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Research Article

Determining the Pricing Strategy and Pricing the Products of Mobile Games: Mathematical Model Approach

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In the technology era, new sectors, occupations, and products or services related to technology arise. Mobile gaming industry is one of those sectors with the technological developments of personal mobile devices. This sector is rapidly growing in terms of the number of companies, employees, games, and financial income; however, this situation increases the competition and companies in this sector survive as if they succeed a sustainable profit from the game by selling their products or services. These products can be grouped into four which are the game itself, cosmetic products, in-application purchases, and advertisements or product placements during the gameplay. This study outlines a two-staged decision process for deciding which products should be priced and how much they should be charged for every customer. The first stage is an enumeration of all sixteen alternatives of pricing strategies for four products which are game, in-game boost-ups, cosmetics and advertisements, and expert decision to choose among those alternatives which would fit to the concerned mobile game. In the second stage, a mathematical model is used to price for obtaining the maximum profit for the company. Another mathematical model is also proposed for pricing the products differently for each customer according to their psychological player profile as if the decision-maker prefers such a pricing strategy. Implication and extensions of the models are discussed, and their real-life application is also presented in the study.

1. Introduction

In the past two decades, the video game industry has been one of the most important parts of the entertainment industry and still has an increasing market share. According to Marchand and Hennig-Thurau [1], the video game industry has more limited scientific research than other types of entertainment (movies, music, etc.). Very similar to this study, the authors focused on the processes that create value from the perspective of consumers and customers regarding these games, which reach many players with many game tools. In Wijman's study [2], the ten largest companies in the game industry are included. It is also stated that the income generated by these ten companies is 80% of the total market. According to Wijman's another study [3] and the Global Games Market Report published by Newzoo's Analytics Platform, the 2020 global game market is targeted to generate $159.3 billion in revenue, with an annual growth of 9.3%. The highest portion of this increase is seen in mobile games. According to Wijman's study [3], the three main reasons for this situation are that mobile games are easier to access than other games, they are wider to play, and there is no need for a fixed place. The development time of mobile games is shorter than that of other game types, so updates and developments can be integrated into the games faster in addition to these three reasons. The mobile game industry, which started to become widespread in the early 2000s, is observed to be seen with an increasing trend in each following year.

The information gained from the industry shows us the place of the game industry in our lives and its value for both companies and players. It is expected that the number of games developed, the number of game companies, and the number of players are going to increase with the developments in technology and portable devices. In other words, the game industry is a sector that has not yet reached the

saturation level although the revenues and player numbers are very high.

The most important sources of income for gaming companies are players and advertisements. The number of players has a direct effect on in-game purchase revenue and advertising deals. Similarly, the biggest demand for players is games. Players expect the games to meet their expectations based on their psychological profile, motivation to play the game, and/or their wishes. In short, the most important point is the players and game companies as customers of each other. At this point, one of the biggest question is whether games are designed with a systematic approach or not.

When we think about how a systemic game design should be, it is necessary to consider that there are customers on both sides. The aim of this study is to maximize the revenues of the game companies to become competitive in the gaming industry. There are two main motivations of this research which are the greatness of the mobile gaming industry and a need for a systematical approach to bring a profitable and sustainable business model for mobile game companies depending on their player profile types. Looking at many games, it is seen that they do not have a systematic approach; they only focus on earning income or do not care about player satisfaction, although the game industry is so large and increasing gradually. As far as we know, there are not any studies directly related to this research article. The closest topic to this study is Budak [4] which states that the pricing decisions of mobile games should be handled with a holistic approach. Budak [4] is also one of the motivations of this study which is the first study that describes the pricing problem of the mobile game industry. Budak [4] outlines that pricing decision for mobile gaming companies has a significant effect on the profitability of the company and structures this pricing decision problem with the problem structuring methodology of drivers, pressures, state, impact, and response model of intervention (DPSIR). The main contributions of this study are the proposed mathematical models by using the problem structuring of this sector's pricing problem and the guidance to the mobile game companies for obtaining these models' components.

Herviainen et al. [5] evaluate the advantages and disadvantages of the freemium pricing model strategy in their study for video games. Other studies that are related to pricing on games are as follows: Choi et al. [6] proposed a discount sales strategy on pricing in games and Ernst [7] focused on pricing of in-game products considering player satisfaction.

In this study, we propose a systematic decision support model on pricing the products of mobile game companies. This decision support system has two steps, and the first step is to decide which products are to be priced. These products are the game itself, in-game purchases, advertisement, and product placement in the game. As an example, we do not think that it is a feasible approach to have all the in-game products together or none of them, but we also say that these decisions will differ according to the structure of the games. Scenarios have been created for the combination of products, and these scenarios are divided into feasible and unfeasible scenarios according to the opinion of a game developer and the mobile game companies' decision-maker. The options that will increase the number of active players who play the game and keep them connected to the game and the options that can create a certain source of income for the companies are determined as feasible.

The second decision step is deciding on the price of the products which are identified as products to be priced in the first step by the decision-maker of the company. Two different mathematical models are proposed for this step of the decision support system, and the decision-maker can use one of the appropriate ones according to the company strategy. These mathematical models are aimed at maximizing the income of the game companies by using the parameters to be obtained through the survey conducted in the application part. The most important parameter of the model is the prices of in-game products to be obtained with the opinions of the players. The reason why the mathematical model is handled in two stages is whether the price parameter to be used in the model is the same for all players. It is suggested to present a determined price to all players thanks to the data obtained from the survey results as a mathematical model created with a single price, so that it can be stated that the first model determines a fixed price for a product and it applies to the all of the players. The second model, on the other hand, determines a profile-based price for each of the player profile types. The objective function in both of the models is the maximization of the income to be obtained for mobile game companies.

In the application part of the study, a world-wide popular mobile game is chosen to do a real-life application of the model. With the survey, all players are asked for the maximum price they can afford for a product which are priced inside this popular game. Therefore, parameters of the second step of the decision support model are obtained by applying this established survey. The models are solved by using these parameters obtained from the survey results and compared with the real-life situation. Solutions obtained from the proposed model are evaluated in the application section of this research, and results are discussed and compared with the two methodologies of demand-based pricing for service companies of Calabrese and De Francesco [8] and a different version competitive pricing of Von Neumann and Morgenstern [9].

This study contains five main sections. In the second part of the study, there are studies in the literature on pricing and decision support models and their applications in the game industry. In Methodology, the decision support model, mathematical models, and the survey to be used for obtaining the parameters in the application phase of this study are introduced. In the application part, one popular mobile game from the top 100 of game stores is chosen to try out the proposed models in real life. The data obtained are specified in this section, and the mathematical model is solved and results are evaluated. In Conclusion, an assessment and the gains of the study are mentioned and suggestions for the future studies in this field of research are identified.

2. Literature Review

In this section of the study, we mentioned the researches on various types of decision-making processes related to mobile or video games and pricing researches on this field.

Lee and Kim [10] conducted a study on determining the factors that increase the number of players and to identify the threats that may occur in order to ensure the continuity of the high number of users that mobile games have gained in the early times. This study includes a guideline to the game companies in the design, marketing, and management of mobile games, and output baseline hazard, determinants of attracting power, and determinants of holding power affect the growth of the company. Pathania et al. [11] aimed to increase customer satisfaction by emphasizing the importance of strategic decisions to power management on mobile games. Tsiropoulou et al. [12] considered convex pricing with a game theoretic approach for the distributed uplink power control in multiservice wireless networks. Toka et al. [13] investigated the resource allocation of network function virtualization and pricing of the games of service providers with equilibrium prices and resource market model. Choi and Kim [14] constructed a descriptive model for deeply understanding why players continue to play the concerned online game by considering the factors of customer loyalty, flow, personal communication, and social interactions. Gil and Warzynski [15] examined the relationship and regression between vertical integration and the performance of video games, and they found out that these are correlated with each other with direct proportion. Kim et al. [16] structured a decision model which finds out the positive relation between character design with cosmetic product inside the game and online buying behaviors and satisfaction of the game users. Chen et al. [17] ran a simulation model to the test level of the player losses of a mobile game with respect to the network failure, network delay, and preventive systems. Bailey and Katchabaw [18] considered the difficulty level of the game which is regulated according to the player's expectation by using the autodynamic difficulty technique. The study included an experimental environment which allows the emergence of various factors related to autodynamic difficulty. Hamari and Lehdonvirta [19] stated that selling virtual products for real money is a common revenue model for online games and tested their hypothesis with game designers. Piselli et al. [20] proved that player satisfaction is related to the performance of subject and complexity of the game by testing this claim with a simple cognitive model and a normative model. Chen et al. [21] proposes a decision-making model for the choice of a pricing strategy with the opinion of decision-makers who are experts in the online gaming industry. This study includes the eigenvector method, fuzzy set theory, Delphi method, and multicriteria decision-making method.

There are also studies related to the pricing of the mobile games in the literature. Harviainen et al. [5] focused on the service design part of the freemium pricing strategy that consists of four design workshops which are exploration, creation, reflection, and implementation. In these design workshops, combined designs have been developed to take into account the customer experience and soften the disadvantages of the freemium model. Choi et al. [6] stated that a discount sales strategy is one of the most important sales strategies in all markets, and this study examines the effects of the discounted sales strategy on the video game market. The discount amount and the discount rate have a positive impact on the sales volume and would also pose a threat to the competitor companies. Civelek et al. [22] stated that in-game purchases, game design, virtual currency, and strong competition with other companies create great challenges for game developers. Civelek et al. [22] also developed a duopoly model for integrating and pricing virtual money into free-to-play games. Ernst [7] focuses on the pricing of in-game products, considering players' satisfaction and in-game progress, and constructs the strategy on personalized pricing. Nojima [23] investigated the relationship between pricing models and the motivation of players to play multiplayer online games and conducted an experimental research in a Japanese firm to examine the determinants of pricing models which are relationship between monthly fixed fee, continuous play and social motivation, and relationship between per-item billing, relatively short play period, and high immersion. D. Lescop and E. Lescop [24] examined the free pricing strategy used by mobile game companies and proposed five main topics that are used to gain profits in the mobile gaming industry. These titles are being visible, being free, being addictive and stress and release, and capitalizing and offering more.

Calabrese and De Francesco [8] proposed a pricing approach for service industry and used a demand-based pricing approach. The proposed approach is mathematical and considers the factors of value addition, nonmonetary costs, and effective communication to customers. The mathematical formulation of the demand-based approach is given below, and p_i is for the price of the ith service, p_{ci} is for the competitor's price of the ith service, W is for the weights, KVAA_i represents the value addition of the ith service, the reduction of the nonmonetary costs are shown with NMC_i, and EC_i represents the effective communication to the customers. C_v, OVH, M_{up} represent the direct costs, overhead costs, and mark-up above cost rates, respectively.

$$p_i = \left(W_{\text{KVAA}_i} \times \text{KVAA}_i + \Delta W_{\text{NMC}_i} \times \text{NMC}_i\right) \times \left(W_{\text{EC}_i} \times \text{EC}_i\right), \forall i, \tag{1}$$

subject to

$$p_i \geq (C_v + \text{OVH}) \times M_{\text{up}} \text{ or } p_i \geq p_{ci}, \forall i. \tag{2}$$

According to Von Neumann and Morgenstern [9], there is a game theoretical situation in pricing and the concept of expected profits helps to explain the behavior of companies in tenders. The most important point in the tender bidding is that the lower the bid is from the other companies, the higher the probability of winning the tender. The expected profit is calculated by multiplying the probability of the companies winning the tender and the profit to be obtained from the tender [9]. The abovementioned two methods are

Table 1: Sixteen alternative scenarios for mobile game companies' pricing strategy.

Mobile game products	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Game	✓	✓	✓	✓	✓	✓	✓	☒	☒	☒	☒	☒	☒	✓	☒	☒
In-game boost-up products	✓	☒	✓	☒	☒	✓	✓	✓	✓	✓	✓	☒	☒	☒	☒	☒
Adverts	☑	⦸	⦸	☑	⦸	⦸	☑	⦸	☑	⦸	☑	✓	☑	☑	⦸	⦸
Cosmetic products	✓	⦸	⦸	⦸	✓	✓	⦸	⦸	⦸	✓	✓	⦸	✓	✓	✓	⦸

☑ = included in the game; ⦸ = not included in the game; ✓ = priced; ✓ = included in the game and priced; ☒ = free.

dealing with a similar problem of this research with different perspectives; therefore, at the real case study, these are going to be used for the comparative analysis.

As far as we know, there are not any studies related to the pricing of the mobile gaming products; however, there are much more studies and models for pricing the manufacturing goods. Generally, the pricing strategies for manufacturing products are cost-based pricing which is divided into two strategies of cost plus profit procedure and target pricing [25], demand-based pricing [26], and competitive-based pricing [27]. The mathematical models in this study generally have the essence of demand-based pricing for service industry while objecting to maximize the company profit.

3. Methodology

This study is aimed at creating mutual benefits between players and mobile gaming companies by targeting player satisfaction in mobile games and maximizing the earnings for mobile gaming products. To achieve this, a two-step decision process is proposed in this section: deciding the products to be priced with a scenario-based approach and two linear mathematical models to give the pricing decision of the products which are decided to be priced in the first step.

3.1. Strategic Decision of Pricing. The first step focuses on the key strategic decisions on the income structure of mobile game companies. This decision includes whether mobile gaming products should be priced or free and whether mobile gaming products should be included in the game or not. Mobile game companies' products differ from the type of the game, but, mainly, these products are the game itself, in-game boost-up products, cosmetic products, and advertisements in the game. As there are four defined products for mobile game companies, sixteen different scenarios based on these products to be priced or not are established. These scenarios should be examined considering the different aspects of the stakeholders who are considering the problem and the objective. Table 1 demonstrates all of these sixteen alternative scenarios:

Mobile game products are a source of income for gaming companies. At the same time, the decision that these products are going to be priced or free affects the number of players who play the game, the satisfaction level of the existing players, and the total revenue of the mobile game company. This decision should also be made according to the players' psychology profiles of buying behavior. Therefore, giving the decision of which products are going to be free or priced is a strategic decision for the company which is going to affect the number of players, players' satisfaction, and the total income.

The scenarios of 1-4-7-14-15-16 from Table 1 are interpreted as infeasible scenarios. In scenario 1, all of the game products are priced which would be the best scenario for the mobile game company; however, if this scenario is applied, the number of players who play the game would decrease so company would not be able to sell any of the products. In the scenarios of 4, 7, and 14, the game is priced and there are adverts which are undesirable for the mobile gamers because when the players buy a mobile game, adverts are wished since those decrease the satisfaction of the game play. In scenarios 15 and 16, the total income of the mobile game company would be significantly low or zero; therefore, these scenarios could be interpreted as infeasible. After the elimination of these six scenarios among all sixteen of them, ten possible scenarios are left for the mobile game companies.

In real life, mobile gaming companies apply many different strategies among these ten scenarios with respect to their strategy in the market. In this selection process, firstly, the compatibility of ten different scenarios with the strategies of mobile game companies is checked. According to the policies of the companies, the unsuitable ones should be eliminated from these ten feasible scenarios. The scenario selection process is a strategic decision, and it entirely depends on the company policies and decision-makers. The scenario selection process might vary for each game and for each mobile game company. Factors such as company policies, player profiles, and game structure have a direct impact on this selection process. This selection defines this study's first decision step, and after this step, the prices of the products should be determined and this study proposes two different mathematical models for giving the pricing decision of the nonfree game products.

3.2. Mathematical Models for Pricing Decision. The mathematical models were developed to define real-life problems and find optimal solutions to them. Mathematical models consist of decision variables, parameters, and constraints of problems. Mathematical models are implemented under certain constraints and are based on the results of the model to achieve the best solution in the solution set. The most advantageous part of the mathematical models is that the problems in real life that require a lot of resources and time can be solved quickly by using them. Mathematical models are widely used in a wide variety of sectors with many purpose functions.

Table 2: Definitions of the proposed mathematical models' components.

Component type	Symbol	Definition
Set	i	Product set $\{i = 1, 2, \cdots, I\}$
Set	k	Price set $\{k = 1, 2, \cdots, K\}$
Parameter	AI	Advert income
Parameter	PI	Product placement income
Parameter	m_i	Maximum price for the ith product
Parameter	y_i	Equal to 1 if the decision-maker decides the ith product to be priced; otherwise, 0
Parameter	N_{ik}	Forecast of the number of gamers to obtain the ith product with price k
Decision variable	P_{ik}	If the price of the ith product is priced k, then it equals to 1; otherwise, 0

The two proposed mathematical models in this study are constructed upon the demand-based pricing methodology. This method is aimed at estimating the number of products to be sold at different price levels; then, price the product according to the maximum revenue [26]. In this methodology, correctness of estimated demand values is crucial for the accuracy of the pricing decision.

In this study, the parameters to be used in the following models are obtained by applying the survey. Mobile game products are defined as the set of i, and the prices are defined as the set of k. Definitions of sets, parameters, and decision variables of the proposed mathematical models are given in Table 2.

The first mathematical model determines one price for each player; in other words, each product has a certain price for every single player. By using definitions from Table 2, the first mathematical model for deciding the best price for mobile gaming companies' products is given below:

$$\max \sum_{i=1}^{I} \sum_{k=1}^{K} y_i N_{ik} k P_{ik} + \text{AI} + \text{PI}, \tag{3}$$

subject to

$$\sum_{k=1}^{K} kP_{ik} \leq m_i, \quad \forall i, \tag{4}$$

$$\sum_{k=1}^{K} P_{ik} \leq 1, \quad \forall i, \tag{5}$$

$$y_i \geq \sum_{k=1}^{K} P_{ik}, \quad \forall i, \tag{6}$$

$$P_{ik} \in \{0, 1\}, \quad \forall i, k. \tag{7}$$

The first equation of the proposed mathematical model is the objective function which is the summation of the total possible buyers multiplied by the designated price and other stable incomes from advertisements and product placements. In other words, the objective function of the mathematical model is the total revenue which consists of the summation of three parts that are the total income from all of the in-game boost-up products, advertisement, and product placement incomes, respectively. Therefore, the decision-maker of the mobile gaming company desires to maximize this function. Equation (2) limits the price of the ith product to the maximum price level so the price assignment cannot be higher than the company's maximum price level. The third equation assembles that there could be only one price assignment to a product, and the fourth constraint guarantees if a product is decided to be free, then there will not be a price assignment for that product. Equation (5) demonstrates the mathematical definition of decision variables.

In contradistinction to the first proposed model, the second mathematical model gives different prices for different psychological player profiles while optimizing the total revenue. Therefore, a new set of j should be added to the definitions in Table 2 which is the profile set of the players, and definitions of the N_{ik} parameter and P_{ik} decision variable should be renewed as N_{ikj} and P_{ikj} which add the jth index to these components of the model.

$$\max \sum_{i=1}^{I} \sum_{k=1}^{K} \sum_{j=1}^{J} y_i N_{ikj} k P_{ikj} + \text{AI} + \text{PI}, \tag{8}$$

subject to

$$\begin{aligned} \sum_{k=1}^{K} kP_{ikj} &\leq m_i, \quad \forall i, j, \\ \sum_{k=1}^{K} P_{ikj} &\leq 1, \quad \forall i, j, \\ y_i &\geq \sum_{k=1}^{K} P_{ikj}, \quad \forall i, j, \\ P_{ikj} &\in \{0, 1\}, \quad \forall i, k, j. \end{aligned} \tag{9}$$

In the previous model, losses occur from some players as the decision-maker uses a single price for a product. In this strategy, it is aimed at preventing losses in profit by using the maximum price that each player type can give. However, there are strong communication networks between mobile

game players. There is a risk of spreading personalized pricing among players who play that particular mobile game. If one player knows that another player has been given a different price for the same product, the purchase behavior is expected to be decreased. This is one of the biggest risks of personalized pricing strategy. For this reason, this situation should be determined by the risk taker of this decision who is the decision-maker of the company's pricing strategy and prices of the products, and which model should be used has to be determined accordingly.

3.3. Finding the Parameters of the Proposed Mathematical Models. To obtain accurate results from the proposed mathematical models, the model parameters should be found out or forecasted correctly. Any failure in obtaining accurate parameter values is going to end up with the wrong results. In the first proposed mathematical model, there are five parameters, and in this section of the study, the ways that the decision-makers should use to obtain the parameters are going to be explained.

The first four parameters given in Table 2 which are AI, PI, m_i, and y_i should be obtained from the decision-maker of the company. As these parameters are defined accordingly to the strategy of the mobile game company, the decision-maker of the company should define and value these parameters. The y_i parameter should be defined in the first decision step this study proposed; therefore, each of the products would be output to be priced or not. AI and PI parameters should be equal to zero if y_i of this product is equal to zero. The fifth parameter which is N_{ik} is the core parameter of the decision model because this parameter defines the customers' buying behavior depending on the price. This parameter should be obtained from the mobile game's players. This could only be achieved via a survey or an interview with the players. The survey should involve the question of "What is the maximum price that you can give for this product?" and this question should be asked to the interviewees for each of the products. By asking this question, the number of players that would afford each price is going to be found out.

3.4. Real-Life Application and Model Solutions. In this part of the study, the single-priced model introduced in the methodology section is applied on a popular mobile game's pricing decision from the daily life. Model parameters are determined by the data obtained from the results of the survey which is done by interviewing this popular game's players. The survey consists of the questions for the maximum price that the player is willing to pay for each product of the game so that parameter of N_{ik} is found.

In this application, model parameters are obtained by applying the survey to twenty-four different players. To make the model results more objective, it has been paid attention that the participants have different age, gender, educational background, and monthly income. It is known that the number of participants is also a factor directly affecting the accuracy of the model results. However, due to the COVID-19 pandemic process, which has become widespread all over the world, it has made it difficult to reach the participants during the application phase.

The mobile game selected for the application matches with scenario 8 according to Table 1. This game can be downloaded for free from mobile stores. There are not any advertisements and cosmetic products in the game. The developers of the game aim to reach many players by offering the game for free. In addition, it is aimed at increasing player satisfaction by not including ads in the game. Along with these, the game company sells in-game boost-up products to generate its revenue.

As stated in Methodology, the objective function in the proposed model is defined as the sales revenue of in-game products and the sum of the advertisements. In this selected game, the only source of income is the in-game boost-up products.

In the selected game, boost-up products for the game are divided into three main groups such as rocks, gold, and chests. These products enable players to win the game by adding competitive advantage. It can be said that the players in the profile who are competitive and love to succeed are highly interested in these products. The game strategy and structure have also been developed based on the superiority of the players. Players want to level up by winning the battles they have entered. At this point, the game company aims to generate more income by marketing the in-game products to their players.

According to the single price-oriented mathematical model proposed in the application, the game itself, advertisement, and cosmetic products are not priced or available for the selected game. In the model, the y_i parameter where $i = 1$, 3, and 4 takes the value of zero for these products. The proposed model is run through all of the subproducts for in-game boost-ups. According to the survey results, N_{ik} is given in Table 3.

By using the given parameters from the survey and also given in Table 3, the first mathematical model is solved and its solution and the current application of the mobile game company are given in Table 4.

According to Table 4, the product of "80 rocks" should be priced as 5$; the participants of the survey who are willing to pay this price are 11 players, and therefore, the total income would be 55$ from this product. In the real case, that product is priced as 6.99$ and the total income would be approximately 28$ according to the survey participants. Based upon the model results, each decided price should be less than the actual prices of the mobile game company's current prices, and in total, the mobile game company would be able to make 4,948$ (8,723$-3,771$) more revenue compared to the actual situation. As we mentioned before, the model results are sensitive to the model parameters and the main parameter of this model obtained by a small survey to show the application phase of the mathematical model, so it is not really reliable to say that these model results should be applied and the company should change their product prices. Nonetheless, making the prices cheaper would change the justice of the game and the game would be stereotyped as a pay-to-win game or eventually products would become redundant for the customers as many players buy these boost-ups for cheaper prices.

Table 3: Model parameter of N_{ik} for each in-game boost-up product.

(a)

80 rocks		500 rocks		1,200 rocks		2,500 rocks		6,500 rocks		14,000 rocks	
k ($)	N_{ik} (#)	k	N_{ik}	k	N_{ik}	k	N_{ik}	k	N_{ik}	k	N_{ik}
1.5	22	5	23	10	22	21	22	8	22	30	22
2	21	8	22	11	21	25	21	23.5	21	100	20
3	17	9	21	20	20	36	19	25	20	150	17
3.5	12	10	20	25	17	40	18	27	19	180	14
5	11	15	14	30	16	50	17	50	18	200	13
10	4	18	12	35	9	60	13	60	17	220	12
14	2	20	11	40	8	70	12	100	16	250	11
30	1	23	6	45	6	75	11	120	12	300	9
		30	5	50	5	80	10	130	11	350	8
		35	4	55	4	100	5	150	10	380	7
		40	2	70	3	120	4	160	9	450	6
				75	2	130	3	175	7	500	5
				90	1	145	2	200	6	600	4
						160	1	250	5	620	3
								300	4	750	2
								360	2	800	1
								400	1		

(b)

1,000 gold		10,000 gold		100,000 gold		Lightening crate		Fortune crate		King's crate	
k	N_{ik}	k	N_{ik}	k	N_{ik}	k	N_{ik}	k	N_{ik}	k	N_{ik}
1	19	1	23	1	22	1	23	1	23	1	22
2	14	2	22	25	21	5	22	5	22	10	21
2.5	7	5	21	35	19	6	10	10	19	20	20
3	6	8	20	50	18	7	9	14	15	25	18
3.5	5	10	19	66	17	8	8	15	13	30	17
5	2	12	11	90	16	9	7	20	11	35	16
		15	10	100	15	10	6	22	9	40	15
		18	8	120	7	20	3	25	8	42	11
		20	6	150	6	30	1	30	7	50	10
		25	4	180	5			33	4	60	8
		28	3	200	4			42	3	80	7
		34	2	265	2			45	2	84	4
		35	1	270	1			50	1	90	3
										120	2
										125	1

Comparison of the methodology can also be done by using different pricing strategies from the literature. The proposed mathematical model is expected to be the best method for this decision problem of pricing as it is using a linear mathematical model. In this part of the study, two methods from literature is going to be applied to this real case and the total revenue of these methods would be calculated according to the real-life parameters which are given in Table 3. The first pricing method that is going to be used is the demand-based approach for service industry by Calabrese and De Francesco [8]. The second pricing method is a different version of a competitive bidding strategy which makes a competition between the prices of the services from the ideas of von Neumann and Morgenstern [9].

Calabrese and De Francesco [8] formulated the pricing according to the value addition of the service product, so the pricing decision is given by using their formulation. The determined prices from equations (1) and (2) and the

Table 4: Model solution and actual scenario of the mobile game company.

Products	Model solutions			Real-life (current) scenario		
	Model solution price ($)	N_{ik}	Total income from each product ($)	Real price ($)	N_{ik}	Total income from each product (real price) ($)
80 rocks	5	11	55	6.99	4	27.96
500 rocks	20	11	220	34.99	4	139.96
1,200 rocks	30	16	480	69.99	3	209.97
2,500 rocks	50	17	850	134.99	2	269.98
6,500 rocks	100	16	1600	349.99	2	699.98
14,000 rocks	350	8	2800	699.99	2	1,399.98
1,000 gold	2	14	28	3.5	4	14
10,000 gold	10	19	190	28	3	84
100,000 gold	100	15	1500	250	2	500
Lightning crate	5	22	110	15	3	45
Fortuna crate	20	11	220	42	3	126
King's crate	40	15	600	112	2	224
Expressions	5	14	70	15	2	30
		Total income	8,723		Total income	3,771

Table 5: Solutions of two methods from literature.

Products	Calabrese and De Francesco [8]			Von Neumann and Morgenstern [9]		
	Model solution price ($)	N_{ik}	Total income from each product ($)	Model solution price ($)	N_{ik}	Total income from each product (real price) ($)
80 rocks	1.5	22	33	14	2	28
500 rocks	10	20	200	20	11	220
1,200 rocks	20	20	400	40	8	320
2,500 rocks	40	18	720	70	12	840
6,500 rocks	100	16	1,600	100	16	1,600
14,000 rocks	200	13	2,600	250	11	2,750
1,000 gold	1	19	19	10	0	0
10,000 gold	10	19	190	15	10	150
100,000 gold	100	15	1,500	100	15	1,500
Lightning crate	5	22	110	10	6	60
Fortuna crate	10	19	190	22	9	198
King's crate	20	11	220	40	15	600
Expressions	5	14	70	5	14	70
		Total income	7,852		Total income	8,336

values of N_{ik} depending on these prices are given at the left-hand side of Table 5.

Von Neumann and Morgenstern [9] state that the best price is the competitive prices in the market. In gaming industry, as the games are different, companies are not competing with each other in terms of selling a single product, so products of different companies do not race with each other. Their competition is on the players' time spending inside their game. For the pricing decision in this case study, the philosophy of Von Neumann and Morgenstern [9] is inserted with the change of taking each price as competitors of each other. The best line of the maximum revenue is found, and those prices are given on the right side of Table 5 according to N_{ik} values from the applied questionnaire. Total revenues are also given at the bottom, and it can be seen that the proposed mathematical model's solution is greater than or equal to other methods' solution in terms of the total income for all of the products. The ranking of total revenue is the proposed mathematical model, differentiated method of Von Neumann and Morgenstern [9], demand-based pricing approach of Calabrese and De Francesco [8], and real-life scenario in descending order for this real-life case of a popular mobile game from the game stores.

According to Table 5, the second pricing method is better than the demand-based methodology under the parameters of the questionnaire with the total revenue of 8,336$. The first pricing method has 7,852$ of total income which is still better than the real scenario of the mobile gaming

company. On the other hand, these two methods do not give a better solution than the proposed model which is expected from the mathematical perspective, but it should not be considered and stated as a better methodology than the other methods because the model is deterministic, and it is assumed that the parameters represent the whole customers. From the mathematical perspective, the proposed mathematical model guarantees the best solution for the given parameters, but if these parameters are different than the real situation, then the other methods might get the better results. In other words, these methods are concise and accurate on their own decision problems, but for the specific problem of this research, the other methods could not compete with the proposed model.

The model solution gives a general idea about pricing the products to the mobile game company, and it also gives a forecast on the total income of the mobile game manufacturing company. The price decision-maker of the mobile game company should give the final decision by using the model solution and the qualitative properties of the game, customers, and company's strategy. The proposed mathematical models guarantee the optimal total revenue under the obtained parameters, and if the decision-makers could be able to identify the parameters correctly, then the main goal of making maximum profit would be satisfied undoubtedly.

Another managerial implication of the models' results is the promotion decisions. The parameters of the proposed models are dynamic in real life so when the decision-makers want to make the shop of the mobile game popular and/or make people familiar with the shop, the decision of making a promotion and the amount of the discounts should be made. There are two ways to decide on these problems which are reassigning the model parameters according to the current situation or compromising with the maximum total income to the maximum number of customers who bought a product from the game store by adding another constraint of limiting the total income to the model. Therefore, the proposed models are reusable and generalized models so that the decision-makers can change their decisions depending on the changes in the market and variations of the game players on different time intervals. All in all, it can be easily said that the proposed models are quite useful for the mobile game companies and for the decision-makers of pricing as it gives a demand-based guideline for the price of the products.

4. Conclusion

The growth rate and market share of the game industry is in an increasing trend and newly developing portable devices, and the high-quality graphic resolution of these devices also increase the interest of the players in mobile games. Therefore, mobile gaming companies need strategies that will increase the satisfaction of the players and at the same time keep the company revenues at the maximum level. Considering the growth rate of the sector, it is seen that studies on this subject are insufficient in the literature. Depending on the competition between companies in the game industry, a study in which the decision-making model and mathematical model are integrated would help companies provide competitive advantage.

In the study, first, the coexistence of four different main product groups (the game itself, boost-up products, advertisements, and cosmetic products) was revealed into sixteen different scenarios for a mobile gaming company. The feasible or nonfeasible situations of the scenarios are shown, taking into account player satisfaction and the purpose of gaming companies to generate revenue. Two different mathematical models were developed. The one-price mathematical model chooses the optimal solution for a product among the maximum prices available from players. Maximum revenue is calculated using the best prices for all products. The second mathematical model suggests a special pricing strategy for players. Special price is offered for each player, focusing on the maximum prices players can give. The advantages and disadvantages of both of the models are mentioned in the study as well. By using the survey, the parameters of the proposed model are obtained. A popular mobile game company and the strategy they use are selected, and questions are directed to the players of this particular game. The maximum income to be obtained for the firm is calculated by using the mathematical model results. Not many participants are reached due to the health problems experienced today. However, considering the participants in the survey, it is seen that the income obtained with optimal prices is much more than the income obtained with the prices used in the game.

In future studies, these mathematical models should also be used for games with different strategies. All scenarios can be tested on this developed mathematical model in order for companies to reach their targeted maximum income. In addition, the fact that the number of participants of the survey to be conducted has different country, job, age, and gender may increase the applicability of the model. Considering the games applied all over the world, pricing strategies can be created with sample clusters selected from different regions.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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