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Research Article

Evolutionary Game Analysis of Industry-University-Research Cooperative Innovation in Digital Media Enterprise Cluster Based on GS Algorithm

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In order to study all the advantages and disadvantages of digital media enterprises, technological innovation can only be completed through cooperation. A kind of industry-university-research cooperative innovation evolutionary game method based on GS algorithm is proposed for digital media enterprise clusters. This method analyzes the evolutionary game theory of innovation and puts forward the evolutionary stability strategy of cooperative innovation between enterprises and research institutions. The results show that decreasing V is beneficial for the evolutionary game to approach the equilibrium point $(1,1)$; that is, the greater the cost of independent innovation is compared with collaborative innovation, the stronger the willingness of both sides of the game to collaborative innovation. Enterprises and scientific research institutions are two different subjects with different interests. If they want to complete innovation cooperation, they need to formulate a perfect set of rules so that both sides of the game can carry out cooperative innovation according to the principles, so as to achieve the goal of cooperation.

1. Introduction

For enterprises or decision-makers in reality, complete rationality is difficult to meet high standards and requirements, especially in the current economic environment, and when decision-making problems are relatively complex, the ideal limitations of decision-makers are very obvious. In this case, evolutionary game theory can provide these groups with more abundant game theory tools to deal with problems related to rational limitations, while in terms of industrial clusters and cooperative innovation behaviors among enterprises, there is a close relationship between them [1]. Industrial cluster can gather the same type of enterprises or related enterprises together and promote win-win cooperation among enterprises by means of cluster supply chain relationship. Enterprises in the cluster can also promote the formation of cooperative innovation network through the evolution of

industry-university-research cooperative innovation, and the phenomenon of technology diffusion and knowledge spillover under this innovation mode can promote the spatial aggregation of enterprises. In the mode of industrial cluster, enterprise cooperative innovation between behavior is based on supply chain network and cluster supply chain network and needed a chain in the middle and lower reaches of the suppliers, manufacturers, distributors, and other support and also needed to merge the government agencies, research institutions, and financial institutions to provide support for cooperative innovation of industrial cluster [2]. Therefore, it can be seen that the evolution of industry-university-research cooperative innovation in enterprise clusters is not accomplished overnight and requires a lot of attention. Therefore, starting with GS algorithm and taking digital media enterprises (Figure 1) as the research object, this article focuses on the evolutionary game of cluster industry-university-research cooperative innovation.

FIGURE 1: Digital media technology.

2. Literature Review

Wen et al. also introduced concepts such as enterprise cluster and industrial area for industrial cluster, but "industrial cluster" is the most widely used. The research on industrial cluster mainly focuses on the forming principle, the source of competitive advantage, and the evolution mechanism of industrial cluster [3]. According to Kobrin et al., the new economic geography school believes that the aggregation of industries in a certain region is caused by the external economy of enterprises, leading to the aggregation of related industries, and then the phenomenon of scale economy, scope economy, and path dependence is generated. And he thinks that historical accidental factors play an important role in the formation of industrial clusters [4]. Gao and Ding have made a comprehensive and specific definition of industrial cluster: Industrial cluster refers to the collection of enterprises and institutions in a specific field that are interconnected and located together, including a group of interconnected enterprises and other entities that play an important role in competition. In addition, he believes that industrial clusters will extend up and down the industrial chain, involving raw material suppliers and distributors, and there will be auxiliary enterprises and institutions to join [5]. Wang, Z. et al. analyzed the formation principle of industrial clusters in detail. Through the diamond model theory, he concluded that talent gathering, unobstructed information flow, cooperation between enterprises, interdependence between enterprises, capital supply, and public attitude are the endogenous factors promoting the formation of industrial clusters, and the government policy is the external driving force to promote the formation of industrial clusters, and the two together constitute seven main driving mechanisms for the formation of industrial clusters [6]. Lara-Prieto and Flores-Garza divided the location factors affecting industrial clusters into agglomeration factors and regional factors and believed that agglomeration factors were composed of two stages: The first stage is the scale expansion of enterprises through their own advantages. When enterprises expand to a certain scale,

relevant industries will gather to them. This is the second stage of agglomeration factor, which is also the aggregation stage of relevant enterprises within the industry [7]. Zhang et al. believe that industrial clusters are formed when enterprises gather to a certain scale. In this book, he also analyzes the reduction of general costs as the reason for the clustering of industries in certain regions. Since the reform and opening up, China's economy has achieved rapid growth, especially after the 1980s, various regional economic factors are constantly active [8]. Mahmoud et al. took them as objects to academic the theory of industrial clusters. Starting from the core competitiveness of enterprises in the cluster, the learning ability of the cluster, and the aggregation degree of resources in the cluster, some scholars have concluded that the internal and external environment of the cluster plays an important driving role in the formation of the cluster brand [9]. Gangwar et al. divided the formation of cluster brands into four stages: brand initial stage, regional brand stage, cluster brand establishment stage, and brand maturity stage; Based on the academic of industrial parks in western China, it is found that the current construction of industrial parks in China only pays attention to the geographical concentration of enterprises and neglects the economic benefits of industrial clusters [10]. De Ayala et al. analyzed this phenomenon by applying the theory of regional economics and the theory of industrial cluster development and pointed out that this phenomenon was caused by the misunderstanding of the concept between industrial cluster and industrial park or the short-term behavior taken by the local government due to the policy pressure [11]. This phenomenon is not conducive to the long-term development of regional economy. Based on this, they put forward some policy suggestions to transform these unreasonable industrial parks into industrial clusters.

3. Method

3.1. Enterprise Industry-University-Research Cooperation GS Algorithm Matching Process. Small and medium-sized enterprises (SMES), the demander of technology in the industry-university-research cooperation, aim to maximize economic
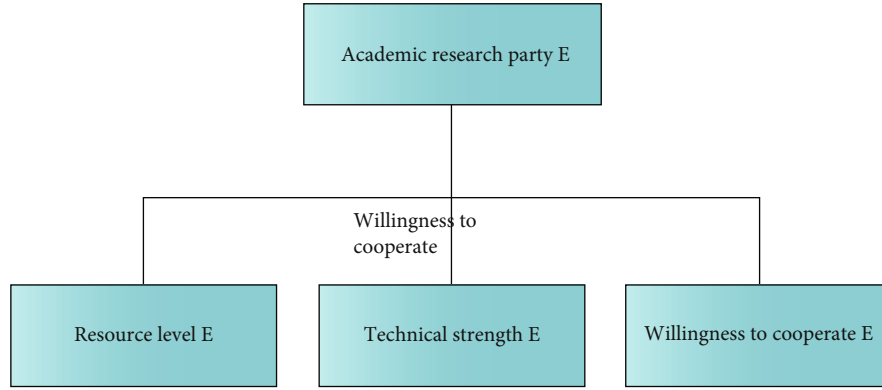
FIGURE 2: Factors taken into consideration by the industry side in preference to the research side.

benefits, whose purpose of participating in the cooperation is to improve their R&D strength, so that they can be in a favorable position in the future competition. As the product of the market economy, enterprises have information advantages that the academic and research sides do not have. They have good platforms and resources for the marketization of achievements, such as management and capital, and can transform scientific research resources into real productivity [12]. They can quickly grasp the changes of market demand through timely information feedback, When their research and development strength (except some large enterprises have their own research and development centers, which can develop innovative results to meet market demand, most small and medium-sized enterprises do not have these strength) cannot realize the innovation of technological products, the external competitive pressure will be transformed into the internal motivation to seek cooperation.

3.1.1. Analysis of Preference Factors. Colleges and universities and institutes are national key basic research; by the analysis of the above literature review, the small and medium-sized enterprises industry-university-institute cooperation pattern has a lot; for different cooperation modes, the factors involved are different, and the process is complex, and most of them are qualitative indicators [13]. Therefore, the industry side considers different factors in its preference for the research side. Based on interviews with small and medium-sized enterprises and relevant literature on their choice of cooperation partners, this article establishes the factors that small and medium-sized enterprises prefer to consider for universities and institutes, as shown in Figure 2.

3.1.2. The Formation of Preference Ranking of Industry Side. Since the factors used to evaluate the academic and research side are almost qualitative indicators with great uncertainty and difficulty in quantification, it is difficult to form the industrial side's preference for the academic and research side with quantified indicators. In this article, the fuzzy comprehensive evaluation method is used to analyze the formation of the preference ranking list of the industrial side to the academic and research side, which can transform the qualitative index into quantitative index [14].

3.1.3. The Fuzzy Evaluation Matrix Is Established. Fuzzy evaluation matrix of industrial side to academic and research side:

$$R = (R_1, R_2, R_3, R_4, R_5). \tag{1}$$

According to the questionnaire collected by industry experts and normalized, the fuzzy evaluation values of each factor are shown in Table 1:

Firstly, a fuzzy comprehensive evaluation is carried out on the second-level indicators, and its matrix is set as

$$B = (B_1, B_2, B_3),$$

$$B_1 = W_1 \times R_1 = (0.15, 0.2, 0.4, 0.25)$$

$$\times \begin{pmatrix} 0.2 & 0.3 & 0.3 & 0.1 & 0.1 \\ 0.4 & 0.1 & 0.3 & 0.2 & 0 \\ 0.4 & 0.2 & 0.1 & 0.2 & 0.1 \\ 0.3 & 0.3 & 0.2 & 0.2 & 0 \end{pmatrix}$$

$$= (0.345, 0.22, 0.195, 0.185, 0.555),$$

$$B_2 = W_2 \times R_2 = (0.1, 0.4, 0.2, 0.3)$$

$$\times \begin{pmatrix} 0.5 & 0.4 & 0.0 & 0 & 0.1 \\ 0.4 & 0.2 & 0.1 & 0.3 & 0.1 \\ 0.4 & 0.2 & 0.2 & 0.2 & 0 \\ 0.3 & 0.3 & 0.1 & 0.1 & 0.1 \end{pmatrix}$$

$$= (0.34, 0.25, 0.15, 0.19, 0.07),$$

$$B_3 = W_3 \times R_3 = (0.4, 0.4, 0.2)$$

$$\times \begin{pmatrix} 0.6 & 0.1 & 0.2 & 0.1 & 0 \\ 0.4 & 0.3 & 0.2 & 0.1 & 0 \\ 0.5 & 0.2 & 0 & 0.2 & 0.1 \end{pmatrix} \tag{2}$$

$$= (0.5, 0.2, 0.16, 0.12, 0.02).$$

Table 1: Industrial party's evaluation matrix of academic and research party's ambiguity.

Second-level indicators	V_1	V_2	V_3	V_4	V_5
E_{11}	0.2	0.3	0.3	0.1	0.1
E_{12}	0.4	0.1	0.3	0.2	0
E_{13}	0.4	0.2	0.1	0.2	0.1
E_{14}	0.3	0.3	0.2	0.2	0
E_{21}	0.5	0.4	0.1	00.3	0
E_{22}	0.3	0.2	0.1	0.2	0.1
E_{23}	0.4	0.2	0.2	0.1	0
E_{24}	0.3	0.3	0.2	0.1	0.1
E_{31}	0.6	0.1	0.2	0.1	0
E_{32}	0.4	0.3	0.2	0.1	0
E_{33}	0.5	0.2	0	0.2	0.1

First-level indicators.

Secondly, fuzzy comprehensive evaluation is carried out on the first-level indicators.

$$A = W \times B = (0.35, 0.4, 0.25)$$
$$\times \begin{pmatrix} 0.345 & 0.22 & 0.195 & 0.185 & 0.055 \\ 0.34 & 0.25 & 0.15 & 0.19 & 0.07 \\ 0.50 & 0.20 & 0.16 & 0.12 & 0.02 \end{pmatrix} \quad (3)$$
$$= (0.38175, 0.227, 0.16825, 0.17075, 0.05225).$$

(1) Academic and Research Party. (1)1. Factors Taken into Consideration by the Academic and Research Side to the Industry Side and the Formation of Preference Ranking. In order to cooperate with the industry side, the academic and research side must first consider various factors and standards of the industry side; the same as the industry's selection of academic and researcher, the selection of academic and researcher is mostly at the qualitative stage at present, and many of them rely on subjective speculation. With the help of the relevant indicators of the balanced Scorecard theory and the cooperation willingness of the industry [15], this article designs the indicator factors considered by the academic and researcher for the industry, as shown in Table 2:

The balanced scorecard method balances the relationship between long-term and short-term indicators, internal and external indicators, financial and nonfinancial indicators, and related interest groups. The biggest advantage is to consider the innovation and learning perspective of the enterprise. However, since BSC is used to measure the performance and evaluate the strategy of an enterprise, it is impossible for the academic and research institute to obtain every indicator. Moreover, there are many indicators, and the academic and research institute has no energy to special-

ize in them. Therefore, the academic and research institute only use BSC to analyze the factors that the academic and research institute consider in favor of the industry.

(1)2. The Formation of Preference Ranking of Academic and Research Parties. This section is the same as the process of forming the preference ranking list of the industry side to the research side, and the fuzzy comprehensive evaluation method is used to form the preference ranking list of the research side to the industry side. The method is similar, but due to time constraints, the process is omitted here.

3.2. The Matching Process of GS Algorithm Matching Model for Small and Medium-Sized Enterprises. According to the known preference ranking list, it is assumed that small and medium-sized enterprises (i.e., industry) need to seek partners, while universities and institutes (i.e., universities and research institutes) also need to seek partners, but it is assumed that the demand is not as urgent as that of industry:

First of all, the industrial side of m expresses its intention to cooperate with the leading industrial side according to the ranking of the academic and research side [16]. After receiving the intention of the industrial side, the academic and research side accepts the industry side ranked in the first place according to its own ranking and rejects all the industries behind the ranking.

Secondly, the academic and research party ranked second in the rejected industry direction shows intention to cooperate with it. If the academic and research party has no partner, it will accept the industry party ranked first. At the same time, considering the situation that the academic and research party has already cooperated with them, if the industrial party that expresses its intention to cooperate with them now ranks ahead of the existing cooperative partner, the industrial party that expresses its intention to cooperate with them now is accepted, and the former cooperative partner is rejected; If the industry party that expresses its intention to cooperate with it is ranked behind the existing partner, it will reject the industry party that expresses its intention to cooperate with it and continue to cooperate with the former industry party.

In accordance with the above steps, the industry parties that are not accepted continue to express their interest to the other parties in order of preference until they are accepted by one of the parties [4]. The academic and research side will accept the industry side ranked first according to their preference, until all the industry side and the academic and research side find their own cooperation partners; the match will end, which is always stable. Intuitively, if an industry prefers to work with a particular institution rather than the one it is currently working with, it is because that particular institution has rejected it. Similarly, if a university prefers to work with a particular industry rather than its current partner, it is because that particular industry is already working with another university, but not itself.

3.3. Matching Process of GS Algorithm under Full Matching. In fact, there will be a lot of problems when GS algorithm is applied to the matching problem of industry-university-

TABLE 2: Factors taken into consideration for the preference of the academic and research parties to the industry side.

		Solvency ratio
	Financial perspective	Operating capacity ratio
		Profitability ratio
		The scale of R&D spending
Industry party U	The customer perspective	Social reputation
		Customer satisfaction
		Delivery time U31
	Internal process perspective U3	Production capacity U3
		Service process U32

research cooperation in SMES, which needs to be paid attention to. In fact, partners will look for a variety of strategic behavior, game behavior, resulting in unstable matching results [5].

3.3.1. The Strategic Behavior of Distorting Preferences of the Industry Side and the Academic Side. The preference ranking list of industry side and academic side is shown in Table 3:

The specific cyclic process of the algorithm model can be deduced from the preference ranking list, as shown in Tables 4 and 5: namely, whether the industry side first expresses the intention to cooperate with the academic and research side or the academic and research side first expresses the intention to cooperate with the academic and research side, the stable matching state can be obtained [17].

However, if e_2 knows that the partner obtained according to the GS algorithm is its third choice, e_2 may take a strategic behavior, distort its preference, and get the partner it thinks is more satisfied while hurting other partners. The rest are unacceptable choices, and the list of preferences becomes Table 6:

3.3.2. Game Behavior between Industry and Academic Research. The particularity of the industry-university-research cooperation of small and medium-sized enterprises, especially the diversification of interest demands in the purpose of economic behavior [18], and the incompleteness of the contract signed by the industry side and the research side, may lead to the distortion of preferences, resulting in strategic behavior, or the game between the two sides. If small and medium-sized enterprises send insincere signals to academic and research side, they need to pay a certain cost, indicating that strong small and medium-sized enterprises send low input resources, while weak small and medium-sized enterprises send high input resources.

In order to make weak small and medium-sized enterprises send out signals of true cooperation, the cost of sending false signals can be increased, so as to curb the speculation of small and medium-sized enterprises [19]. There are a large number of small and medium-sized enterprises, and the competition is not uniform. The academic and research side cannot know which small and medium-

TABLE 3: Preference ranking list of industry and academic.

Preference ranking	Industry party			Academic and research party		
	e_1	e_2	e_3	u_1	u_2	u_3
1	u_1	u_1	u_2	e_1	e_3	e_1
2	u_2	u_2	u_1	e_2	e_1	e_2
3	u_3	u_3	u_3	e_3	e_2	e_3

TABLE 4: The matching cycle in which the industry side first expresses its intention to cooperate with the academic and research side.

Circulation	u_1	u_2	u_3
The first circulation	$e_1 e_2$	e_3	—
The second circulation	e_1	$e_3 e_2$	
The third circulation	e_1	e_3	e_2

TABLE 5: Matching cycle process in which academic and research parties express their intention to cooperate with industry parties.

Circulation	e_1	e_2	e_3
The first circulation	$u_1 u_3$	—	u_2
The second circulation	u_1	u_3	u_2

TABLE 6: Preference ranking list of both industry and academic and research sides.

Preference ranking	Industry side			Academic and research sides		
	e_1	e_2	e_3	u_1	u_2	u_3
1	u_1	u_1	u_2	e_1	e_3	e_1
2	u_2		u_1	e_2	e_1	e_2
3	u_3		u_3	e_3	e_2	e_3

sized enterprises have technical needs, and they are unwilling to form a target set of small and medium-sized enterprises. Because universities and institutes are afraid to give their painstaking research and development innovation
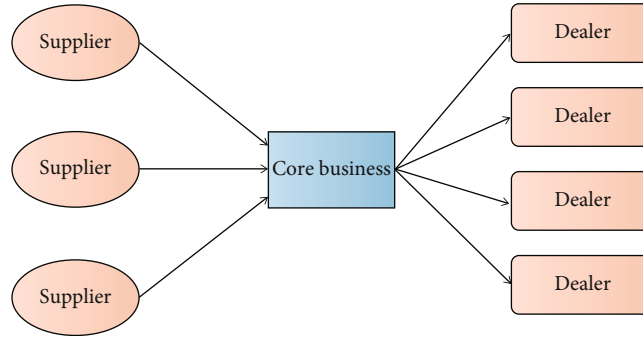
FIGURE 3: Organizational pattern diagram of single-core cluster supply chain.

results to small and medium-sized enterprises, they rarely consider cooperation with small and medium-sized enterprises, and even if they do consider cooperation with small and medium-sized enterprises, they only carry out low-end cooperation projects. Therefore, there may be universities and institutes do not have a preference ranking list for smes. However, in the algorithm matching model, the matching parties must form a strict preference sorting list and then obtain the matching result through matching GS algorithm, so a place that can form the preference sorting list must be established [20].

3.4. Organization Mode of Industry-University-Research Cluster Supply Chain

3.4.1. Organization Mode of Single-Core Industrial Cluster Supply Chain. The single-core cluster supply chain organization mode means that there is only one core enterprise in the producing area cluster. There are a large number of upstream and downstream enterprises as well as auxiliary enterprises or institutions around them, which form a relatively complete and complex supply chain network system, as shown in Figure 3.

3.4.2. Organization Mode of Multicore Industrial Cluster Supply Chain. The organization pattern of multicore industrial cluster supply chain is the most common in industrial cluster. In this organization mode, the core enterprise, like other links in the supply chain, has multiple competitors or potential competitors. Core enterprises form a complex supply chain network system by cooperating with upstream and downstream enterprises in logistics, capital flow, and information flow [21]. Each core enterprise has trade relations with several upstream and downstream enterprises, and the upstream and downstream enterprises may also have trade relations with several core enterprises at the same time, which makes the supply chain model of multicore industrial cluster more complicated. The multicore cluster supply chain can be divided into parallel multicore cluster supply chain organization mode and cross-multicore cluster supply chain organization mode according to the different cross situations among enterprises, as shown in Figures 4 and 5.

4. Experimental Analysis of Interfirm Cooperative Innovation in Industrial Cluster Supply Chain

4.1. Basic Model Analysis and Establishment

4.1.1. Establishment of Game Matrix. There are two types of enterprises in an industrial cluster, and these two types of enterprises have two behavior choices, respectively, innovation and imitation. If neither of them innovates, they each get a gain of 0, and if one of them innovates, they get a gain of 1. However, due to the technology spillover brought by informal communication in industrial clusters, innovative enterprises can only obtain M $(0.5 < m < 1)$ in income 1. Innovation will have innovation cost, and the enterprise that chooses imitation will gain 1-M through imitation and do not have to pay innovation cost. If both firms innovate, they will each get a return of p. In reality, it is difficult for the enterprises in an industrial cluster to be completely the same. Because of the differences in technological means, human capital, corporate culture, and other aspects, some enterprises are more suitable for innovation, while others are not, which can be reflected in the difference in innovation costs [22]. Therefore, the two types of firms are divided on the basis of their innovation costs. We can assume that the innovation cost of player 1 is lower than that of player 2, namely z1 < z2, because player 1 has more talent reserves and a more suitable enterprise culture for innovation. In reality, whether an enterprise innovates or not ultimately depends on which strategy can gain more benefits in market competition. Strategies that can gain more benefits will naturally be imitated and "inherited" by more enterprises, while those that cannot gain more benefits will naturally be abandoned by most enterprises, thus being "eliminated." This process of survival of the fittest does not happen in an instant but needs time.

In order to better reflect and explain the independent innovation behavior of enterprises under the condition of abandoning the completely rational hypothesis, we can only analyze the dynamic evolution process of enterprise innovation behavior determined by market choice. First, assuming that in an industrial cluster, not of all of the enterprise carry out independent innovation at the beginning (this also basically accords with the practice of China's manufacturing
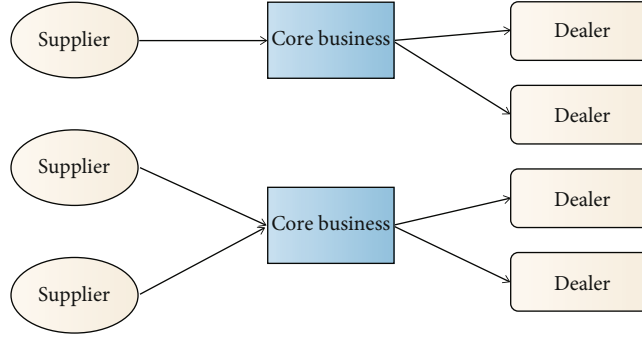
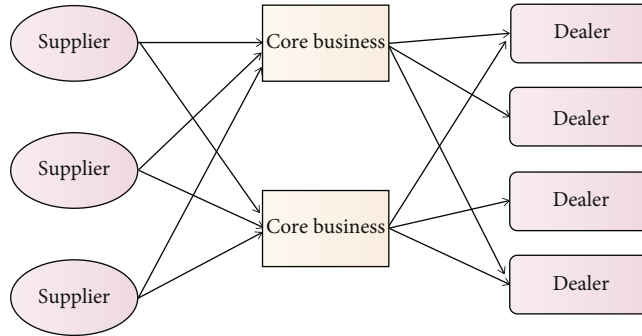FIGURE 4: Organizational model of parallel multicore industry standard group.

FIGURE 5: Organizational pattern of cross-type multicore industrial cluster.

industry cluster), but for some reason, there are some enterprises carry out independent innovation, so if this part of the enterprise to obtain the larger income, there will be more enterprises to study the enterprise to carry out the independent innovation strategy. However, if the enterprise of independent innovation fails to achieve success or even leads to losses, other enterprises will learn from experience and give up independent innovation.

4.1.2. Basic Model Analysis. Under normal circumstances, the market demand for products will increase with the increase of cooperative promotion investment between manufacturers and suppliers, and the cost per unit product will decrease with the increase of R&D investment. Assuming that 1 unit of product needs 1 unit of raw material, we can conclude that the total consumer demand function and the cost function of unit product are as follows:

$$D(I_r) = D_0 + aI_r,$$
$$C(I_s) = \frac{C_0 - bI_s}{D(I_r)}. \tag{4}$$

among which $D(I_r)$ is the total demand of consumers, I_r is the cooperative promotion investment between manufacturers and dealers, when $I_r \geq 0$, and then D_0 is the market size when no promotion investment is made.

Through the above analysis, we can conclude that the profit function of the system is

$$\pi_0 = D(I_r)(w - C(I_s) - c_m) - I_r - I_s. \tag{5}$$

w is the unit price of the product and c_m is the production cost of the manufacturer excluding raw materials. In the above profit function, taking I_r and I_s as independent variables, the partial derivatives can be obtained according to the profit maximization conditions:

$$I_r = \frac{bD_0 - 1}{ab},$$
$$I_s = \frac{a(w - C_0) - 1}{ab} I_r. \tag{6}$$

The above I_r, I_s, and π_0, respectively, show the promotion cooperation investment, the R&D cooperation investment, and the maximum profit value of the system when there is only one supplier and one dealer.

The analysis is similar for suppliers associated with manufacturers. The game cooperation between raw material suppliers is also based on complete static information, and profit maximization is the prerequisite for cooperative investment of each supplier. The profit of the supplier is corresponding to the cost of the manufacturer. Therefore, in order to gain a larger market share, the supplier must reduce the price through technological research and development to reduce the cost of the manufacturer. Similarly, it is assumed that if a raw material supplier's R&D investment is higher than that of other suppliers, its demand for raw materials will be higher than that of other raw material suppliers, and other suppliers will make additional investment until all suppliers occupy the same market share. The total R&D investment of all raw material suppliers must be equal to

the amount that maximizes the manufacturer's profits. Because if the amount of investment is less than the value, additional investment can also reduce the cost, and if the value is greater than the value, the cost will be higher than the minimum value, resulting in unreasonable resource allocation. Therefore, according to the completely static game analysis, rational suppliers will also choose to evenly distribute raw material supply to maximize profits [23].

4.2. Game Analysis of Cooperative Innovation among Enterprises in Multicore Cluster Supply Chain.

4.2. Game Analysis of Cooperative Innovation among Enterprises in Multicore Cluster Supply Chain. If one dealer spends more on promotion than the other dealers, its market demand will be higher than that of the other dealers, and all dealers are not willing to lag behind and increase their investment until each dealer has an equal market share. And the total investment of all dealers must be equal to the amount that maximizes the manufacturer's profits. If the investment is less than this value, the manufacturer will consider that the product supply is less than the optimal output in order to maximize its own profits, thus causing dealers to lose part of the market share to competitors. If the investment is greater than this value, it will cause waste due to market saturation. Therefore, dealers will choose to evenly distribute market share to avoid a lose-lose situation. Then:

$$I_{Krj} = \frac{I_r^*}{N}. \tag{7}$$

Make w_1 the preferential product supply price offered by the manufacturer to the dealer. The total profit function corresponding to all dealers is

$$\pi_{Kr} = D(I_{Kr}^*)(w - w_1) - s_{Kr}I_{Kr}^*$$
$$= \left(D_{K0} + a_K\left(\sum_{j=1}^{N}I_{Kr}\right)\right)(w - w_1) - s_{K1}\left(\sum_{j=1}^{N}I_{Krj}\right). \tag{8}$$

Taking Krj as an independent variable and taking its derivative and finding the optimal profit solution, it can be concluded that

$$\frac{d\pi_{Kr}}{dI_{Krj}} = a_K(N-1)(w - w_1) - Ns_{K1}I_{Kij}. \tag{9}$$

To maximize profits when

$$s_{K1} = \frac{a_K(N-1)(w-w_1)}{I_{Kij}^*},$$
$$\frac{w - \left(D_{K0} + a_KI_{Kij}^*\right)}{s_{K1}I_{Kij}^*} < w_1 < w. \tag{10}$$

At this point, the sum of the maximum profits of all dealers is

$$\pi_{Kr} = D(I_{Kr}^*)(w - w_1) - s_{Kr}I_{Kr}^*$$
$$= (D_{K0} + a_KI_{Kr}^* - a_K(N\text{-}1)(w\text{-}w_1)). \tag{11}$$

The game cooperation between raw material suppliers is also based on complete static information, and the analysis is similar to the organization mode of single-core cluster supply chain, so the repeated analysis will not be made here. Finally we can conclude that all suppliers have equal market share and the total R&D investment must be equal to the amount that maximizes the manufacturer's profit.

5. Conclusion

The cooperative innovation among enterprises can not only reduce the cost and improve the overall profit of supply chain, but also enhance the core competitiveness of industrial clusters. Therefore, the institutions and enterprises in the cluster should take some measures to promote the cooperative innovation behavior among enterprises. This article puts forward some countermeasures and suggestions from the government level, industry level, and enterprise level to promote the cooperation between enterprises in the supply chain.

5.1. Policy. The cooperative innovation among enterprises in the cluster not only promotes the improvement of the economic benefits of the enterprises that adopt the cooperative innovation strategy. At the same time, because of the existence of spillover effect, some enterprises that do not adopt cooperative innovation strategy will also have a positive promotion effect, which is easy to make some enterprises to adopt speculative strategy to reduce their own costs. If this behavior is not stopped, the overall benefits of the cluster will not be optimized and even affect the cooperation between enterprises in the supply chain. Therefore, the government must put forward reasonable policy suggestions to promote the smooth cooperation between enterprises in the cluster supply chain. The government's regulation of the market economy is mainly manifested in macroeconomic regulation and control as well as market supervision and guidance. Studies on the development of industrial clusters in some successful areas in China in recent years show that the regulation policy of the "invisible hand" of the government plays an important role in the development of industrial clusters and the construction of supply chains within clusters through policy guidance and provision of basic public goods and services. Especially in the initial forming stage of industrial cluster, the guidance of regional policy and the cultivation of regional cooperative innovation culture are very important.

5.2. Cluster Supply Chain Level. Information communication among enterprises in the cluster is not only between upstream and downstream enterprises in the supply chain, but also with government agencies, financial institutions, intermediary institutions, and scientific research and training institutions in the cluster. In this way, enterprises in the supply chain can make timely production adjustments according to the market and government information, realize the maximum

use of resources and cost savings, and bring greater economic benefits to the cluster. Therefore, it is very necessary for the development of the whole cluster to design a reasonable information communication platform and continuously strengthen the information exchange between enterprises and institutions on each node of the cluster.

In the industrial cluster supply chain system, the core enterprises dominate the development of the whole supply chain to a large extent. Core enterprises are located at the key nodes of the supply chain and have absolute advantages over upstream and downstream enterprises and related auxiliary enterprises in production and manufacturing, technological level, economic strength, and market position, which also leads to the development of core enterprises that determines the economic lifeline of the supply chain network. Therefore, giving full play to the leading role of the core enterprises in the cluster supply chain will achieve greater network benefits, which requires the core enterprise in their own development at the same time, also to strengthen the cooperation with businesses around and provide technical guidance and cost compensation to them, with core businesses in order to make sure they are able to improve the innovation ability, exert their own advantages, thereby giving impetus to the development of the whole supply chain, and enhance the core competition of the cluster.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

Acknowledgments

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