Profit Analysis for Video Game Releasing Strategies: Single-player vs. Multiplayer Games

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A video game publisher may release a game in a multi- and/or a single-player version. The major difference between these two versions is that, unlike its single-player counterpart, a multiplayer game allows its players to cooperate and/or compete with other human players, thus bringing them additional fun from social interactions. This study examined the game publisher's strategies on which version(s) of the game should be released and how their prices may be affected when different versions are available. We drew insights from psychology literature on why people play games and used three important factors to analyze players' adoption of video games. Based on these factors, we built a two-dimensional Hotelling model to analyze product differentiation strategies for a game publisher and studied how a player might adopt appropriate game versions based on factors associated with their intrinsic characteristics. We then derived the optimal pricing strategies for a game publisher to target the intended group of players when she releases (i) only the single-player version, (ii) only the multiplayer version, or (iii) both versions. The profits for the three releasing strategies were then compared and the optimal strategies associated with different cost parameters were identified.
Keywords: Video Game pricing strategy, two-dimensional Hotelling model, price discrimination

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I. INTRODUCTION AND LITERATURE REVIEW

In the new era of electronic entertainment, video games, especially online video games, become one of the fastest-growing industries. Global revenues of video games are estimated to reach $100 billion in 2014 (Gamerista, 2014). The industry has generated more annual revenue than Hollywood (Pavlik, 2008). In 2013, the massively multiplayer online game (MMOG) market alone is around $14.9 billion (GlobalCollect, 2013). Many video game-related segments, ranging from game designers, distributors, to game console manufactures, expand rapidly in order to grab a share of this lucrative market. A typical video game can be available in two different versions: a single-player version and a multiplayer version. The single-player game is a game in which a player plays solo with or against the artificial intelligence designed into the game. The Multi-player game is one in which a player plays with or against real persons. Single-player games are mostly played on a local computer or game console while multiplayer games are mostly played over a computer and/or the six-generation game consoles over the network.

Single-player games often charge a one-time purchasing fee and an additional fee for each subsequent upgrade. In contrast, multiplayer games often charge a subscription fee in addition to an initial registration fee if there is any. Other emerging online multiplayer games pricing models include charging by the total amount of playing time and the 'come-stay-pay' model where players are only charged for in-game acquisitions. Before the Internet age, single-player games dominate the video game market. However, with the pervasive Internet connectivity, publishers of multiplayer games have steadily gained ground and captured a significant share of the market. Many classical single-player games, such as Call of Duty and Doom, also began to offer multiplayer components in their game franchises. The new trend in the development of multiplayer games is the introduction of MMOGs, in which gamers can freely create or assume a character or a role in a persistent, dynamic and virtual community. Online players from all over the world can "meet" and "play together" to conquer challenging tasks or fight against each other to compete for virtual goods. Therefore, multiplayer games have advantages over single-player games by connecting to other players through networks. It provides a form of social interactions absent in single-player games. ZDnet.com reported that even some CEOs socialized and found new customers and business partners via "World of Warcraft", which has been considered by some techie CEOs as the "new golf" (Farber and Dignan, 2006). In addition, for many MMOG players, playing a game is not only a hobby, but also a business. A gamer can sell virtual goods harvested from the game, including weaponry and spells, at online auction sites. This virtual economy, in the context of MMOGs, was valued U.S. $2.1 billion in 2007 (Lehtiniemi and Lehdonvirta, 2007).

Multiplayer games offer some exciting new features, especially in the social and the human intelligence aspects, that single-player ones lack. However, not all games have been migrated to multiplayer versions. Game publishers, following the well-tested purchase fee model, still develop numerous single-player games for computers, game consoles and mobile devices. Furthermore, not all migrations from single-player to multiplayer games, such as *Twilight War (based on Half-Life 2), Sim Online (based on the Sims),* have been successful. One of the major reasons for the continuing existence of single-player games is that they rely heavily on compelling stories to ensure an intense and exciting game playing experience. Their story lines are highly structured, in comparison with those of multiplayer ones where other players may disrupt the expected flow and outcome. In addition, single-player games provide a great training platform for players who are not yet comfortable with their performance in a multiplayer environment.

With the choice of offering different versions of a game, the publisher is facing the decision on which version(s) of the game to offer. Understanding players' motivation of playing video games may help the publisher develop an optimal game release strategy. A large body of research has been focusing on explaining why people play games, (e.g. Baek, 2005; Choi and Kim, 2004; Wu and Liu 2007a, 2007b). The thesis is that millions of players willingly participate in various game plays because they expect to get something out of their game plays (Bartle, 2004). Players are either attracted to the game by the intricacy of the storyline, the level of challenges, or the opportunities to socialize and interact with other players. Thus, players will take part in a game as long as the perceived utility from a game play outweighs the purchase cost.

Yee (2006) divides players into two categories: (1) achievers who seek game mastery, competition, and glorification, and (2) socializers who want to interact with others and develop in-game relationships. Liu et al. (2007b) analyzes how to induce players' maximal amount of effort in a competitive environment so as to maximize the overall playing. The finding is particularly suitable for small games played by sending short messages through a cell phone. Aboolian el al. (2012) looks at massively multiplayer online game and how to determine the locations of the servers so as to provide the best overall service quality globally. Liu el al. (2007b) focuses on how to make online games more competitive from the economic and psychological perspectives.

Ryan et al. (2006) employs the Self-Determination Theory (SDT) to explain players' motivation. SDT is a general theory of human motivation and the choices people make with their free will and full sense of choice, without any external influence and interference (Deci and Ryan, 1985). Ryan et al. (2006) also suggests that there were three universal, innate and psychological needs that motivate the self to initiate behavior: Need for Competence; Need for Autonomy; and Need for Relatedness. Competence refers to the need to be challenged and in control. In the context of gaming, the need for competence is partially fulfilled if a player is given positive feedback or receives an award when completing a task. Autonomy is mostly concerned with a player's willingness to play the game and the degree of choices the player may have during the game play (Ryan, Rigby and Przybylski, 2006). Autonomy can be enhanced if a game offers the player more control on movements and strategies as well as more choices for tasks and goals. Relatedness refers to the need to connect to others socially, and it is mostly experienced in online multiplayer games.

In this study, we extend the SDT theory to explain a consumer's choice between a multiplayer game and a single-player game. As far as the need of social interaction is concerned, a multiplayer game has an advantage as it connects players together and allows them to collaborate with or compete against each other. Many tasks in multiplayer games require cooperation among players to accomplish them. Game players seeking autonomy and competence can satisfy their needs from either multiplayer or single-player games. While both types of games offer challenges to meet players' competence need, they differ sharply in that artificial intelligence is used to challenge and reward players in a single-player game but a multiplayer game depends heavily on the human intelligence of other players. A game publisher can offer players certain levels of autonomy through game designs and storylines. For example, the degree of control a player has over the sequence of actions is largely determined by the game design. It can be argued that multiplayer games introduce a greater level of uncertainty to the game play, although this may negatively impact the sense of autonomy.

Little research to date has been done to address two essential questions for game release. First, are multi- and single-player versions of the same game complementary or substitute products? Second, what is the best pricing strategy for this prospering industry? This paper attempts to fill the gap by addressing the following research questions:

- Do these two game versions compete for the same group of potential gamers?
- If both versions are to be available, can the profile of the gamers for

each version of the game be effectively characterized?

- How do gamers choose between the two game versions and how do their selections affect the profitability?
- Under what conditions can price discrimination become financially beneficial for releasing both game versions?

To answer these questions, we extend the standard one-dimensional Hotelling model (Hotelling, 1929) for product differentiation to a two-dimensional setting where a group of potential players differ in their valuation of the intrinsic valuations. With this extended two-dimensional Hotelling model, we will be able to identify the characteristics of the players who are more likely to play a particular version of a game. We then examine if providing both multi- and single-player versions of a game can help the publisher better target the intended players and therefore allow the publisher to price discriminately. We also look at both multi- and single-player games from a product differentiation point of view and analyze the game publisher's potential pricing strategies and their respective profitability. This work provides an economic analysis on why providing both multi- and single-player versions of a game can induce product differentiation and therefore increase the publisher's profit. In addition, to our best knowledge, this paper is the first to study the issue of how a potential game player chooses different game versions. Our analysis provides useful insights for both the game distributors and the game designers.

The rest of this paper is organized as follows. In Section 2, we develop an analytical game-theoretical model to analyze the multiplayer/single-player problem. Analyses and results are presented in Sections 3. Finally, the strengths, the limitations, and future extensions of this study are discussed in Section 4.

II. MODEL FORMULATION

We begin our discussion with a demonstrative model, which considers a continuum of all game players with differential valuations. Since this study focuses on the analysis of the releasing strategies of two different versions of a game, we assume that the total mass of the potential players is a constant and normalize the mass, without loss of generality, to 1. The players may play a multiplayer game for two reasons: the fun/accomplishment (i.e. competency-seeking and autonomy-seeking) and the fun/interaction (i.e. relatedness-seeking). The former derives a utility (α) from playing games for competency-seeking and autonomy-seeking while the latter derives a utility (β) from interacting with other players for relatedness-seeking. We also assume these two utilities are additive. That is, a player's total gaming playing utility, $u = \alpha + \beta$. Players differ in their valuation of utilities α and β. The distributions of α and β are different from game to game, depending on the design of the game, which is at the discretion of the game publisher. For simplicity, we assume that $\alpha \sim U\left[0, A\right]$, and $\beta \sim U\left[0, B\right]$. That is, the players are distributed uniformly over the rectangular space $\left[0, A\right] \times \left[0, B\right]$ of the two dimensional plane (see Figure 1).

The game publisher can invest in improving a game's storyline and levels of challenges, hence increasing the maximum value of α (i.e., increasing the value of A). Similarly, improving the interactive features of the game can enhance the players' social interactive value β (i.e. increasing the value of B). One special case is that $B = 0$, when the game does not provide any features for interacting with other human players. In other words, it is essentially a single-player version of the game. In that case, the player's distribution region $[0,A]\times[0,B]$ shrinks to a one-dimensional segment $[0,A]$. The costs associated with improving both dimensions are $C_A(A)$ and $C_B(B)$ respectively, which are assumed to be monotonically increasing and convex for $(A,B)\in\mathbb{R}_+^2$. We adopt the commonly used cost function forms $C_A(A)=c_{a0}+c_a\cdot A^2$ and $C_B(B)=c_{b0}+c_b\cdot B^2$, where c_{a0} and c_{b0} are the sunk costs for providing features in each dimension and c_a and c_b are the coefficients reflecting the difficulty in improving each dimension. As common to most digital products, we assume that the variable cost for serving an addition consumer is negligible.

The game publisher can decide on the size of investments in terms of $C_A(A)$ and/or $C_B(B)$, taking into account factors such as marketing conditions and development cost. Her possible decisions include (i) only single-player version ($B=0$), (ii) only multiplayer version, and (iii) both multiplayer and single-player versions. If both versions are to be offered, the game publisher will incur an additional versioning cost $\delta\geq 0$ due to the need to market and package a new version of the same game. When the game versions are ready to be released, the publisher determines the final prices and markets to the consumer. In this paper, we focus on the situation where a player will only purchase one version of the game. In reality, some players may choose to purchase both versions of the game so that they can gain their skills on a single-player offline version and then play with their peer players online with a better relative performance. We do not consider this situation in this study as those players normally account for a negligible portion of the market and ignoring this possibility will not materially alter our results.

We summarize the timeline in Figure 2. Period 0 is the planning phase, at which the game publisher decides what version(s) to offer to the market and how much to invest in developing along each of the game dimensions to maximize the potential market (i.e. the value of *A* and *B*). At period 1, the game development is complete and ready to be released. The game publisher will announce the price(s) for the version(s) offered. At period 2, the players decide whether and which version to buy.

FIGURE 1. THE DISTRIBUTION OF GAME PLAYERS

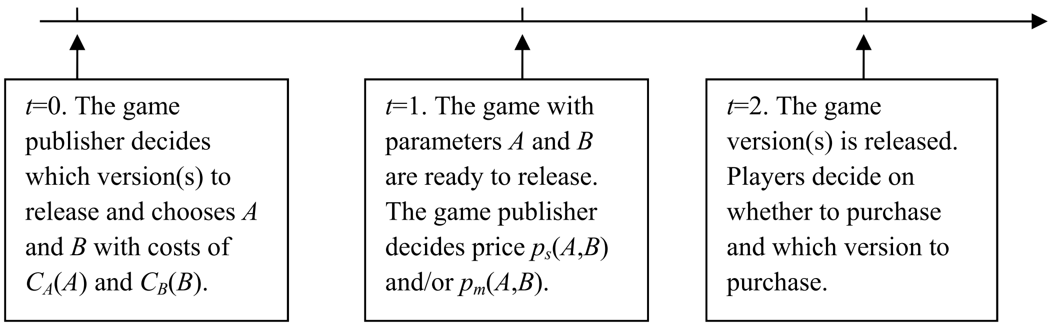

FIGURE 2. THE TIMELINE OF THE GAME RELEASE

III. ANALYSIS AND RESULTS

We use backward induction to analyze the decisions at each stage of this multi-period process. The demand and the publisher's revenue at time t=2 were analyzed first, in terms of the maximum utilities $\left(A,B\right)$ and price(s). We then examine the pricing decision at time t=1 and the parameter choices $\left(A,B\right)$ at time t=0. Lastly, we compare the profits of different versioning strategies: single-player only, multiplayer only, and both versions. We will use subscripts "s", "m", and "b" to denote the three cases where applicable.

3.1. Single-player Version Only

If the game publisher decides to offer only the single player version of the game, the parameter B is set as 0. Given the publisher's choice of A_s and p_s, players will purchase the single-player game if and only if their valuation of the game play, $\alpha \geq p_s$. When the total market size is normalized to 1, the total demand of the single-player games D_s can be expressed as a function of A_s and p_s:

$$D_s\left(p_s,A_s\right)=1-F\left(p_s\right)=\frac{A_s-p_s}{A_s} \tag{1}$$

The game publisher's expected revenue by selling such a game is

$$r_s\left(p_s,A_s\right)=p_s\cdot D_s=\frac{p_s\left(A_s-p_s\right)}{A_s}. \tag{2}$$

Considering the game publishers' pricing and investment decision, the overall expected profit of selling the single-player game is calculated as:

$$\pi_s\left(p_s,A_s\right)=r_s\left(p_s,A_s\right)-c_{a0}-c_a\cdot A_s^2=\frac{p_s\left(A_s-p_s\right)}{A_s}-c_a\cdot A_s^2-c_{a0}. \tag{3}$$

Proposition 1 [optimal pricing decision for single-player game]:
If the game publisher decides to offer only the single-player version, then the optimal price

for the single-player game is $p_s^*\left(A_s\right)=\frac{A_s}{2}$ and the maximum revenue gained by optimal pricing $r_s\left(p_s^*,A_s\right)=\frac{A_s}{4}$.

Proof: this is the standard monopoly pricing result derived by solving the maximization problem $\max_{p_s\geq 0} r_s\left(p_s^*,A_s\right)$. □

Note that the value of the optimal revenue here is a half of the optimal price because the total market size is normalized to 1. This should not affect the interpretation of optimal conditions and comparisons of different strategies. Therefore, we will use the normalized market size, instead of a constant, to keep our presentations throughout this paper concise. The optimal price p_s^* has a positive linear relationship with the maximum game play utility A_s, which can be controlled by the game publisher. To increase A_s, the publisher needs to invest more to make the game more interesting or challenging. As a result, players will value it more, as reflected in the game players' distribution. Proposition 2 describes the optimal investment decisions.

Proposition 2 [the optimal investment decision for a single-player game]:
The optimal choice of the maximum game play value $A_s^*=\frac{1}{8\cdot c_a}$, the resulting single-player price $p_s^*=\frac{1}{16\cdot c_a}$ and the maximum profit $\pi_s^*=\pi_s\left(p_s^*,A_s^*\right)=\frac{1}{64c_a}-c_{a0}$.

Proof: From Proposition 1, we have the optimal price charged, which is a function of the maximum game play value A. Plugging the optimal price function to the game publishers' profit function (Equation 3), we have:

$$\pi_s\left(p_s,A_s\right)=\frac{A_s}{4}-c_a\cdot A_s^2-c_{a0}$$

Maximizing $\pi_s\left(p_s,A_s\right)$ by taking first order derivative on A_s, we can easily obtain that the only value that maximizes π_s is $A_s^*=\frac{1}{8\cdot c_a}$. Plugging $A_s^*=\frac{1}{8\cdot c_a}$ into the optimal pricing function $p_s^*\left(A_s\right)=\frac{A_s}{2}$ and the profit function $\pi_s\left(p_s,A_s\right)=\frac{A_s}{4}-c_a\cdot A_s^2-c_{a0}$, we obtain the results stated in Proposition 2. □

As shown in Proposition 2, the optimal price, maximum profit, and most importantly the optimal investment decision increase as the cost factor c_a decreases. The result shows that a single-player game can incorporate more interesting features given a certain investment budget if the game publishers can cut down the development cost.

3.2. Multiplayer Version Only

When a multiplayer game with parameters $\left(A_m,B_m\right)$ is designed and released, with a price p_m, a player's utility is composed of two parts: $u_m=\alpha+\beta$. That is, a player will purchase the multiplayer game if and only if $\alpha+\beta \geq p_m$. The overall demand of the multiplayer game D_m can be calculated as (see Figure 3 for demonstration):

$$D_m\left(p_m,A_m,B_m\right)=\frac{1}{A_m\cdot B_m}\int_0^{A_m}\left(B_m-\left(p_m-\alpha\right)^+\right)^+ d\alpha\ , \tag{4}$$

where the notation $\left(x\right)^+=\max\left\{0,x\right\}$ for $\forall x$.

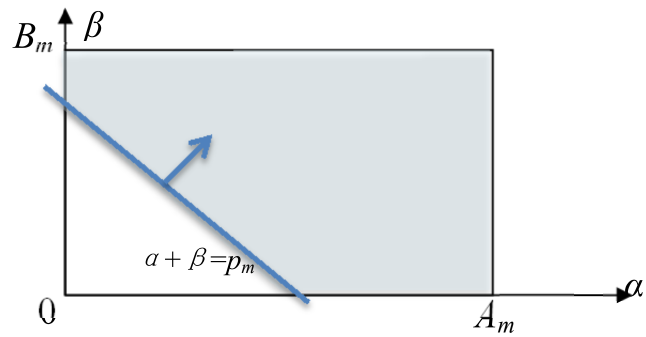

FIGURE 3. PLAYER DISTRIBUTION FOR MULTIPLAYER VERSION ONLY

The game publisher's revenue by selling the multiplayer game is

$$r_m\left(p_m,A_m,B_m\right)=p_m\cdot D_m\left(p_m,A_m,B_m\right). \tag{5}$$

The overall profit:

$$\pi_m\left(p_m,A_m,B_m\right)=r_m\left(p_m,A_m,B_m\right)-c_a\cdot A_m^2-c_b\cdot B_m^2-c_{a0}-c_{b0}. \tag{6}$$

Proposition 3 [the optimal pricing decision for a multiplayer game]:
Given $\left(A_m,B_m\right)$, the game publisher shall evaluate the relative values of A_m and B_m to determine the optimal prices. More specifically, when

i. $A_m\le\frac{2}{3}B_m$, the game publisher could charge an optimal price $\frac{1}{4}A_m+\frac{1}{2}B_m$ to maximize the sale revenue, which will be $\frac{1}{16B_m}\left(2B_m+A_m\right)^2$;

ii. $\frac{2}{3}B_m\le A_m<\frac{3}{2}B_m$, the game publisher could charge an optimal price $\frac{\sqrt{6A_mB_m}}{3}$ to maximize its' sale revenue, which will be $\frac{2\sqrt{6A_mB_m}}{9}$; and

iii. $A_m>\frac{3}{2}B_m$, the game publisher could charge an optimal price $\frac{1}{2}A_m+\frac{1}{4}B_m$ to maximize the sale revenue, which will be $\frac{1}{16A_m}\left(2A_m+B_m\right)^2$.

Proof: Equation (4) shows the general form of the demand function. We could first focus on the case when $B_m\le A_m$. Depending on the relative value of p_m, A_m, and B_m, there could be three possibilities:

(a) When $p_m\le B_m\le A_m$, we have:

$$D_m = \frac{1}{A_m \cdot B_m}\left[\int_0^{p_m}\left(B_m - (p_m - \alpha)\right)d\alpha + \int_{p_m}^{A_m} B_m \, d\alpha\right] = \frac{1}{A_m \cdot B_m}\left[A_m \cdot B_m - \frac{1}{2}p_m^2\right]$$

(b) When $B_m \le p_m \le A_m$, we have:

$$D_m = \frac{1}{A_m \cdot B_m}\left[\int_{p_m - B_m}^{p_m}\left(B_m - (p_m - \alpha)\right)d\alpha + \int_{p_m}^{A_m} B_m \, d\alpha\right] = \frac{1}{A_m}\left[\frac{1}{2}B_m + (A_m - p_m)\right]$$

(c) When $A_m \le p_m \le A_m + B_m$, we have:

$$D_m = \frac{1}{A_m \cdot B_m}\left[\int_{p_m - B_m}^{A_m}\left(B_m - (p_m - \alpha)\right)d\alpha\right] = \frac{\left(A_m + B_m - p_m\right)^2}{2A_m \cdot B_m}$$

For given values (A_m, B_m), we could find the optimal value of p_m by taking first order derivative of the revenue $r_m = p_m \cdot D_m$ over p_m.

In case (a), we have $p_m^* = \frac{\sqrt{6A_m B_m}}{3}$, which satisfies the boundary condition $p_m \le B_m \le A_m$ only when $\frac{2}{3}A_m \le B_m \le A_m$.

In case (b), we have $p_m^* = \frac{1}{2}A_m + \frac{1}{4}B_m$, which satisfies the boundary condition $B_m \le p_m \le A_m$ only when $A_m \ge \frac{3}{2}B_m$.

In case (c), the first order condition has two solutions: $p_m^* = \frac{1}{3}\left(A_m + B_m\right)$ and $p_m^* = A_m + B_m$, neither satisfies the boundary condition $A_m \le p_m \le A_m + B_m$ and the second order condition concavity condition. Hence there is no optimal solution when $p_m \in \left(A_m, A_m + B_m\right]$.

In summary, when $A_m \ge B_m$, optimal price.

$$p_m^* = \begin{cases} \frac{\sqrt{6A_m B_m}}{3} & \text{when } \frac{2}{3}A_m \le B_m \le A_m \\ \frac{1}{2}A_m + \frac{1}{4}B_m & \text{when } A_m \ge \frac{3}{2}B_m \end{cases}$$

Symmetrically, we can obtain similar results when $A_m \le B_m$ as

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$$p_m^* = \begin{cases} \frac{\sqrt{6A_m B_m}}{3} & \text{when } \frac{2}{3}B_m \le A_m \le B_m \\ \frac{1}{2}B_m + \frac{1}{4}A_m & \text{when } B_m \ge \frac{3}{2}A_m \end{cases}$$

Combining the two results, we can derive the optimal price and revenue.

The contour lines of prices with respect to (A_m, B_m) are shown in Figure 4 below.

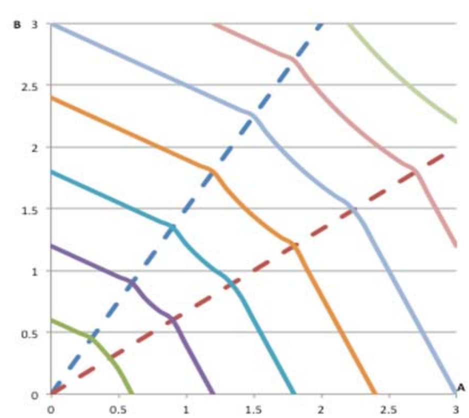


FIGURE 4. CONTOUR LINES FOR THE OPTIMAL PRICES GIVEN (A_m, B_m)

The blue and red dotted lines represent the boundaries separating the cases: $A_m = \frac{2}{3} B_m$ and $A_m = \frac{3}{2} B_m$, which separate the three cases of different pricing functions. The result of Proposition 3 suggests the following pricing strategies:

(1) The optimal price increases along with the values of A_m and B_m: the more the game publisher invests to maximize the play value and the interactive value, the higher the price she can charge.

(2) When B_m is relatively small (i.e., $B_m \leq \frac{2}{3} A_m$, under which the game has limited interactive features and focuses more on the game play itself), we have $\frac{\partial p_m^*}{\partial A_m} = \frac{1}{2}$ and $\frac{\partial p_m^*}{\partial B_m} = \frac{1}{4}$. That is, the price is more sensitive to the level of game play features rather than the interactive features since they are the dominating component of the game. When B_m is relatively large, or A_m is relatively small (i.e., $A_m \leq \frac{2}{3} B_m$), we have $\frac{\partial p_m^*}{\partial B_m} = \frac{1}{2}$ and $\frac{\partial p_m^*}{\partial A_m} = \frac{1}{4}$. That is, the game emphasizes on the interaction rather than the storyline itself. The price is more sensitive to the level of the interactive features compared to the level of game play features.

(3) In an extreme case when B_m=0, the game is the same as a single-player version and the price converges to the single-player version price, i.e. $\lim_{B_m \to 0} p_m^*(A_m, B_m) = p_s^*(A_m) = \frac{1}{2} A_m$. The result confirms that, given the same game investment ($A_m = A_s$), the single-player game is a special case of the multiplayer game with B_m=0.

(4) In another extreme case when A_m=0 or the multiplayer game contains purely interactive functions and not much of a game per se, the situation becomes very similar to social networking websites, such as Facebook without games, Linkedin, etc., where the users are there for networking with the fellows, and it will not derive any value if no other users join the game.

(5) if $B_m > 0$ and $A_m = A_s$, then $p_m^*(A_m, B_m) > p_s^*(A_m)$ and $r_m^*(A_m, B_m) > r_s^*(A_m)$. That is, adding some interactive features will always increase the players' valuation, the game publisher is able to raise the price and hence increase the revenue.

Corollary 1 [multiplayer game optimal price characterization]: Given (A_m, B_m), the game publisher's optimal price for a multiplayer game, $p_m^* \leq \max(A_m, B_m)$.

Proof: The proof of the corollary will be done for the following three cases. For each case, it is sufficient if we can prove that either $p_m^* \leq A_m$ or $p_m^* \leq B_m$ is true.

i. When $A_m \leq \frac{2}{3} B_m$, we have

$$p_m^* = \frac{1}{4} A_m + \frac{1}{2} B_m \leq \frac{1}{4}\left(\frac{2}{3} B\right) + \frac{1}{2} B = \frac{2}{3} B;$$

ii. When $\frac{2}{3}B_m \le A_m < \frac{3}{2}B_m$, we have

$$p_m^* = \frac{\sqrt{6A_m B_m}}{3} < \frac{\sqrt{6\left(\frac{3}{2}B_m\right)B_m}}{3} = B_m;$$

iii. When $A_m > \frac{3}{2}B_m$, we have

$$p_m^* = \frac{1}{2}A_m + \frac{1}{4}B_m \le \frac{1}{2}A_m + \frac{1}{4}\left(\frac{2}{3}A_m\right) = \frac{2}{3}A_m.$$

Summarizing all three cases above, we successfully conclude corollary 1.

Corollary 1 has an important implication. If the publisher sets the price at $p_m^* > \max(A_m, B_m)$ then all players who purchase the game are those with both $\alpha > 0$ and $\beta > 0$. While those are the "high-end" customers the publisher would definitely like to target, this corollary suggests that focusing only on this "high-end" market would limit the overall demand and result in a lower profit.

Proposition 4:
If a game publisher decides that the multiplayer game is the only version to offer to the market, then the game publisher should choose the game parameter $\left(A_m^*, B_m^*\right)$ based on the cost coefficients c_a and c_b as follows:

i. When $c_b < \frac{4}{9}c_a$,

$$\left(A_m^*, B_m^*\right) = \left(\frac{3c_a - \sqrt{c_a^2 - 2c_a c_b}}{16c_a^2}, \frac{c_a + c_b + \sqrt{c_a^2 - 2c_a c_b}}{16c_a c_b}\right).$$

The resulting price is

$$p_m^* = \frac{2c_a^2 + 5c_a c_b + \left(2c_a - c_b\right)\sqrt{c_a^2 - 2c_a c_b}}{64c_a^2 c_b}$$

and the game publishers' profit is:

$$\pi_m^* = \frac{31}{64c_b} + \frac{17c_a c_b - c_b^2 + \left(8c_a - 5c_b\right)\sqrt{c_a^2 - 2c_a c_b}}{256c_a^2\left(c_a + c_b + \sqrt{c_a^2 - 2c_a c_b}\right)} - c_{a0} - c_{b0}.$$

ii. When $c_b \in \left(\frac{4}{9}c_a, \frac{9}{4}c_a\right)$,

$$\left(A_m^*, B_m^*\right) = \left(\frac{6^{\frac{1}{2}}}{18 \cdot c_a^{\frac{3}{4}} \cdot c_b^{\frac{1}{4}}}, \frac{6^{\frac{1}{2}}}{18 \cdot c_a^{\frac{1}{4}} \cdot c_b^{\frac{3}{4}}}\right).$$

The resulting price is $p_m^* = \frac{1}{9 \cdot c_a^{\frac{1}{2}} \cdot c_b^{\frac{1}{2}}}$ and the profit

$$\pi_m^* = \frac{1}{27 \cdot c_a^{\frac{1}{2}} \cdot c_b^{\frac{1}{2}}} - c_{a0} - c_{b0}.$$

iii. When $c_b > \frac{9}{4}c_a$,

$$\left(A_m^*, B_m^*\right) = \left(\frac{c_b + c_a + \sqrt{c_b^2 - 2c_a c_b}}{16c_a c_b}, \frac{3c_b - \sqrt{c_b^2 - 2c_a c_b}}{16c_b^2}\right).$$

The resulting price is

$$p_m^* = \frac{2c_b^2 + 5c_a c_b + \left(2c_b - c_a\right)\sqrt{c_b^2 - 2c_a c_b}}{64c_a c_b^2}$$

and the profit

$$\pi_m^* = \frac{31}{64c_a} + \frac{17c_a c_b - c_a^2 + \left(8c_b - 5c_a\right)\sqrt{c_b^2 - 2c_a c_b}}{256c_b^2\left(c_a + c_b + \sqrt{c_b^2 - 2c_a c_b}\right)} - c_{a0} - c_{b0}.$$

Proof: To prove Proposition 4, we need to plug in the optimal pricing decisions derived in Proposition 3 into the profit function (equation 6). Then, optimize the profit function by taking first order derivatives over A_m and B_m to derive the first order conditions. Solving the first order conditions we obtain the results above. Second order conditions are also checked to rule out the non-maximized solutions.

This result in Proposition 4 shows that $A_m^* > A_s^*$ and $B_m^* > B_s^* = 0$. That is, multiplayer game features increase the price and demand, hence motivating the game publisher to design a better game. Based on this result, we recommend that a transitional single-player game publisher consider bundling the game with additional interactive features to boost the demand by including people who may not value the game play itself but cherish the added interaction utility. That is, they play the game mostly because the game allows them to interact with their friends, family, and other peers.

Next, we will examine another possibility: both versions of the games are provided.

3.3. Both Single and Multiple player Versions

Now that the game publisher not only offers a multiplayer version of the game with parameters $\left(A_b, B_b\right)$ with price p_{bm}, but also offers a single-player version of the game with parameters A_b and price p_{bs}. A player will be able to choose whether to play the multiplayer or single-player version of the game. Here we assume that the players will not purchase both of the games. A player will choose a multiplayer version of the game if and only if the following two conditions hold simultaneously:

(i) The player's valuation of multiplayer game is higher than its price:
$u_{bm} = \alpha + \beta > p_{bm}$.

(ii) The player's net utility (i.e. valuation of multiplayer play less the price of multiplayer game) is higher than that when playing the single-player version:
$u_{bm} - p_{bm} > u_{bs} - p_{bs}$.
Or equivalently, the added multiplayer interaction value β is higher than the price premium of a multiplayer game over its single-player counterpart:
$\beta > p_{bm} - p_{bs}$.

Figure 5 below shows the players' version choices given p_{bm} and p_{bs}. The top area filled with blue dotted 45-degree lines indicates those players who will purchase the multi-player version, while the area filled with dashed horizontal lines represents those players purchasing the single-player version.

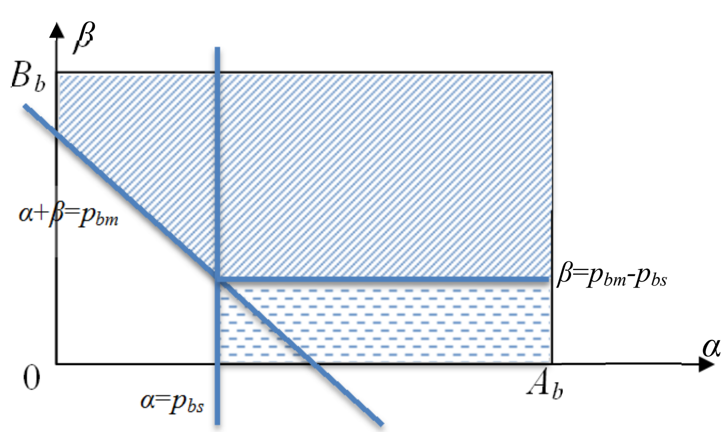


FIGURE 5. PLAYER DISTRIBUTION FOR BOTH VERSIONS

Based on Figure 5, we could write out the demand of the multiplayer version D_{bm} expression as:

$$D_{bm}\left(p_{bm},p_{bs},A_b,B_b\right)=\tfrac{1}{A_b\cdot B_b}\int_0^{A_b}\int_{\langle p_{bm}-\alpha\rangle_{(p_{bm}-p_{bs})^+}^{B_b}}^{B_b} 1\cdot d\beta d\alpha\ , \tag{7}$$

where the notation $\langle x\rangle_a^b=\min\{b,\max\{a,x\}\}$ for $\forall B\geq A\geq 0$. The demand of the single-player version D_{bs} can be calculated as:

$$D_{bs}\left(p_{bm},p_{bs},A_b,B_b\right)=\tfrac{1}{A_b\cdot B_b}\int_{p_{bs}}^{A_b}\int_0^{\langle p_{bm}-p_{bs}\rangle_0^{B_b}} 1\cdot d\beta d\alpha\ , \tag{8}$$

The overall revenue of selling both versions of the game:

$$r_b\left(p_{bm},p_{bs},A_b,B_b\right)=p_{bm}\cdot D_{bm}\left(p_{bm},p_{bs},A_b,B_b\right)+p_{bs}\cdot D_{bs}\left(p_{bm},p_{bs},A_b,B_b\right). \tag{9}$$

The game publisher's profit, including both designing and versioning costs, is:

$$\pi_b\left(p_{bm},p_{bs},A_b,B_b\right)=r_b\left(p_{bm},p_{bs},A_b,B_b\right)-\delta-c_a\cdot A_b^2-c_b\cdot B_b^2-c_{a0}-c_{b0}\ . \tag{10}$$

Note that an additional versioning cost $\delta\geq 0$ is incurred if the game publisher provides both versions of the game.

Proposition 5 [The Optimal Pricing decision for both versions]:
If both versions are offered and parameters $\left(A_b,B_b\right)$ have been chosen, the optimal prices $\left(p_{bm}^*,p_{bs}^*\right)$ that maximizes the game publishers' sales revenue are expressed as:

$$\left(p_{bm}^*,p_{bs}^*\right)=\begin{cases}\left(\frac{1}{3}A_b+\frac{1}{2}B_b,\frac{2}{3}A_b\right) & \text{if } A_b<\frac{3}{2}B_b\\ \left(\frac{1}{2}A_b+\frac{1}{4}B_b,\frac{1}{2}A_b+\frac{1}{4}B_b\right) & \text{if } A_b\geq\frac{3}{2}B_b.\end{cases}$$

The corresponding optimal revenue

$$r_b^*\left(A_b,B_b\right)=\begin{cases}-\frac{1}{27B_b}A_b^2+\frac{1}{3}A_b+\frac{1}{4}B_b & \text{if } A_b<\frac{3}{2}B_b\\ \frac{1}{16A_b}\left(2A_b+B_b\right)^2 & \text{if } A_b\geq\frac{3}{2}B_b.\end{cases}$$

Proof: To calculate the revenue, we can expand equation (9) by substituting and expanding equations (7) and (8). We then obtain the following expression:

$$\begin{aligned}&r_b\left(p_{bm},p_{bs},A_b,B_b\right)\\&=p_{bm}\cdot D_{bm}\left(p_{bm},p_{bs},A_b,B_b\right)+p_{bs}\cdot D_{bs}\left(p_{bm},p_{bs},A_b,B_b\right)\\&=\tfrac{p_{bm}}{A_b\cdot B_b}\int_0^{A_b}\int_{\langle p_{bm}-\alpha\rangle_{(p_{bm}-p_{bs})^+}^{B_b}}^{B_b}1\cdot d\beta d\alpha+\tfrac{p_{bs}}{A_b\cdot B_b}\int_{p_{bs}}^{A_b}\int_0^{\langle p_{bm}-p_{bm}\rangle_0^{B_b}}1\cdot d\beta d\alpha\\&=\begin{cases}\tfrac{p_{bm}}{A_b\cdot B_b}\left(A_bB_b-A\left(p_{bm}-p_{bs}\right)-\frac{1}{2}p_{bs}^2\right)+\tfrac{p_{bs}}{A_b\cdot B_b}\left(p_{bm}-p_{bs}\right)\left(A-p_{bs}\right) & \text{when } p_{bs}\leq p_{bm}\leq B_b\\ \tfrac{p_{bm}}{A_b\cdot B_b}\left(\frac{\left(A_b-p_{bs}\right)+\left(A_b+B_b-p_{bm}\right)}{2}\left(B_b-p_{bm}+p_{bs}\right)\right)+\tfrac{p_{bs}}{A_b\cdot B_b}\left(p_{bm}-p_{bs}\right)\left(A-p_{bs}\right) & \text{when } p_{bs}\leq B_b\leq p_{bm}\end{cases}\end{aligned}$$

Simplifying the above equations and taking the first order derivatives with respect to p_{bs} and p_{bm}, we can derive the optimal solutions:

$$\left(p_{bm}^*,p_{bs}^*\right)=\begin{cases}\left(\frac{1}{3}A_b+\frac{1}{2}B_b,\frac{2}{3}A_b\right) & \text{when } p_{bs}\leq p_{bm}\leq B_b\\ \left(\frac{1}{2}A_b+\frac{1}{4}B_b,\frac{1}{2}A_b+\frac{1}{4}B_b\right) & \text{when } p_{bs}\leq B_b\leq p_{bm}\end{cases}.$$

Imposing boundary conditions

$p_{bs}^* = \frac{2}{3}A_b < p_{bm}^* = \frac{1}{3}A_b + \frac{1}{2}B_b < B_b$ and $p_{bm}^* = \frac{1}{2}A_b + \frac{1}{4}B_b < B_b$, we could conclude that the boundary condition is: $A_b < \frac{1}{4}B_b$ and $A_b \geq \frac{3}{2}B_b$, respectively. Plugging the price results back to the revenue function, we obtain the results shown in Proposition 5.

Comparing the prices of the multiplayer-only case with those of the both-version case, we can provide the following two important insights:

(1) When $A_b \geq \frac{3}{2}B_b$ or when the investment in interaction features is relatively small, $r_b^*(A,B) = r_m^*(A,B)$. The optimal strategy under this condition is to charge the same price for both versions, i.e $p_{bm}^* = p_{bs}^*$. That is, all players with β >0 will choose the multiplayer version and all those who do not value game interaction at all (i.e. β=0) will be indifferent between these two versions. The overall demand for the single player version is approximately 0. The game publisher is not able to extract additional revenue through the single-player version. Hence, the revenue $r_b^*(A_b,B_b)$ is equivalent to the case when only multiplayer game is offered $r_m^*(A_b,B_b)$. Considering the fact that the game publisher needs to pay additional versioning cost δ to offer the two different versions, we can readily conclude that it would not be optimal for the publisher to offer both versions to the market in this case.

(2) When $A_b < \frac{3}{2}B_b$, the game has significant interaction components. In this case, we have that $r_b^*(A_b,B_b) > r_m^*(A_b,B_b)$. That is, the game publisher can increase sales by offering two different versions of the game and discriminate its potential customers via their heterogeneous valuation of the interactive features. By comparing the optimal prices for this case with the multiplayer-only case, we can gain the following insights:

a. Since $p_{bm}^*(A_b,B_b) > p_{bs}^*(A_b,B_b)$, there will always be a positive demand for the single-player version of the game.

b. The following inequality will always hold: $p_{bm}^*(A_b,B_b) > p_m^*(A_b,B_b)$. That is, the optimal price for a multiplayer version game when both versions are available is higher than that when only the multiplayer version is available. The game publisher can charge a higher price for the same game and reap the benefit of price discrimination. The intuition is that the game publisher will attract those potential players with a low interaction value β using the single-player version of the game. The multiplayer version of the game will be targeted for those who value both the game itself (i.e. high α) and the interaction features (i.e. high β). Thus, the game publisher is able to increase the price in this "high-end" market.

c. $p^*_{bs}\left(A_b, B_b\right) > p^*_s\left(A_b\right)$, which suggests that for the same single-player game, the single-player version buyers will pay a higher price when a multiplayer counterpart is offered. The reason is that the single-player game is focused only on the customers with a high game play value (α) but a low interaction value (β). A lower single-player version price will attract some potential customers with relatively high interaction value and hurt the profitability of the multiplayer version game. Given the fact that the multiplayer version is always sold at a higher price, the game publisher would have an incentive to increase the single-player game price to avoid this situation. Please note that the incentive constraint of purchasing multiplayer game is $\beta > p_{bm} - p_{bs}$. Reducing p_{bs} will increase the threshold on the right hand side, and hence reduce the demand of the more lucrative multiplayer game.

Now we examine the choice of game design parameters $\left(A_b, B_b\right)$. Since the profit is the same as the multiplayer only version if $B_b \le \frac{2}{3}A_b$, we will focus on the situation when $B_b > \frac{2}{3}A_b$.

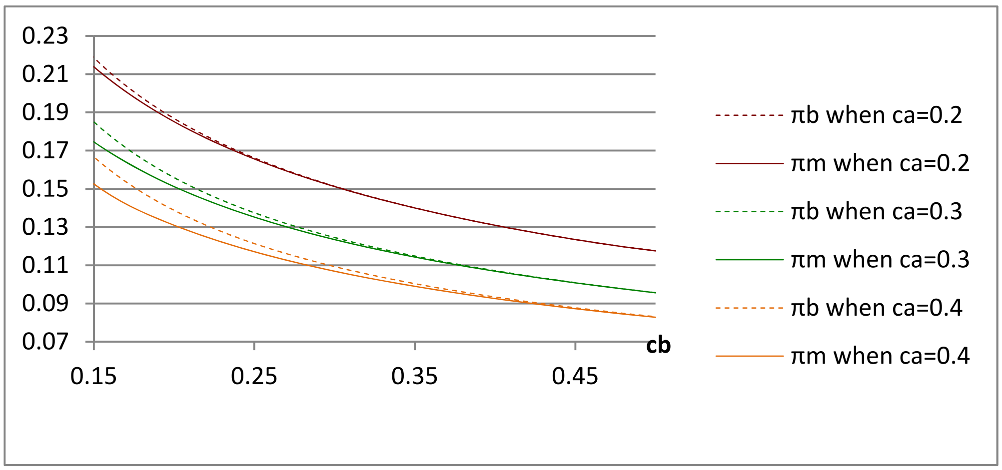
Proposition 6 [The Optimal Investment for Both Versions]:
If $c_b < \frac{9}{4}c_a$, there exists a unique solution (A^*_b, B^*_b) , in which B^*_b solves: $(8c_bB^*_b - 1)(27c_aB^*_b + 1)^2 = 3$ and $A^*_b = \frac{9B^*_b}{54c_aB^*_b+2}$.

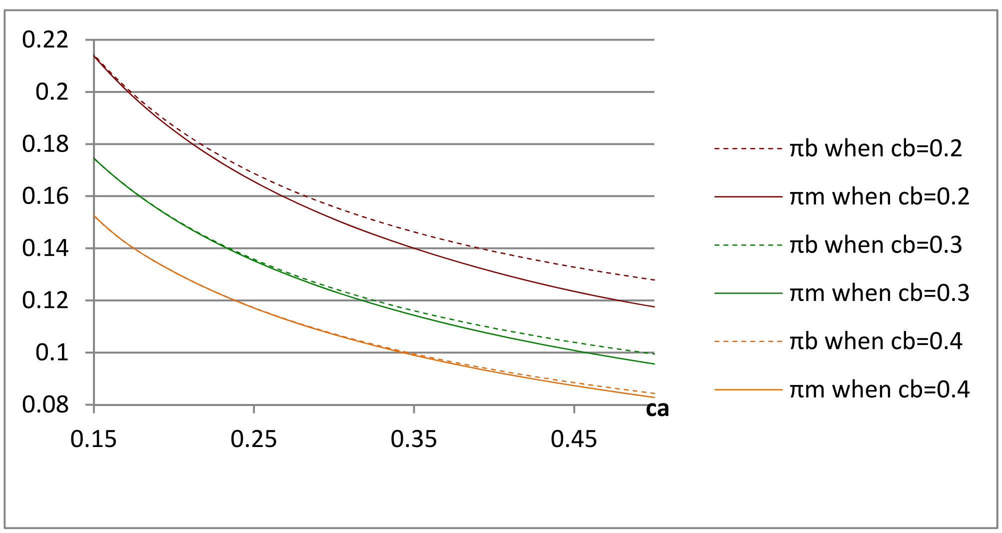
Proof: Proposition 5 show that the game publisher shall only provide both products when $B_b > \frac{2}{3}A_b$. In this case, we have the optimal pricing solution $\left(p^*_{bm}, p^*_{bs}\right) = \left(\frac{1}{3}A_b + \frac{1}{2}B_b, \frac{2}{3}A_b\right)$. Plugging the optimal prices back in the profit function (10), we can derive the following expression for game publisher's overall profit for providing both versions, including the developing and versioning costs:

$$\pi_b = \frac{1}{3B_b} \cdot \left(\frac{3}{4}B_b^2 - \frac{5}{9}A_b^2 + \frac{5}{3}A_bB_b\right) - \delta - c_aA_b^2 - c_bB_b^2 - c_{a0} - c_{b0}$$

Taking the first order derivative, we can obtain the condition listed in Proposition 6. Note that the solution is unique for this bivariate third-order equation since the other pair of solutions do not meet the second order concavity condition.

Now let us first ignore the versioning cost δ (i.e. assume that δ=0). If $c_b \ge \frac{9}{4}c_a$, or if the cost parameter of developing the interactive features is relatively high comparing to the cost of developing the game play features (i.e. more than 2.25 times of c_a), the game publisher will only offer the multi-player version game even though the companion single-player version can be provided at no addition cost. The reason is that, when the cost of developing the interactive feature is relatively high, the game publisher will choose a relatively low value for B_b. That is, the game will not contain rich interactive features any way. In this case, it may not be worth discriminating the players along the interaction dimension. As shown in Figures 6 (a) and (b), the profit of offering multiplayer version is lower than that of offering both versions when the versioning cost (δ) is 0 and c_b is relatively smaller. The difference, however, will shrink and eventually reduce to 0 when $c_b > \frac{9}{4}c_a$. These two graphs also show that, not surprisingly, both profits (π_m and π_b) decreases as c_a and c_b increase.





FIGURES 6. (a) AND (b).
COMPARISON OF π_m AND π_b c WHEN c_a AND c_b VARY (δ=c_{b0}=0)

3.4. Which Version(s) to Offer?

This section uses a numerical study to compare the game publisher's profits for the three different versioning strategies discussed in section IV.I – III. As discussed in the previous three sections, the profitability from these three versioning strategies depends on the cost factors: (i) the versioning costs c_{b0} and δ and (ii) the cost coefficients associated with improving the play and interactive features, c_a and c_b. Figures 7 (a)-(c) compare the three versioning choices when the above four parameters vary.

The top area in each figure shows when the single-player version is optimal. All three figures show similar shapes, indicating that it is optimal to offer only the single-player version when the cost of improving the interactive features c_b is relatively large. The c_b threshold value decreases when the sunk costs c_{b0} and δ increase.

The bottom right area is when c_b is relatively lower comparing to c_a. In this case, the game publisher will be able to invest more in developing the interactive features and hence be able to provide two quite different game versions: the one with no interactive features (the single-player version) and the one with a lot of interactive features. This ability allows her to profitably discriminate the game market and attract two different gamer groups to maximize the profit. Also notice that the comparison among the three figures shows that the c_b threshold decreases when δ increases. That is, when the cost of marketing one additional game version increases, it is harder for the game publisher to offer additional features unless c_b is really low.

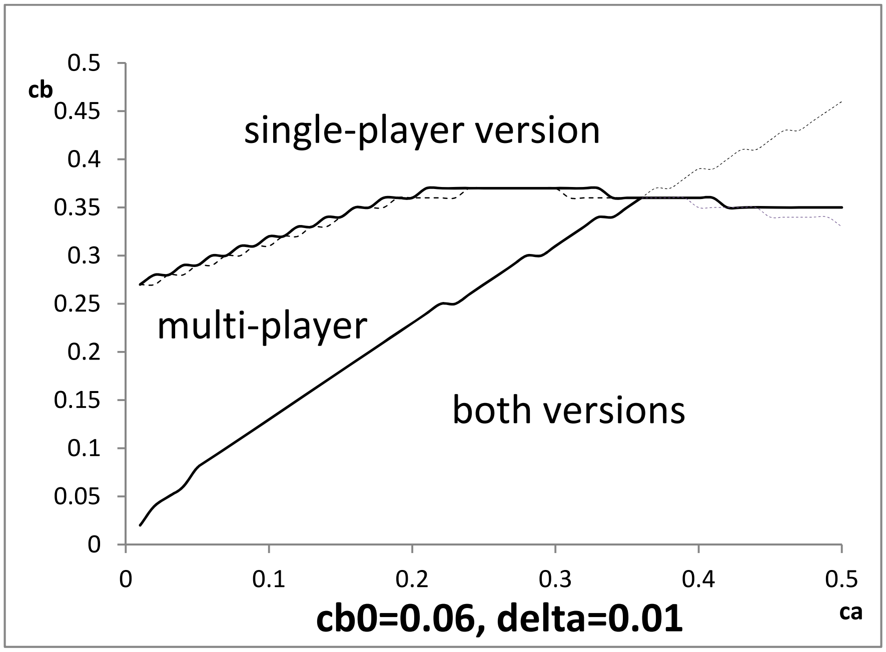
When c_{b0} increases, it does not have much impact on the publisher's choice between the multi-player version and both versions. However, the game publisher would be more likely to choose the single player version when c_b is large. The general explanation is that both c_{b0} and c_b are associated with developing the interactive feature. When both cost parameters are too large, the game publisher will be discourage to invest in the B dimension. Hence, a single-player game version might be the best they could offer.

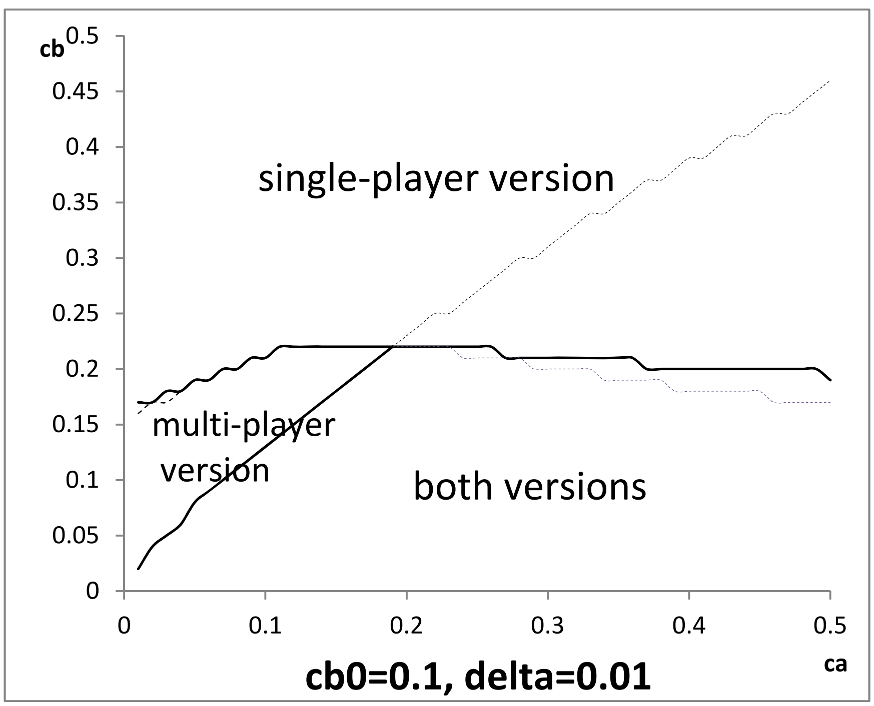
The mid-left area represents when only multi-player version should be chosen. The intuition is that the publisher will find it profitable to offer only this version of the game when c_b is relatively low so that the publisher has the incentive to invest and develop the multiplayer version but not so low as to be able to offer a highly interactive game to discriminate the market.

IV. CONCLUSION AND LIMITATION

In this paper, we build a two-dimensional Hotelling model to capture two major characteristics of a video game player. We look at how these two factors affect their choice of the game version (multiplayer versus single-player). The result allows us to examine the demand for different game versions and therefore analyze game publishers' version releasing strategies.

Our results support the observation that there exit several versioning and pricing strategies in the current gaming market. These strategies mostly depend on multiple cost parameters associated with the game development and marketing. These costs include those for game stories, challenges, interactions and versioning. Publisher should only offer the single-player version when the cost of interaction is high. Depending on the relative proportion of interaction cost and the cost of game stories and challenges, the publisher should develop either just a multi-player version or both versions to maximize profit. These results provide interesting insights for game publishers on how to target game players based on their preferences. They also provide useful guidance for publishers to best manage their product portfolios by allocating budges on various production and marketing costs.





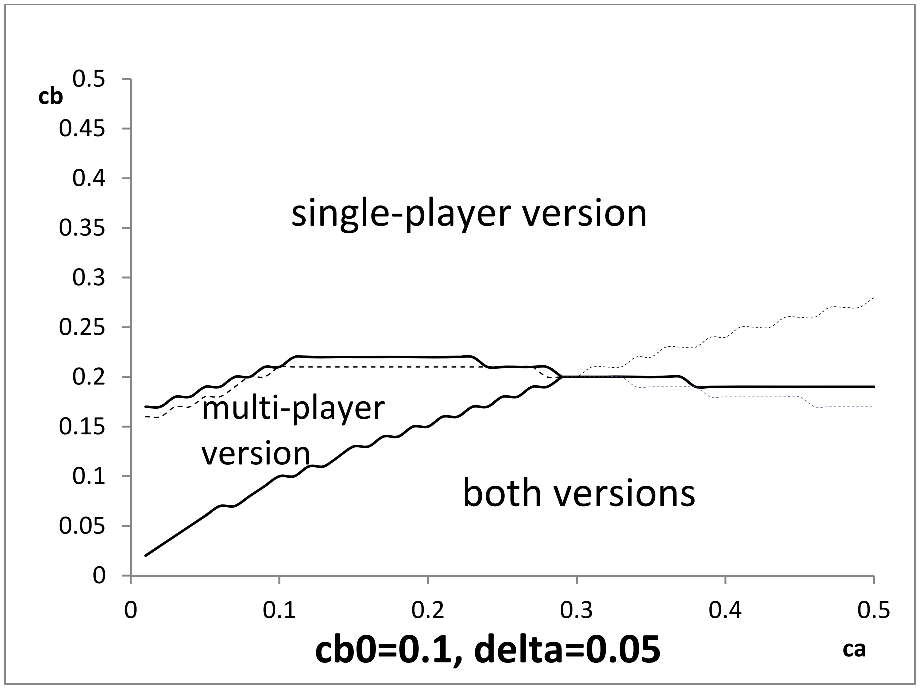


FIGURE 7. (a), (b) & (c).
DIFFERENT VERSIONING STRATEGIES WHEN c_a AND c_b VARY

In our current analysis, we use a one-time only subscription fee scheme when studying the multiplayer version of the game. This is a simplified version of the current monthly fee strategy (with limited game periods). In the future research, we will expand our research to include the strategy for time-based pricing scheme, in which the cost of play is strictly dependent on the amount of time a player spends on a game.

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