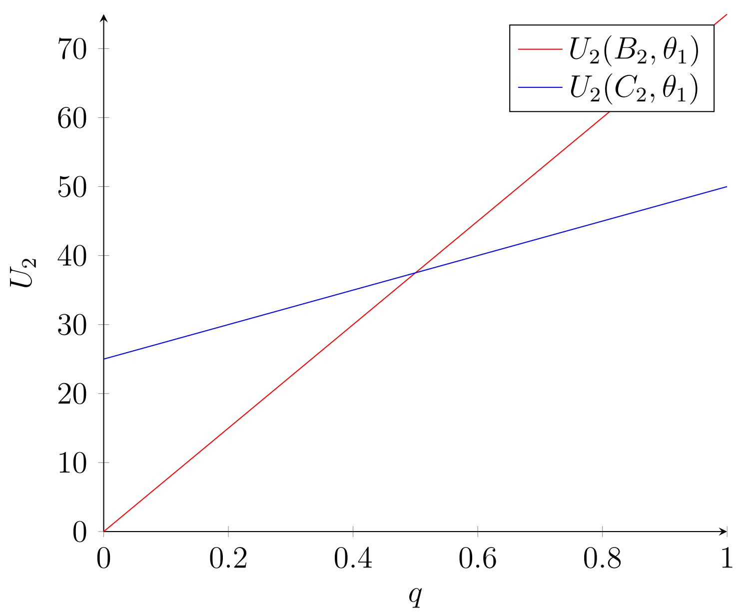
> **Additional Assumption**: Suppose q is the probability for G_i to choose the strategy B_i and then $(1-q)$ is the probability for G_i to choose the strategy C_i, where $0 \leq q \leq 1$.

We then can simulate with this model to see how changes in q values affect those game companies to choose different strategies for their optimal utility values. Two companies have their beliefs (θ_i) on their opponent

$$\theta_i = q(B_i) + (1-q)(C_i) = \begin{cases} U_1(B_1, \theta_2) = 75q + 0(1-q) = 75q \\ U_1(C_1, \theta_2) = 50q + 25(1-q) = 25 + 25q \\ U_2(B_2, \theta_1) = 75q + 0(1-q) = 75q \\ U_2(C_2, \theta_1) = 50q + 25(1-q) = 25 + 25q \end{cases}$$



Utility functions for G_1 with the belief (θ_2) of a mixed strategy on G_2 respect to its own pure strategy B_1 and C_1. When $q < \frac{1}{2}$, G_1's best response is C_1 (free), and when $q > \frac{1}{2}$, G_1's best response is B_1 (coin). When $q = \frac{1}{2}$, the best response is no matter choosing C_1 or B_1.



Utility functions for G_2 with the belief (θ_2) of a mixed strategy on G_2 respect to its own pure strategy B_2 and C_2. When $q < \frac{1}{2}$, the best response for G_2 is C_2 (free), and when $p > \frac{1}{2}$, the best response for G_2 is B_2 (coin). When $q = \frac{1}{2}$, the best responses are C_2 and B_2.

From the previous three models, we can see that game companies should develop virtual currency exchange channels, and provide some internal ways to obtain tokens for free as well. Using mixed strategies is more helpful for game companies to find the optimal solution according to the opponent's strategies.

2.3 Model Extension: Dynamic Situation

What if Changed Probability Gacha Games? After the mobile game is released, the system content can be updated according to the needs of players, investors, game manufacturers and other parties. Now, the market expands and there are $k_g = 100$ gamers with \$10 and each sponsor has \$5 to invest. Suppose that G_2 wants to hold a game event to increase the probability of getting rare rewards after a gamer does 50 draws, which can attract more gamers' payments.

Thus, G_2 provides the probability for getting rewards from the pool in first 50 draws is still 0.5 ($p_i = 0.5$ when $0 \leq i \leq 50$), but starting in 51 draws, the company plans to improve the percentage each 10 draws until the gamer reaches his/her 100 draws., p_i will be constant when $i \geq 100$. If the gamer draws 10 more times, the probability of winning will increase α. This means that the highest probability is $0.5 + 5\alpha$, where α is unknown by G_1.

The game company G_1 heard the news that G_2 will hold an event, so G_1 needs to decide what countermeasures to take before the G_2 event version is updated.

Remaining 2 strategies for both game companies:

(1) Coin (B_i): gamers can pay \$10 to get 100 game coins (the virtual currency used in the game) which is valued 100 draws.

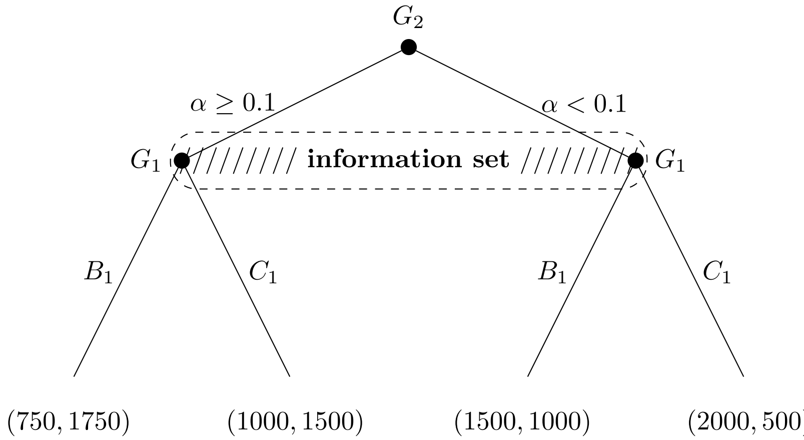
(2) Free (C_i): Open the channel for players to obtain virtual currency by finishing daily duties, so no cost here except time.

New Assumptions:

- Since G_2 host the event for attracting more consumption, this company will choose B_2 during the event periods;
- Because of the expansion of the market, sponsors are willing to invest more, and each sponsor can invest \$15 within the game;
- α is unknown by G_1, but if $\alpha \geq 0.1$, which means the gamers will have the odds of $p_i = 1$ when $i \leq 100$ and the market knows the value of α;
- If G_1 chooses B_1, and then 70 gamers will choose to play G_2 if $\alpha \geq 0.1$, but 40 gamers will choose to play G_2 if $\alpha < 0.1$;
- If G_1 chooses C_1, 60 gamers will choose to play G_2 if $\alpha \geq 0.1$, and 20 gamers will choose to play G_2 if $\alpha < 0.1$;
- The left payoff is U_1, and the right payoff is U_2.

The payoff function for G_i is:

$$U_1 = \sum_{i=1}^{k_g} m_i(\$10) + \sum_{i=1}^{k_s} n_i(\$15) \qquad \text{where} \quad k_s \equiv k_g \; \forall i \in [1, 100]$$



Since there is the information set, strategies for G_1 are B_1 and C_1, and G_1 will definitely choose C_1 because U_1 from C_1 is strictly better than that from choosing B_1 (1000>750, 2000>1500). Then, this action will push G_2 decided its α value as $\alpha \geq 0.1$, which indicates the $SPE = (C_1, \alpha \geq 0.1)$.

3 Reflection

3.1 Discussion

Providing free downloads for mobile games is a business strategy. The main reason is to attract players. This is also a condition that must be met for competition in the mobile game market. Since once game developers choose the paid download mode, they will fall behind in the starting line of the competition in the mobile game market. Only fewer people are willing to download paid games among various free mobile games. Also, if the developer has made a paid game, there are fewer reasons to charge players in the game. However, free-to-download games provide developers with more players to win benefits through in-app purchases in the future.

Large game production companies will get players to spend money as more voluntarily as they can. Each mobile game will set up different rewards to attract players to spend money, beautiful characters, better items and so on. These rewards that satisfy the player's visual and gaming experience always attract players, in order to become stronger in the game. "Microtransactions are a business model that has emerged from within the video game industry in recent years where a typically free-to-play game offers in-game purchases that provide either (1) a competitive edge in a play-to-win environment or (2) a cosmetic upgrade to models within the game" (Liu, 2019). However, many mobile game players can actually become masters without spending money, but the price they pay is a huge time cost. Although many people choose to use money to take shortcuts because their jobs make time extremely valuable, many more people will simply uninstall the game or simply not buy the "product" launched in the game. As a result, mobile game manufacturers have introduced the Gacha mechanism to take advantage of people's gambling psychology, which is effective and successful. "Whilst free-to-play (F2P) games are free to download, the industry has developed novel ways to recoup the costs of development and seek profitability. Popular is the use of a gacha mechanic that incentivises players to buy or accumulate in-game currency which can be used to obtain a randomised virtual item that might – to greater or lesser degrees – enhance or progress the game" (Woods, 2022).

3.2 Strengths and Weaknesses

The above models simulate the corresponding scenarios for static and dynamic conditions to find the best strategy for a game company. These models provide us with a simple visual derivation to cope with the Gacha mechanism of the mobile game market. Moveover, according to the given parameters, it is more beneficial to judge which strategy should be adopted under what circumstances, so as to deal with unknown variables in the future.

There are more realistic elements not included in our models, like differentiated probabilities of the Gacha-mechanism. A free channel will offer pretty bad odds for drawing. There are limited times for player to buy in-game-currency, or diminishing exchange utility: $10 values 100 coins at the first time, but 90 coins at the second time, and then 75 coins and so on. Also, the utility for each game company will be different depends on their costs of making the game (switch revenues to profits as payoffs).

When drawing cards, the concept of "card" is always used, but the card itself does not just represent a card. A "card" often includes several key parts: characters/CG/modes, settings and stories, etc.. Rationality and market values can not simply measure these artistic values. We cannot measure the aesthetics of different people on a unified scale. Maybe a mobile game costs more, but the exquisiteness of its "cards" is worth and such a high cost will also make many people willing to spend for it.

Perhaps introducing more concepts of behavioral economics and psychology into the game theory model can help the model be more perfect, such as what type of consumers are more likely to consume impulsively in high-probability rewards, and where is the limit of this probability. Especially regarding how the psychology of gambling can lure players into an addiction to Gacha mechanics. It is also possible to create specific mechanism rules for specific groups of people for group discussion, such as the difference between players who are more willing to spend money and save time, and players who spend time and then save money, to simulate and modeling with the upper limit of the number of free token.

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