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Article

Competitive Strategies and Operational Optimization of Music Enterprises in the Context of Globalization

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Abstract: In the music market driven by the trend of globalization, different subject music enterprises are limited by their positions and perceptions, and have higher quality strategy needs in competition and operation. This paper adopts the emerging evolutionary game theory to explore the equilibrium stability of decision-making behavior of market players with limited rationality and access to limited information, as well as the factors affecting it. On the basis of the theory of evolutionary games, the mathematical definition of stable equilibrium state under evolutionary stable strategy is designed. At the same time, we further analyze the equilibrium stability of the two-party, two-strategy evolutionary game, and comprehensively construct an analytical model of the evolutionary game. Analyze the development trend of mobile music business in the United States, South Korea, and Japan from 2008 to 2012 as the data samples for the study. The proposed evolutionary game analysis model is used to determine the Nash equilibrium stability zone in the music market competition, and analyze the changes of the average profit of different market players under different parameter values. In particular, when the music producers' concern about fairness is lower than 0.2, the average profit of both the music producers themselves and the music retailers show an upward trend as the music producers' concern about fairness grows.

Keywords: evolutionary game theory; music firms; stable equilibrium; Nash equilibrium

1. Introduction

With the continuous development of the socio-economic landscape and the ongoing refinement of the socialist market economy system, the cultural industry has also achieved significant growth [1-2]. As an important component of the cultural industry, the music industry has also achieved synchronized development under the favorable growth momentum of the digital economy [3-4]. Currently, as the cultural industry continues to expand and develop, music companies have adjusted their competitive strategies and operational models, transitioning from a traditional music education-focused approach to a composite development model encompassing music education, music products, and market marketing and commercial management [5-7]. In the new round of digital economic development, digital enterprises have taken the lead, leveraging their unique business philosophies and digital management models to become market leaders and new growth drivers for the industry. They have provided diverse feasible approaches for the industrialization of the music industry and actively explored the integration and development of cultural arts and the economy [8-9].

Currently, the music industry is beginning to develop marketing strategies centered on digital technology to enhance its competitiveness within the industry. Literature [10] explores the value of media innovation strategies for the commercial success of Iranian music companies, using qualitative methods and interviewing several experts in the industry to conclude that digital music has the ability to achieve sustainable competitive advantages. Meanwhile, literature [11] analyzes potential changes in music industry competition and finds that digital music bundling strategies will lead to increased corporate concentration and expand the market power of music companies, effectively enhancing their competitiveness. Additionally, numerous corporate factors influence the competitive advantage of digital music. Literature [12] constructs a model of factors influencing the competitive advantage of the music industry, obtains quantitative data on the factors affecting the competitiveness of the music industry through a questionnaire survey, and then uses partial least squares regression for multi-factor analysis. The results indicate that factors such as technical capabilities in digital music creation and new product development can influence the competitive advantage of digital music.

In the context of globalization, most companies optimize their operational management by improving music pricing. Literature [13] designed different digital music pricing models, established a mathematical model for single-track pricing issues, and used a decision-making model to provide the most advantageous operational models for various scenarios, thereby achieving the goal of optimizing music company operational strategies. Literature [14] also established a marketing strategy based on optimal pricing for digital music, namely tiered pricing. The study found that tiered pricing combined with reduced album pricing increased music companies' revenue by 18% while also increasing the number of consumers of music albums. Digital music provides new development directions for music companies in the context of globalization. Establishing a marketing strategy centered on digital music is of great significance for enhancing the industry competitiveness of music companies.

In this paper, under the premise of finite rationality, the relevant theories and concepts of replicated dynamic equation-based learning and strategy adjustment models are elaborated in detail. Then it briefly analyzes the mathematical definition of stable equilibrium state under the evolutionary stable strategy. It also explains the main contents of the stability theory of two-party, two-strategy evolutionary game equilibrium, and builds an analytical model of evolutionary game as the theoretical framework of the study. Afterwards, we describe and analyze the development trend of mobile music business in the United States, South Korea and Japan from 2008 to 2012 in order to provide data reference for the research and analysis. Meanwhile, with the support of numerical simulation technology, the stabilization zone of Nash equilibrium in the music market is drawn. Finally, the impact of different parameter value situations on the average profit of different music market entities is analyzed.

2. Evolutionary Game Analysis Model

2.1. Evolutionary Games

In the research of classical game theory, it is generally assumed that the participants of the game are fully rational, and the main research content is how individuals can maximize their benefits by adjusting their strategies under different strategy combinations. However, in reality, individuals are between complete rationality and no rationality, i.e., individuals can only have limited rationality, and individuals often cannot directly judge their own optimal strategies. Each individual needs to learn from other nodes in the network to improve its own strategy to adapt to the changes in the network. Evolutionary game theory is a research tool to study the role of this limited rationality in the game process.

Under the premise of limited rationality, game participants cannot directly choose the optimal strategy, and the core of the game has been converted from the selection of optimal strategy to the learning and strategy adjustment in the process of the game, as well as the stability of the game. Stability in the evolutionary game refers to the proportion of participants choosing a specific strategy remains unchanged, rather than the individual to obtain the maximum expected return of the strategy remains unchanged, which is an important difference between the evolutionary game and the classical game theory.

Under the premise of finite rationality, the key to game analysis is to determine the learning and strategy adjustment patterns of the game participants, and the following briefly describes the learning and strategy adjustment patterns based on replicated dynamic equations.

2.1.1. Replicating the Dynamic Equations

Replication dynamic equations are used to analyze the laws governing the evolution of population strategies over time in the case of larger numbers. It is assumed that a large number of participants in a finite rational game form a population, where the participants do not differ from each other and play a randomized pairwise game, and each game may have a different game opponent. In the case of random pairing game, the replication dynamics well describes that the game participants gradually achieve the stability of their strategies by imitating and learning the strategies of the game opponents.

Currently, the most applied replication dynamics equation is the replication dynamics that describes the dynamic adjustment of a single group. Equation (1) is the differential form of replication dynamics:

$$\frac{dx}{dt} = [f(s,x) - f(x,x)]x \tag{1}$$

where $f(s,x)$ denotes the expected payoff to an individual in the group who chooses a pure strategy s

when the individuals in the group play a game of random matching, as in equation (2):

$$f(x,x)=\sum xf(s,x) \tag{2}$$

$f_{(x,x)}$ denotes the group average expected return. Simply put, when individuals choosing strategy s can get to obtain a higher return than the group average return, the number of individuals choosing this strategy increases, when the return obtained is lower than the group average return, the number of individuals choosing this strategy decreases, and when the return obtained is equal to the group average return, the number of individuals choosing this strategy remains unchanged.

2.1.2. Evolutionary Stabilization Strategies

The evolutionary stability strategy was proposed in the study of biological evolution phenomenon, the behavior of each biological population for survival is regarded as a strategic choice, the biological population can be regarded as a group of individuals are playing a game. If all participants in a population adopt a certain strategy, and at this time no other small group of mutation strategy can invade this group, then this strategy is called an evolutionary stable strategy, that is to say, under the pressure of natural selection, the mutants will either be eliminated in the process of evolution or choose an evolutionary stable strategy in order to adapt to the environment.

Evolutionary stable strategy is the most basic equilibrium concept in evolutionary game theory, which has a wide range of applications in evolutionary games. With the deepening of the research of evolutionary games, the definition of evolutionary stable strategy is also improving, and the following is only given in the case of symmetric games.

Suppose that in a population of N individuals, if for any $y \in A$ and $y \neq x$, there exists a $\bar{\varepsilon}_y \in (0,1)$ such that inequality (3):

$$u[x,\varepsilon y+(1-\varepsilon)x] > u[y,\varepsilon y+(1-\varepsilon)x] \tag{3}$$

For any $\varepsilon \in (0,\bar{\varepsilon}_y)$ is true, then x is said to be the evolutionary stability strategy, where A is the payout matrix for individual games in the group, y is the mutation strategy, $\bar{\varepsilon}_y$ is a constant related to the mutation strategy y, which is called the invasion boundary, $\varepsilon y+(1-\varepsilon)x$ Represents a mixed population consisting of a population that chooses an evolutionary stabilization strategy and a population that chooses a mutation strategy.

2.2. Stable Equilibrium

Based on the mathematical definition of evolutionary stable strategies, the mathematical definition of a stable equilibrium state can be derived as follows: the strategy space is assumed to be equation (4):

$$S=\{s_1,s_2,\cdots,s_i,\cdots\} \tag{4}$$

If there is an evolutionary stabilization strategy $s^* \in S$ and it satisfies the following two conditions

(1) Equilibrium condition: for $\forall s \in S$, both have equation (5):

$$R(s,s^*) \le R(s^*,s^*) \tag{5}$$

(2) Stabilization conditions: for $\forall s \in S$, $s \neq s^*$, both have equation (6):

$$R(s,s) < R(s^*,s) \tag{6}$$

Then the game state Φ^* of the population at this time is a stable equilibrium.

In equations (5)-(6), $R(\cdot,\cdot)$ is the gain function. The “equilibrium condition” mainly ensures that the population maximizes its return in that game state, i.e., equilibrium. The “stability condition” mainly ensures that the population can resist the invasion of other arbitrary variation strategies in the game state, i.e., stability. If the game state of the population can only satisfy the “equilibrium condition”, its mapping in the coordinate system is called the local equilibrium, and must satisfy the above two conditions at the same time, its mapping in the coordinate system can be called the stable equilibrium.

2.3. Stability Theory Analysis of Equilibrium of Two-Party Two-Strategy Evolution Game

Assuming that the game participants are A , B two populations, each of which has a pair of mutually exclusive optional strategies, the set of strategies of the population A is equation (7):

$$S_A = \{s_A^1, s_A^2\} \tag{7}$$

and the strategies $s_{\mathrm{A}}^1, s_{\mathrm{A}}^2$ are randomly selected with probability p_A and $(1-p_A)$ (or proportion of the population) respectively. Similarly, the set of strategies for population B is equation (8):

$$S_B = \{s_B^1, s_B^2\} \tag{8}$$

and the probability that each strategy is selected (or the proportion of the population) is p_B and $(1-p_B)$, respectively.

The overall payoff or payout matrix for this system is equation (9):

$$R = \begin{bmatrix} R_A \\ R_B \end{bmatrix} \tag{9}$$

which have equations (10)-(11):

$$R_A = \begin{bmatrix} R_A^{1,1} & R_A^{1,2} \\ R_A^{2,1} & R_A^{2,2} \end{bmatrix} \tag{10}$$

$$R_B = \begin{bmatrix} R_B^{1,1} & R_B^{1,2} \\ R_B^{2,1} & R_B^{2,2} \end{bmatrix} \tag{11}$$

where: $R_{textA}^{1,2}$ is the income or payment of population A when the population A selects its first strategy s_A^1, and when the population B selects its second strategy s_B^2, the same applies to the other three items. $R_B^{1,2}$ is the income or payment of population B when the population B selects its first strategy s_B^1, and when the population A selects its second strategy s_A^2, the same applies to the other three items.

Let the income or payment of each strategy selected by population A be R_A^{s1}, R_A^{s2} , and the income or payment of each strategy selected by population B is R_B^{s1}, R_B^{s2} , respectively, then there is equation (12):

$$\begin{cases} R_A^1 = p_B R_A^{1,1} + (1-p_B) R_A^{1,2} \\ R_A^2 = p_B R_A^{2,1} + (1-p_B) R_A^{2,2} \\ R_B^1 = p_A R_B^{1,1} + (1-p_A) R_B^{1,2} \\ R_B^2 = p_A R_B^{2,1} + (1-p_A) R_B^{2,2} \end{cases} \tag{12}$$

Then the average gain or payment of the population A , B at this time is equation (13):

$$\begin{cases} R_A^{ave} = p_A R_A^1 + (1-p_A) R_A^2 \\ R_B^{ave} = p_B R_B^1 + (1-p_B) R_B^2 \end{cases} \tag{13}$$

The growth rate of the probability (or proportion of the population) that a population A , B will choose a particular strategy is proportional to the value of that probability (or proportion of the population), and to the difference between the expected return and the average return from choosing that strategy. Thus the replicator dynamic differential equation for populations A , B in this system at continuous time t is equation (14):

$$\begin{cases} \dfrac{dp_A}{dt} = p_A\left(R_A^1 - R_A^{ave}\right) \\ \dfrac{dp_B}{dt} = p_B\left(R_B^1 - R_B^{ave}\right) \end{cases} \forall t \tag{14}$$

The equilibrium stability of the multi-group multi-strategy evolutionary game is only achieved at its pure strategies, so the asymptotic stability of the system is only discussed at all the pure-strategy local equilibrium points, and it is obvious that there are only four pure-strategy local equilibrium points of this system's system of replicators' dynamic differential equations, which are $(0,0)$, $(0,1)$, $(1,0)$, and $(1,1)$, respectively. Then, its corresponding Jacobi matrix, which is a 2×2 -order square matrix, can be further constructed from the replicator dynamic differential equation set as Eq. (15):

$$J_{rd} = \begin{bmatrix} \dfrac{\partial p_A'}{\partial p_A} & \dfrac{\partial p_A'}{\partial p_B} \\ \dfrac{\partial p_B'}{\partial p_A} & \dfrac{\partial p_B'}{\partial p_B} \end{bmatrix} \tag{15}$$

where there are equations (16)-(17):

$$p_A' = \frac{dp_A}{dt} \tag{16}$$

$$p_B' = \frac{dp_B}{dt} \tag{17}$$

To verify the equilibrium stability of the above local equilibrium point (p_A, p_B), we can sequentially substitute it into the Jacobi matrix of the system, and analyze the positive and negative eigenvalues of the real part of the local equilibrium point to determine whether it is a stable equilibrium point. If all the values are negative, then the local equilibrium point is progressively stable, which is called “sink”, i.e., the system is in an evolutionary stable equilibrium state at that point. If they are both positive, the local equilibrium point is unstable, called “source”, i.e., the system is in an evolutionary unstable equilibrium at that point. If both positive and negative, the local equilibrium point is a saddle point, i.e., the system is in a critical state of evolution at that point, which is still an unstable equilibrium state.

3. Competitive and Operational Strategies for Music Businesses

3.1. Development Trend of Mobile Music Business

After years of development, music enterprises in the United States, South Korea and Japan have formed a complete ecosystem, in which the mobile music business plays an important role. Therefore, this section chooses the above three countries as the research object, combing the three countries in 2008-2012 mobile music market users and its development trend, which: (U1) mobile music users, (U2) data service users, (U3) mobile users.

The mobile music market subscribers and its development trend in the United States during 2008-2012 are shown in Figure 1. With the improvement of wireless data services by U.S. communication service providers, the number of (U1) mobile music subscribers has been increasing year by year, and reached 189.5 million subscribers in 2012.

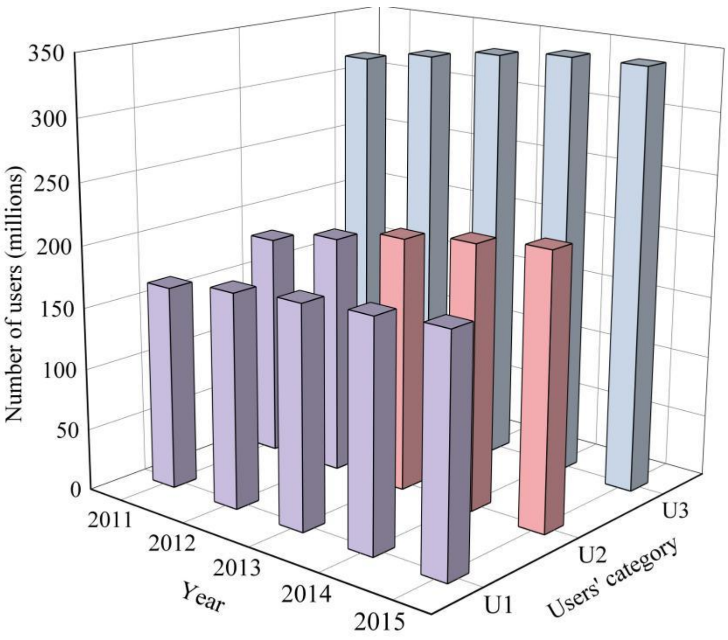


Figure 1. Users of the mobile music market and its development trends(USA).

The revenue and development trend of South Korea's mobile music market during 2008-2012 is shown in Figure 2. With the booming of South Korea's music entertainment industry in the 2010s as well as the market layout strategies of mobile operators, the revenue scale of South Korea's mobile music market has continued to expand. Not only did the market grow at a rate of 58.21% in 2009, but it also generated $233 million in revenue in 2012.

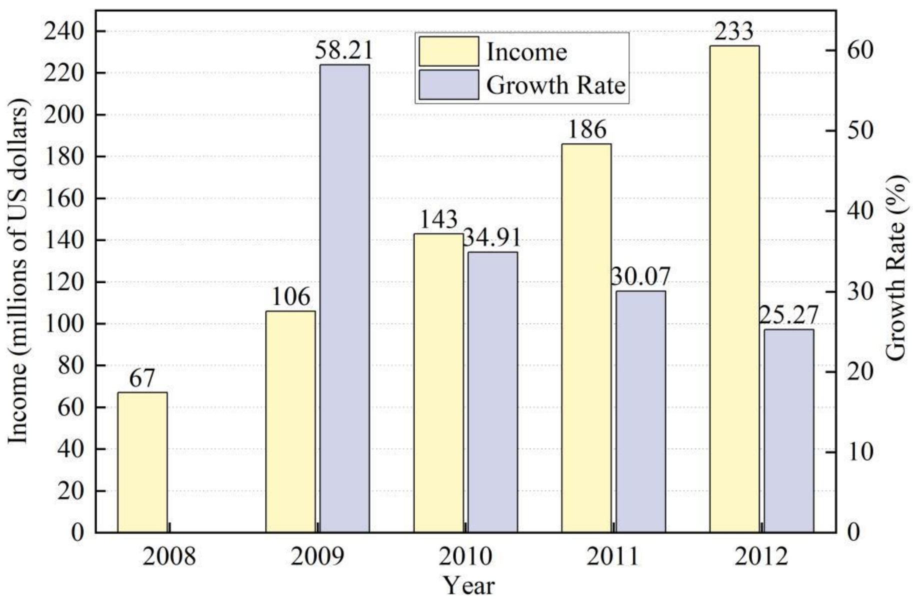


Figure 2. Users of the mobile music market and its development trends(KR).

Japan's mobile music market subscribers and its development trend during 2008-2012 are shown in Figure 3, with its (U1) mobile music subscribers reaching a peak of 6,007,400 subscribers in 2012.

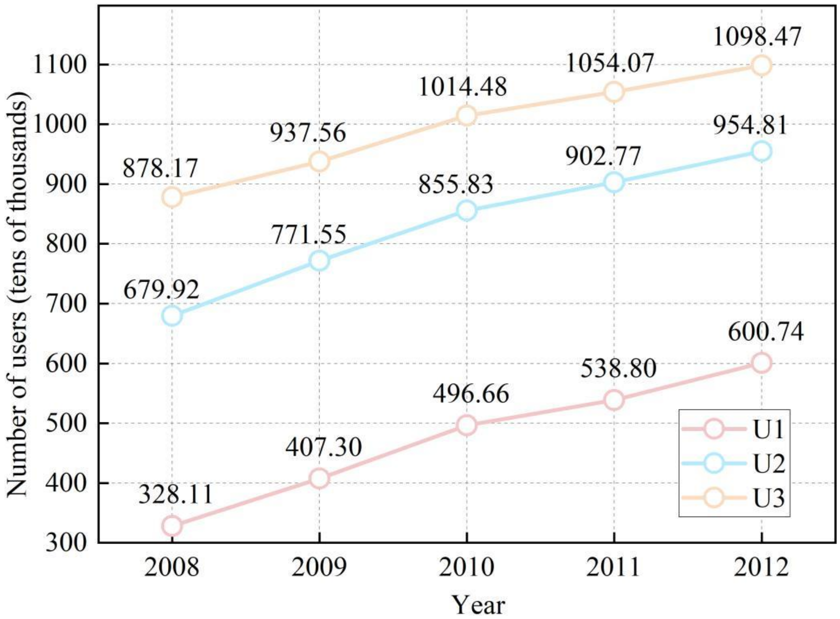


Figure 3. Users of the mobile music market and its development trends(JP).

3.2. Numerical Simulation Experiments

With the help of digital simulation techniques, this section explores the dynamic interaction of the competitive agents of music firms in the music retail market and the complexity of the system's performance under the conditions of variable parameters. In turn, it provides insights into the development of price changes in the dual-channel supply chain (music producers, music labels). The use of α represents the potential market demand size.

3.2.1. The stabilization Zone of a Nash Equilibrium

Assuming that there are currently two music business oligopolies in the music market, the stability domain of the equilibrium point is obtained according to Jury's condition, and the stable region of the equilibrium point can be obtained by substituting the hypothetical parameter values as shown in Figure 4.

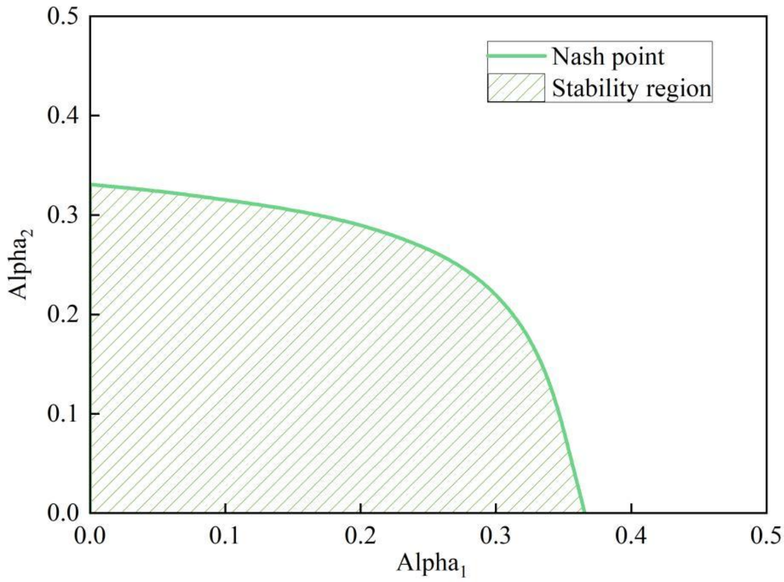


Figure 4. The stable region of the Nash equilibrium point.

When the price adjustment parameters of the duopoly are within the stable region shown in the green shaded area in Figure 4, the game system becomes stable and an equilibrium will eventually be formed.

The price bifurcation when $\alpha_2 = 0.2$ is shown in Fig. 5, and the price bifurcation when $\alpha_1 = 0.15$ is shown in Fig. 6. According to Fig. 5 and Fig. 6, the music market of the duopoly will go through the multiplicative bifurcation to enter into a chaotic state. Once and the system enters the chaotic state, the price fluctuation of the market will be very large, and it is difficult for the enterprise itself to carry out long-term strategic planning, and at the same time, it will not be able to obtain stable profits. In order to prevent the market from changing out of balance, companies need to control the speed and intensity of their own price adjustments.

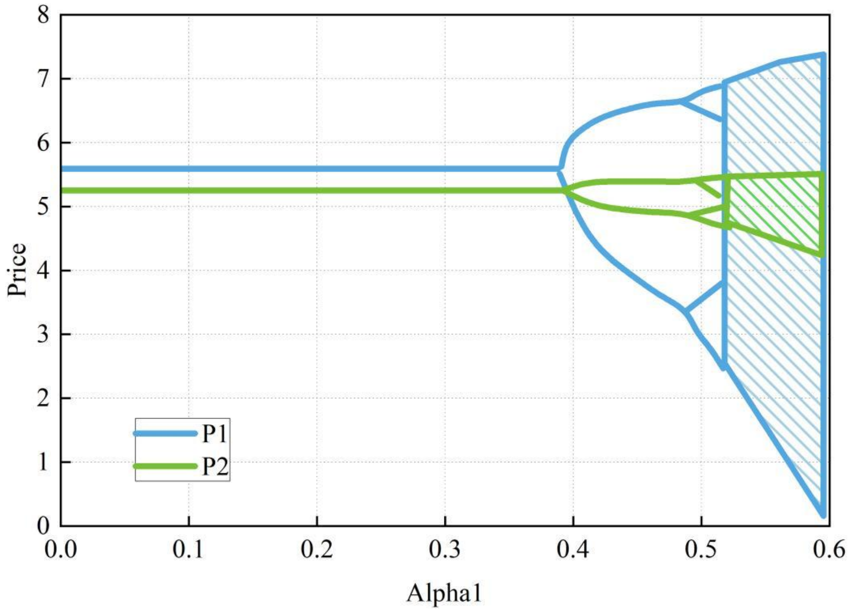


Figure 5. The bifurcation of the price when $\alpha_2 = 0.2$.

It can be seen that the Nash equilibrium point $E^* = (p_1^*, p_2^*)$ is stable when $\alpha_1 < 0.39$, but as α_1 continues to increase, the stability of the equilibrium point will be changed, and ultimately branching, chaos, and other complex phenomena will arise.

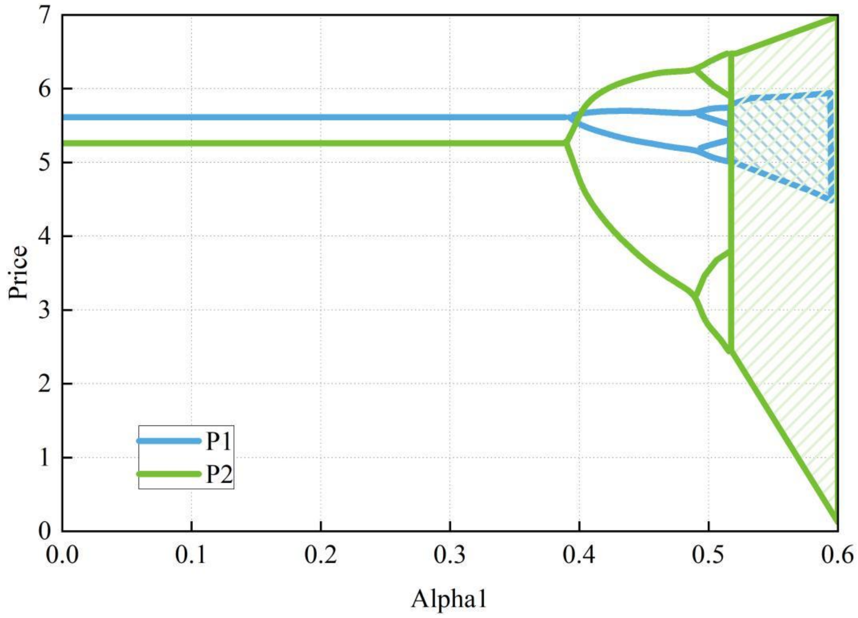


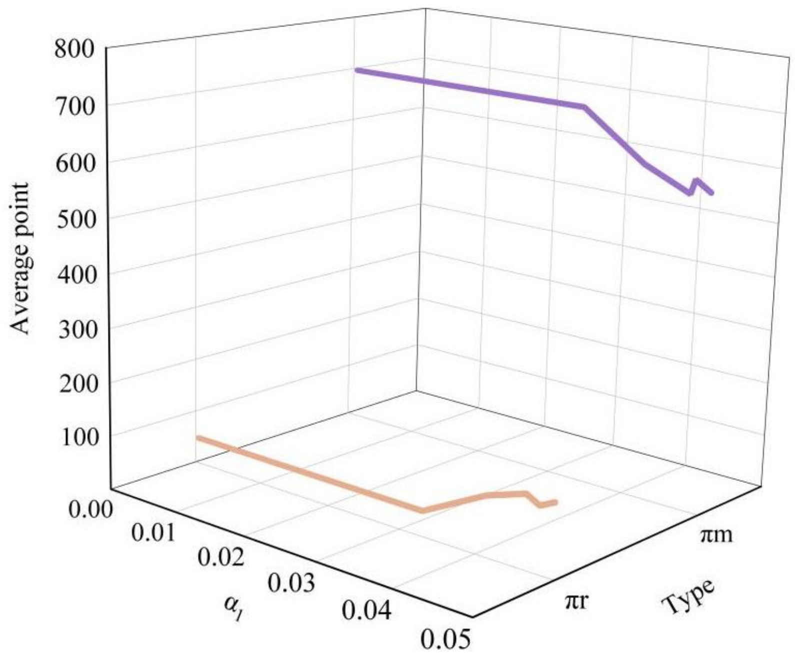
Figure 6. The bifurcation of the price when $\alpha_1 = 0.15$.

It can be seen that when $\alpha_1 = 0.15$, the branching phenomenon caused by changes in the music market price adjustment reaction rate α_2. When $\alpha_2 < 0.35$, the point of Nash equilibrium $E^* = (p_1^*, p_2^*)$ is stable, but as α_2 continues to increase, the stability of the equilibrium point will be changed, and ultimately branching, chaos, and other complex phenomena will arise.

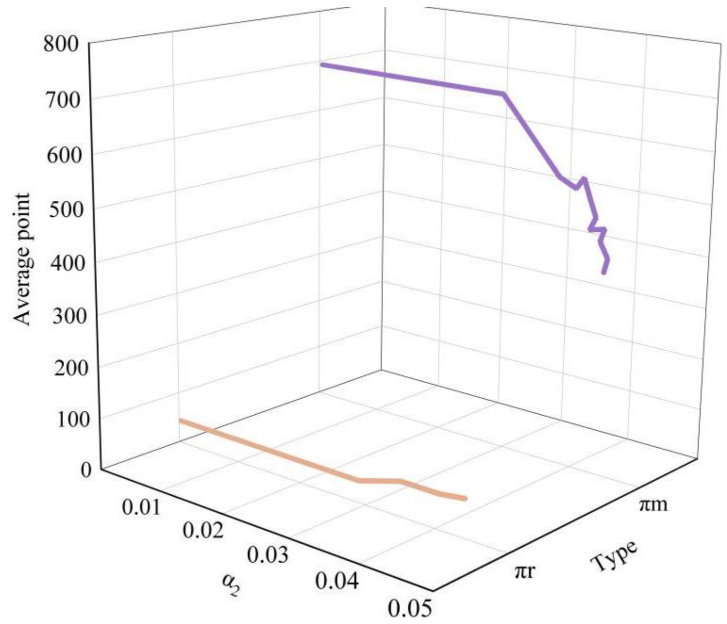
3.2.2. Impact of Parameter Values on Average Profits

Profitability has become one of the key business objectives pursued by firms competing in the music market, and meanwhile, average profitability, a key metric for evaluating music performance, has been a key focus of business research. In this section, we use "πr" to depict the iterative dynamics of the average profitability of music retailers, and "πm" to map the fluctuating profile of the average earnings of music producers.

The impact of the speed of price adjustment $\alpha_i (i = 1, 2)$ on average profits is illustrated in Figure 7, which shows a comparison of the trends in the average profitability of market participants with varying frequency of price changes. Combining Figures 7(a) and 7(b), it can be seen that a more significant change in either the music producer's wholesale price or its online retail price results in a decline in the music producer's average earnings. As the rate of price adjustment increases, the average profit of the system rises in turbulent times compared to stable times, which means that when the system enters into chaos, the average profit of music producers decreases. Music firms strive to keep the system in a state of disruption in their business activities as a way to maintain their competitive position in the market.



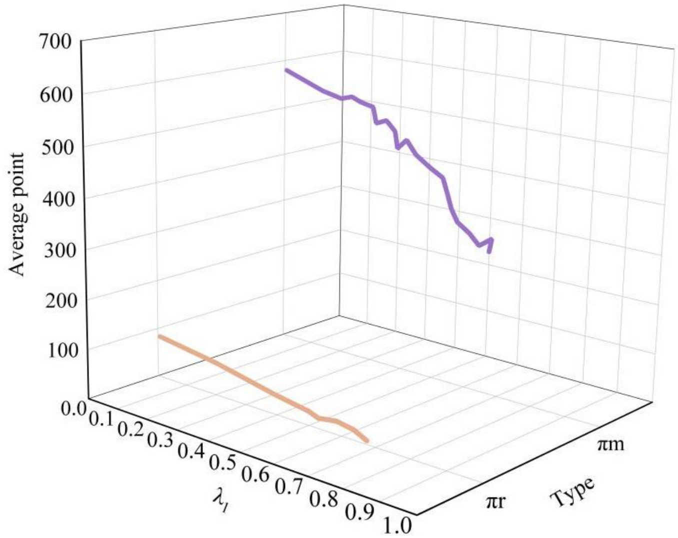
(a) When $\alpha_2 = 0.02$ the average profit varies with α_1



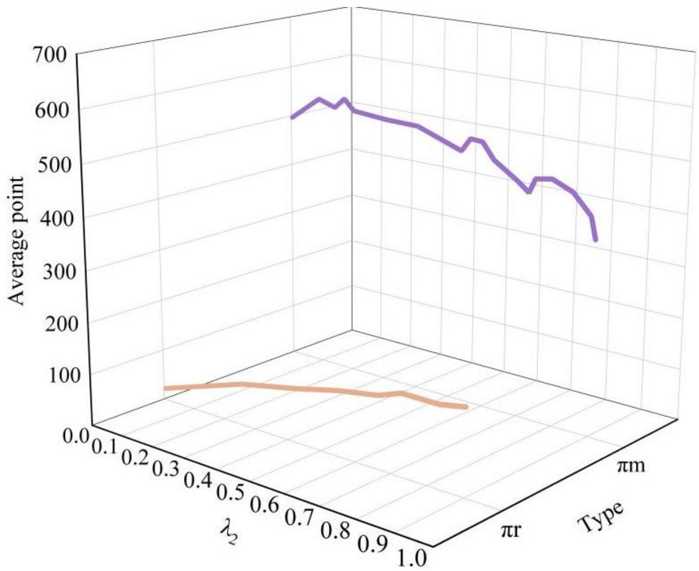
(b) When $\alpha_1 = 0.02$,the average profit varies with α_2

Figure 7. The influence of price adjustment speed $\alpha_i (i = 1, 2)$ on average profit.

The effect of the level of fairness concern on the average profit of retail competitors ($\alpha_1 = 0.02, \alpha_2 = 0.04$) is shown in Fig. 8, which elucidates how average returns fluctuate in response to changes in the music retailer's concern for fairness, all else being held stable. Observation of Figure 8(a) reveals that both music retailers and music producers experience a corresponding decline in their average earnings as a result of the music retailers' heightened focus on fairness, suggesting that the music retailers' fair care actions negatively affect the overall performance of the supply chain, leading to an unfavorable impact on earnings. Whereas, Figure 8(b) shows that when the music producer's concern for fairness is below 0.2, both its own and the music retailer's average surplus trend upwards as the music producer's concern for fairness grows. When music producers' concern for fairness exceeds 0.2, music producers' average surplus decreases as their concern increases, although music retailers' profitability still increases in tandem with music producers' concern for fairness. This implies that in the supply chain, too little fairness concern on the part of music producers has a positive effect on their own revenues and overall performance, while too much fairness concern may not only shrink their profits, but at the same time have a positive effect on the profitability of music retailers.



(a) The average profit of retail competitors varies with λ_1



(b) The average profit varies with λ_1

Figure 8. Average profit of retail competitors($\alpha_1 = 0.02, \alpha_2 = 0.04$).

The synthesis of the above analysis shows that despite being music enterprises, producers and retailers have different positions and are competitors in the music market. Due to the limited cognitive ability, the high attention to the fairness issue by the producers may cause the system to become unstable and fall into disorder, while the increased attention to the fairness issue by the retailers may enhance their profitability. Accordingly, taking into account the trend of globalization, the following suggestions are made for the future competition and operation optimization strategies of music enterprises:

(1) Music producers, as the source of the music market, should react more slowly to the fluctuation of music market prices to help stabilize the overall order and efficiency of the market, and thus improve their own profitability.

(2) Music retailers should be on an equal footing with music producers and adjust their parameters cautiously to achieve their business goals, and adapt to market changes by dealing with systemic chaos effectively through appropriate competitive strategies and variable feedback techniques.

4. Conclusion

In this paper, an evolutionary game model is constructed by integrating evolutionary game theory, stable equilibrium state, and two-party two-strategy evolutionary game equilibrium stability theory. Based on the mobile music business development data of the United States, South Korea and Japan from 2008 to 2012, the proposed model is applied to the simulation experiment of music market competition under the trend of globalization. In the case of duopoly music market, the Nash equilibrium point $E^* = (p_1^*, p_2^*)$ is in a stable state when $\alpha_1 < 0.39$ and when $\alpha_2 < 0.35$. And when music producers' concern about fairness is below 0.2, both their own and music retailers' average surpluses tend to rise as music producers' concern about fairness grows. And when music producers' concern about fairness exceeds 0.2, the average surplus of music producers decreases instead as their concern increases.

Combined with the content of the analysis, it is suggested that the current music companies should hold an equal caring stance in competition and operation with competing entities of different stances to promote their own profitability.

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