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The Analysis of Pricing of Non-fungible Token from a Game Theory Perspective

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Abstract: With the development of the metaverse, the deals of non-fungible Token(NFT) became hot. However, it is very difficult to evaluate the value of NFT because of the influence of its own nature. Although there are many valuation models for NFT, investors still cannot get the accurate and true value of NFT. Such inaccurate estimates will influence the strategy of investors. To understand and alleviate this effect. This article will use evolutionary game theory to construct model to analyze how should sellers and purchasers choose their strategy with the help of valuation models so that they can avoid risk. The conclusion shows that for the sellers, when the earnings of pricing over valuation overcomes is higher than pricing equal to the valuation, it is better to choose the strategy of pricing over valuation. For the purchasers, when the net profit of purchase is positive, it is better to choose the strategy of purchase.

Keywords: NFT, evolutionary game theory, blockchain, valuation.

1. Introduction

Since 2021, metaverse has become very hot. Non-fungible Token(NFT) as an important component part of the metaverse has also made a great progress [1]. NFT now includes the field of games, culture, art and so on [2]. NFT is a kind of digital asset created by blockchain. The security and transactional efficiency are secured because blockchain has the characteristics of immutable and traceable and decentralized storage technology [3]. On this basis, the market transaction of NFT has entered the upsurge. According to the data from EO Intelligence, the global market size of NFT has reached $176.95 billion which is a 214-fold increase from 2020 [1]. However, NFT as an emerging market are facing many challenges. One of the biggest challenges is valuation. So far, many scholars have established the valuation model of NFT. For example, Nadini has created a valuation model which use sales history and visual features to predict trading prices based on machine learning algorithm [3]. However, it is still very hard to predict accurate prices of NFT because the valuation is influenced by Artistic value, technical value, communication and marketing value of NFT [4]. So, the investors maybe cannot get the accurate price of NFT, which will influence their strategies in the market. According to a report from Nonfungible, more and more investors failed in investing in NFT as times goes on [5]. In conclusion, NFT has become a hot investment object. However, it is hard to predict the accurate value of NFT, which will lead to the failure of investment in NFT. This article will use evolutionary game theory to analyze how should investors choose their strategies so that they can avoid failure in investment, which has practical significance.

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2. Literature Review

NFT is a kind of digital property recorded on the blockchain, it can be any digital assets such as pictures, videos, songs, virtual land and so on [6]. The American data expert Melanie Swan has pointed out that any financial assets can be converted to digital assets through blockchain and be traded directly on blockchain [7]. Because NFT is created by blockchain, so it has financial feature, which provides a basis for market transactions. Meanwhile, although NFT is digital data, it has the similar characteristics to the physical art. Besides that, NFT has the 'value of exhibition' compared to the 'value of worship' of physical art because of the virtual technology [8]. So, it is very hard to use the traditional way of asset valuation of financial products to predict the value of NFT because valuation of NFT includes many subjective factors.

At present, authentic right is the main direction of studying because authentic right is the important premise of research of valuation of NFT [3].

Although NFT is traded by cryptocurrency, it has the absolutely different characteristics from the cryptocurrency. The main purpose of cryptocurrency is to act as currency [9]. NFT is considered as pure digital property which is different from the equivalent, undifferentiated, fungible cryptocurrencies. Therefore, NFT is irreplaceable and unique [10]. 'An NFT can provide indisputable answers to questions such as who created this NFT, who owns it, and which of the many copies is the original' [5].

To solve the problem of valuation, many scholars has tried to establish the valuation model of NFT. As mentioned above, Nadini has created a valuation model which use sales history and visual features to predict trading prices. But the valuation is not accurate because some factors are not taken into account. William M. Peaster, the well-known expert of NFT, has mentioned seven factors which can add value to NFT. They are chain security, the property of on-chain, foundry age, creator and community, scarcity, release frequency, richness [4]. This provides a huge help to predict the value of NFT.

3. The Analysis of Pricing of NFT from a Game Theory Perspective

3.1. Trading Model of NFT

At present, mainstream trading of NFT is conducted on the platform. For example, Opensea is the largest trading platform of NFT. Sellers can release their products on chain through trading platform. And purchasers can buy the authentic right of NFT on trading platform. Before sellers selling their products, they can use the valuation model to predict the value and then they can choose their strategy of pricing. Purchasers can also use the valuation model to decide their strategy of buying. In the course of this game, both buyers and sellers are boundedly rational.

3.2. Assumption

3.2.1. Main Problems

This model only considers two problems during this game.

(1)Whether the seller sets the price above the valuation.

(2)whether the purchasers will buy.

3.2.2. Gamer

Suppose the two sides of the game are: Sellers(A); Purchasers(B).

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3.2.3. Strategy

(1)Sellers (A) have two kind of strategies: Pricing above the valuation(H);Pricing equal to the valuation (E).

(2)Purchasers (B) have two strategies against sellers (A):Buy(Y);Not buy(N).

3.2.4. Assumption of Parameters

The assumption of parameters is shown in Table 1.

Table 1: Assumption of parameters

Sellers(A)		Purchasers(B)	
P_1	The actual pricing above the valuation	P_3	The actual cost at P1
P_2	The actual pricing equal to the valuation	P_4	The actual cost at P2
R_1	Other income when selling above the valuation	M_1	The earnings of buying the NFT
R_2	Other income when selling equal to the valuation		
C_1	Costs (platform fee and certification fee, creation cost, etc.)		

3.3. Solution

3.3.1. Payoff Matrix

It can get payoff matrix as shown in Table 2.

Table 2: Payoff matrix

		Purchasers(B)	
		Accept Y(n)	Refuse N(1-n)
Sellers(A)	pricing above the valuation H(p)	$(P_1+R_1-C_1, M_1-P_3)$	$(-C_1, 0)$
	pricing equal to the valuation E(1-p)	$(P_2+R_2-C_1, M_1-P_4)$	$(-C_1, 0)$

3.3.2. Expected Revenue

For the sellers, the expected revenue of adopting strategy Y is

$$U_{21} = M_1 - \mathrm{p} \times P_3 - (1-\mathrm{p}) \times P_4 \quad (1)$$

The expected revenue of adopting strategy N is

$$U_{22} = 0 \quad (2)$$

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The average revenue is

$$\bar{U}_2 = n \times (M_1 - \mathrm{p} \times P_3 - (1 - \mathrm{p}) \times P_4) \tag{3}$$

For purchasers A.
The expected revenue of adopting strategy H is

$$U_{11} = n \times (P_1 + R_1) - C_1 \tag{4}$$

The expected revenue of adopting strategy E is

$$U_{12} = n \times (P_2 + R_2) - C_1 \tag{5}$$

The average revenue is

$$\bar{U}_1 = \left(C_1 - n \times (P_2 + R_2)\right) \times (p - 1) - p \times \left(C_1 - n \times (P_1 + R_1)\right) \tag{6}$$

3.3.3. Replicating dynamic Equation and Solution

$$\begin{cases} f_A(p) = \frac{\mathrm{d}p}{\mathrm{d}t} = p(U_{11} - \bar{U}_1) = n * p * (1 - p) * (P_1 - P_2 + R_1 - R_2) \\ f_B(n) = \frac{\mathrm{d}n}{\mathrm{d}t} = n(U_{21} - \bar{U}_2) = n * (1 - n) * (M_1 - P_4 - P_3 * p + P_4 * p) \end{cases} \tag{7}$$

According to the local stability analysis method proposed by Friedman (1991) to test the nature of the equilibrium point, the paper puts forward the method of local stability analysis. There are five equilibrium points.

$$E_1(0,0) \tag{8}$$

$$E_2(1,0) \tag{9}$$

$$E_3(0,1) \tag{10}$$

$$E_4(1,1) \tag{11}$$

$$E_5\left(\frac{M_1 - P_4}{P_3 - P_4}, 0\right) \tag{12}$$

Then it can get the determinant and trace of the Jacobian at the equilibrium point,as shown in table 3.

Table 3: The determinant and trace of the Jacobian at the equilibrium point

equilibrium point	Det(J)	Tr(J)
$E_1(0,0)$	0	$-M_1 - P_4$
$E_2(1,0)$	0	$-(M_1 - P_4 - P_3 + P_4)$
$E_3(0,1)$	$[(P_1 - P_2 + R_1 - R_2)][-(M_1 - P_4)]$	$[(P_1 - P_2 + R_1 - R_2)] + [-(M_1 - P_4)]$
$E_4(1,1)$	$[-(P_1 - P_2 + R_1 - R_2)[-(M_1 - P_3)]$	$-(P_1 - P_2 + R_1 - R_2) + [-(M_1 - P_3)]$
$E_5(p_0, n_0)$	0	0

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3.3.4. Analysis

When satisfying

$$[-(P_1 - P_2 + R_1 - R_2)] < 0, -(M_1 - P_4) < 0, -(M_1 - P_3) < 0 \quad (13)$$

$E_4(1,1)$ is ESS. The inequation

$$[-(P_1 - P_2 + R_1 - R_2)] < 0 \quad (14)$$

means sellers A can get a higher income by adopting strategy H instead of adopting strategy E. The inequation

$$-(M_1 - P_4) < 0, -(M_1 - P_3) < 0 \quad (15)$$

means the net income of purchasers is positive. The sellers should adopt strategy H and purchasers should adopt the strategy Y.

When satisfying

$$[-(P_1 - P_2 + R_1 - R_2)] > 0, -(M_1 - P_4) < 0, -(M_1 - P_{3)} < 0 \quad (16)$$

$E_3(0,1)$is ESS. The inequation

$$[-(P_1 - P_2 + R_1 - R_2)] > 0 \quad (17)$$

means sellers A can get a higher income by adopting strategy E instead of adopting strategy H. the inequation (18) means the net income of purchasers is positive. The sellers should adopt strategy E and purchasers should adopt the strategy Y. When purchasers adopting N, no matter which strategy do the sellers adopt. The income of purchasers is 0, so when the income of strategy Y is higher than 0, purchasers should adopt strategy.

$$-(M_1 - P_4) < 0, -(M_1 - P_3) < 0 \quad (18)$$

4. Conclusion

NFT as an emerging business concept has a good prospect. However, because of the imperfection of valuation model of NFT, NFT has investment risks. This article uses game theory to analyze what strategy should investors choose with the help of model valuation. The conclusion is when the income of pricing above the valuation is higher than pricing equal to the valuation, sellers should price above the valuation and when then net incomes is positive, purchasers should buy NFT. There are still some shortcomings in the research. For example, the revenue parameters of sellers and buyers in this study are set in a general way. In conclusion, sellers and purchasers should analyze the real value of NFT and face all kinds of phenomena in the market in a rational way, so that they can avoid risk of investment.

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