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Research on Creative Trading Supervision Mechanism Based on Evolutionary Game Theory

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Abstract: Effective trading mechanism can promote the commercialization of creative ideas and the realization of creative value. Under the assumption of bounded rationality in creative transactions, this paper constructs an evolutionary game model between creative producers and consumers, and analyzes the influencing factors, strategy selection, and equilibrium conditions of creative transactions. The study found that in the case of only market mechanism, it is difficult for transaction parties to achieve cooperation. However, with the introduction of a third-party guarantee platform, the willingness of creative product producers to cooperate increased, and transaction parties may choose to choose cooperation, although the stability of such cooperation is weak. By incorporating government punishment and compensation mechanisms into the model, the willingness of creative product consumers to cooperate increased, resulting in the dynamic evolution system of creative product trading moving towards cooperation between transaction parties and ultimately reaching a stable state.

1. Introduction

As a strategic emerging industry, the creative economy has been a new driving force for economic development [1]. While the creative industry in China started relatively late, the number of creative enterprises has been steadily increasing, and the scale of the industry grows rapidly. The value of creativity and the economic potential of creative enterprises have gained wide recognition. With the advancement of new information technologies, the integration between the creative industry and other industries has become increasingly profound, resulting in a constant generation of various creative products. However, compared to the creative industries in developed Western countries, China's creative industry generally faces challenges such as low creative quality, limited innovation synergies, and inefficient creative transactions, making it difficult to develop a competitive advantage [2]. The lack of an effective supervision mechanism for the creative market is an obstacle to the development of Chinese creative enterprises.

Creativity serves as the core asset and competitive advantage of creative enterprises. For creative

businesses, converting creativity into products and achieving profitability ahead of competitors, completing the transformation from "creativity" to "business," is the primary path to realizing creative value [3]. The key to maximizing creative value lies in effectively combining creativity, products, and market, and building a sound industrial ecosystem [4]. Caves (2000) conducted research on the process of creative trading, analyzing how to facilitate trading for both simple and complex creative products based on contract theory and industrial organization theory [5]. Higson et al. (2007) used financial analysis tools to systematically analyze the entire process of creative generation and dissemination [6]. Wu Bibo (2017) redefined and optimized the value chain of creative design [7]. Through analyzing the operational process of the creative industry, Dong Wenjing and Quan Xijian (2015) constructed a model for the operation mechanism of the creative industry [8]. These studies collectively highlight that effective trading mechanisms can promote the commercialization and value realization of creativity. Liu Jia and Yu Mingyan (2018), Zhu Yunjie et al. (2017) found that government support and regulation contribute to the implementation of creative projects [9-10]. These studies mainly focused on the analysis of creative transactions at the macro and theoretical levels, without considering the game relationship and decision-making behavior of the micro-level transaction participants. From the perspective of creative trading practice, both sides of the transaction are affected by information asymmetry, limited cognitive ability and other factors, and usually make decisions based on Bounded rationality. The research objective of this article is to explore how to promote the achievement of creative transactions by regulating and guiding the behavior of both parties involved in the transaction through external regulatory measures, under the premise of bounded rationality. Therefore, this paper introduces external regulatory factors step by step and analyzes the behavioral evolution of creative transaction producers and consumers under different mechanisms, in order to explore effective regulatory mechanisms for creative transactions.

2. Analysis of Evolutionary Game under Market Mechanism

2.1. Model Hypotheses and Establishment

In regard to the scenario of creative product transaction conducted solely through market mechanisms, the following hypotheses were made:

(1) There are two parties involved in the transaction of creative products: the producers and the consumers of creative products. Both parties engage in the transaction with bounded rationality.

(2) Due to information asymmetry between the producer and consumer of creative products, the consumer needs to pay a certain amount of information cost in order to acquire additional information about the creative product. This information cost is considered as part of the trading price.

(3) Both parties involved in the creative transaction have the option to choose between "cooperation" and "non-cooperation" strategies. Here, the "non-cooperation" strategy of creative product consumers refers to the failure to reach a transaction or fulfill transaction obligations according to the transaction agreement, otherwise it is considered as cooperation. The "non-cooperation" strategy of creative product producers refers to the failure to reach a transaction or terminate a transaction agreement, otherwise it is considered cooperation. These choices form four possible strategy combinations: (cooperation, cooperation), (cooperation, non-cooperation), (non-cooperation, cooperation), and (non-cooperation, non-cooperation).

(4) Both parties in creative product transaction make decisions based on their own psychological expectations of returns under uncertainty. The expected returns for both parties are calculated through value perception and strategy weights under different strategies. The weight of cooperation and non-cooperation for the creative product consumer is represented by a and 1-a, where $a \in [0,1]$; the weight of cooperation and non-cooperation for the creative product producer is represented by b and 1-b,

where b∈[0,1].

Table 1: Payoff matrix of both sides of creative product transaction under market mechanism

Game participants		consumer	
		cooperation	non-cooperation
producer	cooperation	U_1-M+kL-T, V1-P-S-kL	W_1- T, V_2-W_1
	non-cooperation	U_2-W_2, W_2-I	0, 0

Where U_1 and U_2 represent the psychological expected returns for the creative product producer under cooperation and non-cooperation strategies respectively, and V_1 and V_2 represent the expected value for the creative product consumer under cooperation and non-cooperation strategies respectively. P denotes the maximum price that the consumer is willing to pay, and M represents the manufacturing cost of the creative product. S represents the search cost incurred by the consumer to obtain the desired product. The creative factor is the most essential part of the creative product. It is beneficial for the consumer to make judgments about the value of the product when critical product information is disclosed during the trading process [11]. However, such information disclosure may facilitate trading completion while also potentially leading to the leakage of critical creative ideas. Inappropriate disclosure of creative information can result in a decrease in the value of the creative product. Creative product producers often screen consumers with genuine needs by setting up paid information. In this case, the value loss to the creative product producer due to information disclosure is denoted as T, and the cost of paid information borne by the creative product consumer is denoted as I. After a single trading is completed, the creative product producer may continue to profit from the idea [12], for example, by making slight modifications to the original creative product and reselling it. This behavior will harm the interests of consumers of original creative products. Assuming the probability of such transaction risks occurring is k, the losses faced by creative product consumers are kL, and the secondary benefits obtained by creative product producers are kL. W_1 and W_2 represent the compensation that the non-cooperative party in the creative product trading provides to the cooperative party.

According to Table 1 and assumed strategy weights, the expected benefit of creative product producers adopting cooperative strategies is as follows:

$$E_{P1} = a(U_1 - M + kL - T) + (1 - a)(W_1 - T) \tag{1}$$

The expected return for the creative product producer under a non-cooperation strategy:

$$E_{P2} = a(U_2 - W_2) \tag{2}$$

The average return for the creative product producer:

$$\overline{E}_P = b\{a(U_1 - M + kL - T) + (1 - a)(W_1 - T)\} + (1 - b)\{a(U_2 - W_2)\} \tag{3}$$

The expected return for the creative product consumer under a cooperation strategy:

$$E_{c1} = b(V_1 - P - S - kL) + (1 - b)(W_2 - I) \tag{4}$$

The expected return for the creative product consumer under a non-cooperation strategy:

$$E_{c2} = b(V_2 - W_1) \tag{5}$$

The average return for the creative product consumer:

$$\overline{E}_c = a\{b(V_1 - P - S - kL) + (1 - b)(W_2 - I)\} + (1 - a)\{b(V_2 - W_1)\} \tag{6}$$

At this moment, the replicator dynamics equation for the creative product producers is:

$$\frac{d_b}{d_t} = b(E_{P1} - \bar{E}_P) = b(1-b)(aU_1 - aM + aKL + W_1 - T - aW_1 - aU_2 + aW_2) \quad (7)$$

The replicator dynamics equation for the creative product consumers is:

$$\frac{d_a}{d_t} = a(E_{c1} - \bar{E}_c) = a(1-a)(bV_1 - bP - bS - bkL + W_2 - I - bW_2 + bI - bV_2 + bW_1) \quad (8)$$

2.2. Analysis of Evolutionary Game Model

Let $\frac{d_a}{d_t} = \frac{d_b}{d_t} = 0$ to get the equilibrium points of dynamic evolution: (0,0),(0,1),(1,0),(1,1),(a*,b*).

Where, $a^* = \frac{W_1 - T}{U_1 - M + KL - W_1 - U_2 + W_2} \in [0,1]$, $b^* = \frac{W_2 - I}{V_1 - P - S - kL - W_2 + I - V_2 + W_1} \in [0,1]$.

By employing local stability analysis method, the evolutionarily stable strategies for the aforementioned system can be obtained. The Jacobian matrix is calculated as follows:

$$J = \begin{bmatrix} (1-2b)(aU_1 - aM + aKL - aW_1 - aU_2 + aW_2 + W_1 - T), b(1-b)(U_1 - M + KL - W_1 - U_2 + W_2) \\ a(1-a)(V_1 - P - S - kL - W_2 + I - V_2 + W_1), (1-2a)(bV_1 - bP - bS - bkL - bW_2 + bI - bV_2 + bW_1 + W_2 - I) \end{bmatrix}$$

The local stability analysis results of the equilibrium points for the dynamic evolution system of creative product trading strategies, based on the results of det(J) and tr(J), along with the conditions for evolutionarily stable strategies, are shown in Table 2.

Table 2: Analysis of determinants and symbolic traces of Jacobian matrix

equilibrium points			(0,0)	(0,1)	(1,0)	(1,1)	(a*,b*)
Scenario 1	W_1-T<0 W_2-I<0	drt(J)	+	+	+	+	-
		tr(J)	-	+	+	±	0
		Type	ESS	Unstable	Unstable	Unstable	Saddle Point
Scenario 2	W_1-T≥0 W_2-I≥0	drt(J)	+	+	+	+	-
		tr(J)	+	-	-	+	0
		Type	Unstable	ESS	ESS	Unstable	Saddle Point
Scenario 3	W_1-T≥0 W_2-I<0	drt(J)	-	+	-	+	-
		tr(J)	+	±	±	±	0
		Type	Unstable	Unstable	Unstable	Unstable	Unstable
Scenario 4	W_1-T<0 W_2-I≥0	drt(J)	-	-	+	+	-
		tr(J)	+	-	+	±	0
		Type	Unstable	Unstable	Unstable	Unstable	Unstable

From Table 2, it can be observed that in Scenario 1, (Non-cooperation, Non-cooperation) is an ESS (Evolutionarily Stable Strategy), indicating that in this situation, both producers and consumers of creative products choose non-cooperation strategies, leading to the failure of creative transaction. In Scenario 2, (Non-cooperation, Cooperation) and (Cooperation, Non-cooperation) are ESS, indicating that one party in the creative transaction chooses a cooperation strategy while the other chooses non-cooperation, resulting in the inability to reach a creative trading. In both Scenario 3 and Scenario 4, the dynamic evolution system of creative product trading strategies does not have a dynamically stable equilibrium point. The above results indicate that, under the influence of market mechanisms alone, the transaction strategies adopted by producers and consumers cannot effectively promote the completion of transactions after long-term repeated games between creative trading parties. The ineffectiveness of market mechanisms in creative trading may be attributed to factors such as the perishability of creative information, information asymmetry between the parties involved,

inefficient matching of creative trading, and high trading costs, which do not meet the requirements of a well-functioning market. The characteristics of creative transaction determine that the unique element of creativity cannot be efficiently traded solely through market mechanisms. Therefore, it is necessary to introduce other mechanisms into the trading process.

3. Evolutionary Game Analysis with the Participation of Third-Party Guarantee Platform

An asymmetry of information is one of the main factors hindering the completion of creative trading and leading to trading defaults [13]. The development of information technology has facilitated the emergence of third-party platforms in the production and trading domains. Introducing a third-party guarantee platform in creative trading is an effective mechanism to ensure trading security [14]. Third-party guarantee platforms are typically composed of entities such as assessment agencies and financial institutions, independent of the trading parties. These platforms can reduce trading risks and increase trust in the trading. On one hand, the independent third-party guarantee platform conducts qualification checks and credit ratings on the parties involved in the trading, ensuring their ability to fulfill contractual obligations and providing this information to all parties. On the other hand, as a neutral third party, in case of disputes in the trading, the platform can independently evaluate the trading matters and relevant evidence, providing objective and impartial arbitration services to protect the rights and interests of all parties involved.

Table 3: Payoff matrix of both parties with the participation of the third-party guarantee platform

Game participants		consumer	
		cooperation	non-cooperation
producer	cooperation	U1-M+kL, V1-P-S-kL	W_1, V_2-W_1
	non-cooperation	U_2-W_2, W_2-I	0 , 0

According to Table 3, the replicator dynamics equation for creative product producers is:

$$\frac{d_b}{d_t} = b(E_{P1} - \bar{E}_P) = b(1-b)(aU_1 - aM + aKL + W_1 - aW_1 - aU_2 + aW_2) \tag{9}$$

The replicator dynamics equation for creative product consumers is:

$$\frac{d_a}{d_t} = a(E_{c1} - \bar{E}_c) = a(1-a)(bV_1 - bP - bS - bkL + W_2 - I - bW_2 + bI - bV_2 + bW_1) \tag{10}$$

Let $\frac{d_a}{d_t} = \frac{d_b}{d_t} = 0$ to get the equilibrium points of dynamic evolution: (0,0),(0,1),(1,0),(1,1),(a*,b*).

Where, $a^* = \frac{W_1}{U_1 - M + KL - W_1 - U_2 + W_2} \in [0,1]$, $b^* = \frac{W_2 - I}{V_1 - P - S - kL - W_2 + I - V_2 + W_1} \in [0,1]$.

Similar to the aforementioned evolutionary process, when W1-T<0 and W2-I<0, (Cooperation, Cooperation) and (Non-cooperation, Non-cooperation) are deemed as ESS. The introduction of a third-party platform will gradually diminish the value of a*. Nevertheless, in creative trading, the producers of creative products are the ones with information advantages, while the consumers of creative products are at an information disadvantage. The involvement of a third-party guarantee platform effectively mitigates the risk of product devaluation resulting from consumers paying for product information, thereby reducing trading risks for creative product producers. However, the producers' behavior of making profit by using creativity for the second time is not restricted, and the value obtained by consumers of creative products from the transaction still has the risk of depreciation. Hence, the introduction of a third-party platform merely amplifies the likelihood of creative product producers opting for cooperation strategies, but cannot inherently facilitate the parties in reaching a

trading agreement.

4. Evolutionary Game Analysis under Government Punitive and Compensatory Mechanisms

Government punishment and compensation mechanisms contribute to maintaining fairness in creative transactions and protecting the rights and interests of both parties involved. On one hand, punishment mechanisms help establish effective contractual relationships between the parties. Clear punitive regulations set benchmarks and boundaries for the behavior of both parties in creative transactions. This enables conscious restraint of improper conduct and ensures the fulfillment of responsibilities and obligations, thereby making transactions more stable. On the other hand, the compensation mechanism can reduce costs and share risks for both sides of the transaction. Due to the information asymmetry between the two sides of the creative transaction, there is the possibility that the transaction cannot achieve the predetermined goal. The compensation mechanism can alleviate the transaction loss and reduce the uncertainty of the transaction to a certain extent. In the transaction, the government's punishment mechanism mainly includes legal sanctions, administrative penalties, market access restrictions, etc., and the government's compensation mechanism mainly includes tax incentives and government subsidies. The penalty costs for producers and consumers of creative products are C1 and C2, and the compensation for producers and consumers of creative products is R1 and R2. In the presence of governmental punitive and compensatory mechanisms, the payoff matrix for both parties is depicted in Table 4.

Table 4: Payoff matrix of both parties under government subsidy and punitive mechanisms

Game participants		consumer	
		cooperation	non-cooperation
producer	cooperation	U_1-M-S1+R1, V1-P-S+R2	W_1+R1, V_2-W_1
	non-cooperation	U_2-W_2, W_2-I+R2	0 , 0

According to Table 4, the replicator dynamics equation for creative product producers is:

$$\frac{d_b}{d_t} = b(E_{P1} - \bar{E}_P) = b(1-b)(aU_1 - aM + W_1 + R_1 - aW_1 - aU_2 + aW_2) \tag{11}$$

The replicator dynamics equation for creative product consumers is:

$$\frac{d_a}{d_t} = a(E_{c1} - \bar{E}_c) = a(1-a)(bV_1 - bP - bS + W_2 - I + R_2 - bW_2 + bI - bV_2 + bW_1) \tag{12}$$

Let $\frac{d_a}{d_t} = \frac{d_b}{d_t} = 0$ to get the equilibrium points of dynamic evolution: (0,0),(0,1),(1,0),(1,1),(a*,b*).

Where, $a^* = \frac{W_1 + R_1}{U_1 - M - W_1 - U_2 + W_2} \in [0,1]$, $b^* = \frac{W_2 - I + R_2}{V_1 - P - S - W_2 + I - V_2 + W_1} \in [0,1]$. When W1-T<0 and W2-I<0, (Cooperation, Cooperation) and (Non-cooperation, Non-cooperation) are ESS.

Under the governmental punitive and compensatory mechanisms, it is optimal for producers of creative products to opt for cooperation. The ultimate convergence of the dynamic evolutionary system of trading involving creative products relies on the choices made by consumers of these products. In the preceding analysis, the primary factors influencing the strategy choices of creative product consumers are twofold. Firstly, the information asymmetry diminishes the level of trust between the parties engaged in the trading. Secondly, the specific attributes of creative products contribute to lower costs associated with opportunistic behavior. Being at a disadvantage in terms of information in trading involving creative products, consumers can seek equitable recompense through punitive mechanisms to address any losses incurred from unfair trading. This serves to safeguard the

interests of creative product consumers and encourages their active participation in trading. In such circumstances, provided that creative product consumers recognize the value of the product and the risks associated with the trading are manageable, the likelihood of them opting for a cooperation strategy is higher than that of choosing a non-cooperation one. Therefore, under the governmental punitive and compensatory mechanisms, the probability of the dynamic evolutionary system of trading involving creative products converging towards a (Cooperation, Cooperation) strategy is the highest.

5. Conclusions and Recommendations

The evolutionary game analysis of decision-making behavior among parties involved in trading of creative products was examined in this paper. The findings reveal that, when solely influenced by market mechanisms, the probability of convergence towards a Pareto-inferior equilibrium state is maximized. This is mainly related to the perishable nature of creative information and the transaction risk caused by the information asymmetry between the parties. However, the introduction of third-party guarantee platforms and the implementation of punitive and compensatory mechanisms by the government increase the probability of ultimate convergence towards a Pareto-optimal equilibrium state. Comparatively, governmental punitive and compensatory mechanisms were found to exhibit higher effectiveness than third-party guarantee platforms. While the latter can increase the transaction willingness of creative product producers, the former can increase the transaction willingness of both parties involved in creative transactions, thereby promoting cooperation between them.

According to the research findings, the following recommendations are proposed: Firstly, strengthen the establishment of intellectual property rights system in creative trading by improving relevant laws and regulations, and increasing the penalties for intellectual property infringement. This will provide a favorable trading environment for the creative industry. Secondly, enhance support for the creative industry by guiding evaluation agencies, guarantee organizations, and other entities to participate in creative trading, and establishing a risk compensation mechanism which can reduce the trading risks borne by both parties. Thirdly, bolster the development of third-party platforms by creating online circulation markets for creative products. Utilize big data analysis techniques to establish a risk warning mechanism for creative trading, enhancing the stability of transactions by monitoring and responding to trading risks.

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