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Analysis on the Choice of Manufacturing Enterprises' Logistics Service Innovation Mode Considering its Influencing Factors

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Abstract

With the development of the information age, logistics services have gradually become part of the market competitiveness of manufacturing enterprises. The development of logistics services for manufacturing enterprises requires continuous innovation to adapt to changes in market demand. However, manufacturing enterprises are faced with the choice of innovation mode when carrying out logistics service innovation. Therefore, this article uses the evolutionary game method to construct an evolutionary game model between manufacturing enterprises, and discusses the choice of enterprise logistics service innovation mode. Through research, it is found that manufacturing enterprises with high level of logistics knowledge are more inclined to adopt continuous logistics service innovation; manufacturing companies' emphasis on logistics service innovation models has an obvious effect on their model selection.

Keywords

Logistics Service; Logistics Knowledge Level; Enterprises' Emphasis; Evolutionary Game.

1. Introduction

The competition among manufacturing companies is becoming increasingly fierce, and whether they can provide services that meet customer needs has gradually become one of the keys to corporate competition. Among them, logistics services are an important component of corporate services. In order to improve the competitiveness of enterprises, enterprises gradually attach importance to logistics services. Logistics service is not only a unique and sustainable way for enterprises to improve their value-added capabilities, but also an important strategy for my country to become a manufacturing power. With the development of manufacturing enterprises and changes in social needs, logistics services of manufacturing enterprises are constantly innovating and developing to adapt to the market environment. Through literature summary, the enterprise logistics service innovation model can be summarized into two types: breakthrough logistics service innovation and continuous logistics service innovation[1-3]. The study found that the learning of logistics knowledge and logistics level of manufacturing enterprises has a positive correlation with the innovation of enterprise logistics services[4], and the emphasis of enterprises on service innovation has a positive impact on service development[5]. Therefore, the following will discuss how enterprises choose logistics service innovation models in the game of market environment under the influence of the level of logistics knowledge and the importance of enterprises on logistics service innovation.

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2. Basic Assumptions

For the convenience of research, two companies in the same industry that have a competitive relationship are selected as the main players of the game, namely, enterprise 1 and enterprise 2, both of which occupy a certain degree of market share in the market. Under the premise that both parties are bounded rationality and the ultimate goal of maximizing benefits, the following hypotheses are proposed:

(1) Enterprise 1 and Enterprise 2 have two strategies, namely breakthrough logistics service innovation and continuous logistics service innovation.

(2) When a manufacturing company develops an innovation strategy, it will face two possibilities of success and failure. Suppose that the company chooses the success rate of breakthrough innovation at the same time as λ_1 and the success rate of continuous innovation at λ_2 at the same time. Because breakthrough innovation refers to corporate behavior with major innovation, the risk is greater than continuous innovation, so it is assumed that $\lambda_1 < \lambda_2$. The success of logistics service innovation is different from the success of pure technological innovation. The success of logistics service innovation includes not only technical success, but also the successful application of service objects. Therefore, when one party chooses breakthrough logistics service innovation, the other party chooses continuous logistics in service innovation, companies that choose breakthrough logistics service innovation face much less competition in the market environment and are easier to achieve success. Assuming that the success rate of choosing a breakthrough innovation company at this time is λ_3, the success of choosing a continuous innovation company the rate is λ_4.

(3) The success rate of corporate innovation is affected by the level of corporate logistics knowledge and the importance of corporate innovation. Assume that the logistics knowledge level of enterprise 1 is A_1, and the logistics knowledge level of enterprise 2 is A_2. Assume a is the spillover effect of enterprise logistics knowledge level, that is, the contribution coefficient of enterprise logistics knowledge level to improve its innovation success rate. Therefore, the extent to which the enterprise's logistics knowledge level increases its success in logistics service innovation is aA_i. In the same way, the emphasis on innovation by enterprises, such as service process development, has a significant positive impact on the performance of service innovation strategies, and has a positive effect on the success of enterprise service innovation. Because enterprises pay different attention to different logistics service innovation models when they choose different logistics service innovation models, it is assumed that the enterprises' emphasis on logistics service innovation is $B_i(0 \leq \lambda_i \leq 1)$, where $i = 1,2$, respectively refer to the choice of breakthrough logistics the degree of importance the enterprise attaches to when it comes to service innovation, and the degree to which the enterprise attaches importance when it chooses continuous logistics service innovation. Suppose b is the spillover effect of the enterprise's emphasis, that is, the contribution coefficient of the enterprise's emphasis on increasing its innovation success rate. Therefore, the increase of the enterprise's logistics service innovation emphasis on its logistics service innovation success is bB_i. In order to ensure the universality of research, it is assumed that there is no difference in the spillover effect of different enterprises' logistics knowledge level and the degree of importance of logistics service innovation.

(4) Assuming that the basic income of logistics service of a manufacturing enterprise is W, the development of logistics service innovation will bring additional income to the enterprise. When the enterprise chooses breakthrough logistics service innovation, the increase coefficient of logistics service income is j, and when it chooses continuous logistics service innovation, The increase coefficient of logistics service income is k. Since breakthrough innovation involves the development of new areas for enterprises and has greater potential benefits, it is assumed that $j > k$.

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(5) Suppose that the total cost of a company when it chooses breakthrough logistics service innovation is m, and the total cost when it chooses continuous logistics service innovation is n. Compared with continuous innovation, breakthrough innovation requires more cost. Therefore, suppose $m > n$.

(6) Suppose that when companies 1 and 2 choose the breakthrough logistics service innovation model or the continuous logistics service innovation model at the same time, the market share between the companies remains unchanged. When one company chooses the breakthrough logistics service innovation model, the other company chooses the continuous logistics service When innovating, companies that carry out breakthrough logistics service innovation are more competitive in the market. They will compete for the market share of some continuous logistics service innovation enterprises, and enterprises that carry out continuous logistics service innovation will lose this part of the market share. Assume this value is S.

3. Model Construction and Analysis

3.1. Payment Matrix Construction

Suppose that the probability of enterprise 1 choosing the "breakthrough logistics service innovation" model is x, the probability of choosing the "continuous logistics service innovation" model is $1-x$; the probability that enterprise 2 chooses the "breakthrough logistics service innovation" model is y, choose The probability of "continuous logistics service innovation" model is $1-y, x, y, \in [0,1]$.

Table 1. Payout Matrix of the Game Model of Enterprise 1, Enterprise 2

		Enterprise 2	
		Breakthrough logistics service innovation y	Continuous logistics service innovation $1-y$
Enterprise 1	Breakthrough logistics service innovation x	$(1+aA_1+bB_1)\lambda_1(1+j)W-m$	$(1+aA_1+bB_1)\lambda_3(1+j)W-m+S$
		$(1+aA_2+bB_1)\lambda_1(1+j)W-m$	$(1+aA_2+bB_2)\lambda_4(1+k)W-n-S$
	Continuous logistics service innovation $1-x$	$(1+aA_1+bB_2)\lambda_4(1+k)W-n-S$	$(1+aA_1+bB_2)\lambda_2(1+k)W-n$
		$(1+aA_2+bB_1)\lambda_3(1+j)W-m+S$	$(1+aA_2+bB_2)\lambda_2(1+k)W-n$

3.2. Duplicate the Dynamic Equation Solution

Through the payment matrix, the dynamic equations for the replication of enterprise 1 and enterprise 2 are obtained as:

$$F(x)=\frac{dx}{dt}=x(U_{11}-U_1)=x(1-x)(U_{11}-U_{12})=x(1-x)[\,y(\lambda_1-\lambda_3)(1+aA_1+bB_1)(1+j)W-y(\lambda_4-\lambda_2)(1+aA_1+bB_2)(1+k)W+(1+aA_1+bB_1)\lambda_3(1+j)W-(1+aA_1+bB_2)\lambda_2(1+k)W-m+n+S] \quad (1)$$

$$F(y)=\frac{dy}{dt}=y(U_{21}-U_2)=y(1-y)(U_{21}-U_{22})=y(1-y)[x(\lambda_1-\lambda_3)(1+aA_2+bB_1)(1+j)W-x(\lambda_4-\lambda_2)(1+aA_2+bB_2)(1+k)W+(1+aA_2+bB_1)\lambda_3(1+j)W-(1+aA_2+bB_2)\lambda_2(1+k)W-m+n+S] \quad (2)$$

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3.3. Evolutionary Stability Analysis

Let $F(x) = 0$ and $F(y) = 0$. According to the definition of evolutionary stability strategy, the system has 5 local stable points, namely $E_1 = (0,0), E_2 = (1,0), E_3 = (0,1), E_4 = (1,1)$, $E_5 = (x^*, y^*)$. among them

$$x^* = \frac{(1+aA_2+bB_1)\lambda_3(1+j)W-(1+aA_2+bB_2)\lambda_2(1+k)W-m+n+S}{(\lambda_4-\lambda_2)(1+aA_2+bB_2)(1+k)W-(\lambda_1-\lambda_3)(1+aA_2+bB_1)(1+j)W} \tag{3}$$

$$y^* = \frac{(1+aA_1+bB_1)\lambda_3(1+j)W-(1+aA_1+bB_2)\lambda_2(1+k)W-m+n+S}{(\lambda_4-\lambda_2)(1+aA_1+bB_2)(1+k)W-(\lambda_1-\lambda_3)(1+aA_1+bB_1)(1+j)W} \tag{4}$$

The determinant and trace corresponding to each equilibrium point are shown in Table 2.

Table 2. Determinant and trace of Jacobian matrix

Equilibrium point	$detJ$	trJ
$E_1 = (0,0)$	$[(1+aA_1+bB_1)\lambda_3(1+j)W-(1+aA_1+bB_2)\lambda_2(1+k)W-m+n+S][(1+aA_2+bB_1)\lambda_3(1+j)W-(1+aA_2+bB_2)\lambda_2(1+k)W-m+n+S]$	$[(1+aA+bB_1)\lambda_3(1+j)W-(1+aA+bB)\lambda_2(1+k)W-m+n+S]+[(1+aA_2+bB_1)\lambda_3(1+j)W-(1+aA_2+bB_2)\lambda_2(1+k)W-m+n+S]$
$E_2 = (1,0)$	$-[(1+aA_1+bB_1)\lambda_3(1+j)W-(1+aA_1+bB_2)\lambda_2(1+k)W-m+n+S][\lambda_1(1+aA_2+bB_1)(1+j)W-\lambda_4(1+aA_2+bB_2)(1+k)W-m+n+S]$	$-[(1+aA_1+bB_1)\lambda_3(1+j)W-(1+aA_1+bB_2)\lambda_2(1+k)W-m+n+S]+[\lambda_1(1+aA_2+bB_1)(1+j)W-\lambda_4(1+aA_2+bB_2)(1+k)W-m+n+S]$
$E_3 = (0,1)$	$-[\lambda_1(1+aA_1+bB_1)(1+j)W-\lambda_4(1+aA_1+bB_2)(1+k)W-m+n+S][(1+aA_2+bB_1)\lambda_3(1+j)W-(1+aA_2+bB_2)\lambda_2(1+k)W-m+n+S]$	$[\lambda_1(1+aA_1+bB_1)(1+j)W-\lambda_4(1+aA_1+bB_2)(1+k)W-m+n+S]-[(1+aA_2+bB_1)\lambda_3(1+j)W-(1+aA_2+bB_2)\lambda_2(1+k)W-m+n+S]$
$E_4 = (1,1)$	$[\lambda_1(1+aA_1+bB_1)(1+j)W-\lambda_4(1+aA_1+bB_2)(1+k)W-m+n+S][\lambda_1(1+aA_2+bB_1)(1+j)W-\lambda_4(1+aA_2+bB_2)(1+k)W-m+n+S]$	$-[\lambda_1(1+aA_1+bB_1)(1+j)W-\lambda_4(1+aA_1+bB_2)(1+k)W-m+n+S]-[\lambda_1(1+aA_2+bB_1)(1+j)W-\lambda_4(1+aA_2+bB_2)(1+k)W-m+n+S]$
$E_5 = (x^*, y^*)$	0	0

From Table 2, it can be directly obtained, $E_5 = (x^*, y^*)$ can be directly obtained as the saddle point. For the stability judgments of the remaining four equilibrium points, the following will discuss the stability strategy of the evolutionary game by situation.

Situation 1:

$\lambda_1(1+aA_i+bB_i)(1+j)W-\lambda_4(1+aA_i+bB_i)(1+k)W+S>m-n, (1+aA_i+bB_i)\lambda_3(1+j)W-(1+aA_i+bB_i)\lambda_2(1+k)W+S>m-n.$

In case 1, the stability analysis of the system is shown in Table 3.

Table 3. Stability analysis of equilibrium point under situation 1

equilibrium point	$detJ$	trJ	result
$E_1 = (0,0)$	+	+	unstable point
$E_2 = (1,0)$	-	uncertain	saddle point
$E_3 = (0,1)$	-	uncertain	saddle point
$E_4 = (1,1)$	+	-	ESS

From the analysis results in Table 3, we can see that the stable state of the system at this time is (1,1), and the corresponding strategy is (breakthrough logistics service innovation,

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breakthrough logistics service innovation). In this equilibrium state, both enterprise 1 and enterprise 2 tend to choose breakthrough logistics service innovation. It shows that at this time, the enterprise chooses the breakthrough logistics service innovation to obtain the best income. Breakthrough innovation enhances the competitiveness of the enterprise, improves the profitability of the enterprise, and seizes market share for the enterprise. If the other company chooses breakthrough innovation and chooses continuous innovation by itself, the risk of market share loss faced by the enterprise may be greater than that of the enterprise choose breakthrough The investment required for sexual service. Therefore, in order to ensure the competitive position of enterprises in the market, enterprises will ultimately choose a breakthrough logistics service innovation model.

Situation 2:

$\lambda_1(1+aA_i+bB_i)(1+j)W-\lambda_4(1+aA_i+bB_i)(1+k)W+S>m-n,(1+aA_i+bB_i)\lambda_3(1+j)W-(1+aA_i+bB_i)\lambda_2(1+k)W+S<m-n$.

In case 2, the stability analysis of the system is shown in Table 4.

Table 4. Stability analysis of equilibrium point under situation 2

equilibrium point	$detJ$	trJ	result
$E_1=(0,0)$	+	-	ESS
$E_2=(1,0)$	+	+	unstable point
$E_3=(0,1)$	+	+	unstable point
$E_4=(1,1)$	+	-	ESS

From the analysis results in Table 4, we can see that there are two stable points in the system at this time, namely (0,0), (1,1), and the corresponding strategy is (continuous logistics service innovation, continuous logistics service innovation), (breakthrough Logistics service innovation, breakthrough logistics service innovation). Under this condition, it is optimal for the enterprise to choose the same strategy at the same time for its profit. Because when only one enterprise chooses breakthrough logistics service innovation, its innovation success rate may be relatively low, and may not necessarily occupy a favorable market position, and the risk of enterprise share loss for interviews with continuous logistics service innovation enterprises is relatively high. Therefore, for two competing companies, they are more likely to choose the same strategy. When the company's revenue from breakthrough logistics service innovation is greater than continuous logistics service innovation, companies will choose breakthrough logistics service innovation, otherwise, they will choose continuous logistics service innovation.

Situation 3:

$\lambda_1(1+aA_i+bB_i)(1+j)W-\lambda_4(1+aA_i+bB_i)(1+k)W+S<m-n,(1+aA_i+bB_i)\lambda_3(1+j)W-(1+aA_i+bB_i)\lambda_2(1+k)W+S<m-n.$

In case 3, the stability analysis of the system is shown in Table 5.

Table 5. Stability analysis of equilibrium point under situation 3

equilibrium point	$detJ$	trJ	result
$E_1=(0,0)$	+	-	ESS
$E_2=(1,0)$	-	uncertain	saddle point
$E_3=(0,1)$	-	uncertain	saddle point
$E_4=(1,1)$	+	+	unstable point

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From the analysis results of Table 5, we can see that the stable state of the system at this time is (0,0), and the corresponding strategy is (continuous logistics service innovation, continuous logistics service innovation). Under these conditions, companies have chosen a continuous logistics service innovation model. For enterprises, breakthrough logistics service innovation is a powerful channel for enterprises to enhance market competitiveness and expand market share. However, breakthrough innovation requires enterprises to invest higher costs and has high risks and uncertainties. Therefore, enterprises From the perspective of investment security, in order to ensure the profit of the enterprise, it is more inclined to a more stable and sustainable logistics service innovation model, which is to make the enterprise stable and profitable.

Situation 4:

$\lambda_1 (1 + aA_i + bB_i)(1 + j)W - \lambda_4(1 + aA_i + bB_i)(1 + k)W + S < m - n,$

$(1 + aA_i + bB_i)\ \lambda_3 (1 + j)W - (1 + aA_i + bB_i)\lambda_2 (1 + k)W + S > m - n.$

In case 4, the stability analysis of the system is shown in Table 6.

Table 6. Stability analysis of equilibrium point under situation 4

equilibrium point	$detJ$	trJ	result
$E_1 = (0,0)$	+	+	unstable point
$E_2 = (1,0)$	+	-	ESS
$E_3 = (0,1)$	+	-	ESS
$E_4 = (1,1)$	+	+	unstable point

According to the analysis results in Table 6, there are two stable points in the system at this time, namely (1,0), (0,1), and the corresponding strategies are (breakthrough logistics service innovation, continuous logistics service innovation), (sustainability) Logistics service innovation, breakthrough logistics service innovation). In addition to considering market competitiveness, the choice of logistics service innovation model for enterprises is also related to their own characteristics. Different enterprises have different levels of logistics knowledge and the importance that enterprises attach to logistics innovation. When an enterprise has a richer logistics knowledge compared to its competitors, and the leaders of the enterprise also attach importance to the development of enterprise logistics services, the enterprise will be more inclined Breakthrough logistics service innovation, while another company does not have the advantage in choosing a breakthrough logistics service innovation, and faces greater innovation risks, so it is more inclined to choose a continuous logistics service innovation model.

4. Numerical Simulation Analysis

In this paper, the initial values of the parameters of this model are set as $\lambda_1 = 0.55, \lambda_2 = 0.8, \lambda_3 = 0.65, \lambda_4 = 0.75, A_1 = 0.5, A_2 = 0.3, B_1 = 0.5, B_2 = 0.3,$ a $= 0.5, b = 0.5, W = 30, j = 0.4, k = 0.2, m = 17, n = 15, S = 3.$ Based on the unknown of the future, it is assumed that the initial intentions of enterprise 1 and enterprise 2 are the same, and the initial value is: $x = y = 0.5.$

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4.1. The Influence of Enterprise Logistics Knowledge Level on Enterprise Evolutionary Behavior

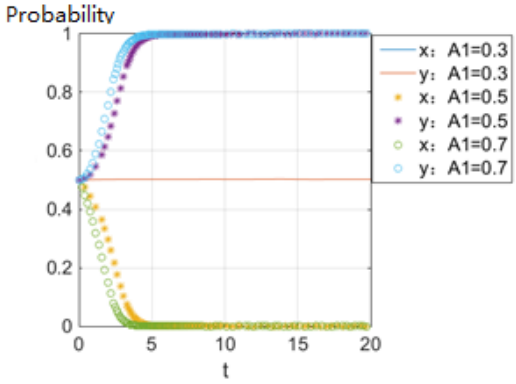

Figure 1. The evolution diagram of changes in the value of enterprise logistics knowledge level

As shown in Figure 1, when the value of the logistics knowledge level of enterprise 1 becomes larger, the evolution trend of enterprise 1 gradually changes from a breakthrough logistics service innovation model to a continuous logistics service innovation. And when the logistics knowledge level of enterprise 1 increases, enterprise 2 accelerates the evolution trend toward a breakthrough logistics service innovation model. It can be seen from the figure that with the increase in the level of enterprise logistics knowledge, enterprises are more inclined to choose continuous logistics service innovation, because continuous logistics service innovation refers to the expansion, improvement, and change of logistics services by manufacturing enterprises. To achieve innovation in logistics services through improvements and changes in form is a means for companies to maintain their competitive advantages and will not enter new market areas. The high level of logistics knowledge has laid a good foundation of innovation knowledge for enterprises' continuous logistics service innovation, which can help enterprises to better carry out continuous logistics service innovation. With the continuous innovation of logistics services carried out by the enterprises on one side, the enterprises with lower levels of logistics knowledge on the other side are more inclined to choose breakthrough logistics service innovations, because under the scenario of weaker logistics knowledge, enterprises can adopt some emerging technologies and new technologies. Service methods, etc. increase their own advantages, thereby enhancing market competitiveness.

4.2. The Impact of the Importance of Enterprise Logistics Service Innovation on the Evolutionary Behavior of Enterprises

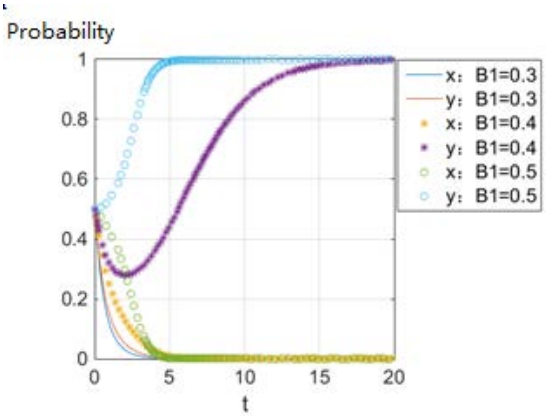

Figure 2. The evolution diagram of the change in the value of the enterprise's emphasis on breakthrough logistics service innovation

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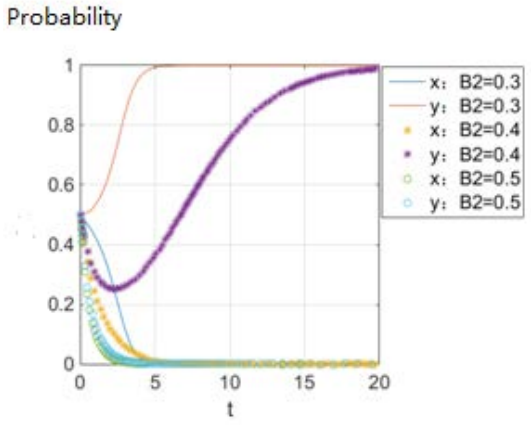

Figure 3. The evolution diagram of the change in the value of the enterprise's emphasis on continuous logistics service innovation

It can be seen from Figure 2 that as companies pay more attention to breakthrough logistics services, company 1 accelerates the slowing down of the evolution to continuous logistics service innovation, and company 2 accelerates the evolution to the breakthrough logistics service innovation model. According to the hypothetical parameters, the logistics knowledge level of enterprise 1 is higher than that of enterprise 2, so enterprise 1 is more inclined to the continuous logistics service innovation model. However, it is found from the figure that the degree of emphasis on breakthrough innovation will affect the choice of enterprises. Whether it is an enterprise with a low level of logistics knowledge or an enterprise with a relatively high level of logistics knowledge, it has an acceleration effect, which has a negative impact on enterprises with a high level of logistics knowledge, and has a positive effect on enterprises with a low level of logistics knowledge. And it can be seen from the figure that when companies pay too little attention to breakthrough logistics services, companies with low levels of logistics knowledge will choose continuous logistics service innovation. Because enterprises with low levels of logistics knowledge need a lot of support from enterprises to carry out breakthrough logistics service innovations, if enterprises pay too much attention to them, it is not conducive for enterprises to carry out such breakthrough projects.

It can be seen from Figure 3 that with the increasing emphasis on sustainable logistics services by enterprises, enterprise 1 accelerates the evolution to sustainable logistics service innovation, while enterprise 2 is affected by the importance of enterprises on sustainable logistics services. Breakthrough logistics service innovation gradually tends to continuous logistics service innovation. This shows that the importance that enterprises attach to continuous logistics service innovation has a positive effect on enterprises with high logistics knowledge. From the evolution process of enterprise 2 as the value of continuous logistics service value changes, it can be found that the value of enterprise logistics service innovation mode has a greater impact on the choice of enterprise logistics service innovation mode.

5. Summary

This chapter uses the evolutionary game research method to study the choice of logistics service innovation mode of manufacturing enterprises, and discusses the influence of manufacturing enterprises' knowledge level of logistics and the degree of enterprise's emphasis on logistics service innovation on the choice of enterprise logistics service innovation mode. First, by copying the dynamic equation, the stability state of the enterprise under different conditions is analyzed separately, and then the MATLAB simulation is used to

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explore the influence of the change of each parameter value on the evolution state of the system.

After discussing the conditions of each situation, it is found that the stability of the system changes with different conditions, but its essence lies in the enterprise's pursuit of optimal returns. When the opposing company chooses a breakthrough logistics service innovation, and the choice of continuous logistics service innovation is faced with excessive market loss risk, the system equilibrium state is (1, 1); the enterprise will choose a breakthrough logistics service innovation model. When breakthrough logistics service innovation requires enterprises to invest in high costs and face greater risks, the system equilibrium state is (0, 0); enterprises prefer to choose continuous logistics service innovation to obtain stable income for enterprises. When a company of one party faces greater risks or losses when choosing different innovation models individually, there are two stable states in the system at this time, namely (0, 0) and (1, 1); in addition to considering market competitiveness and innovation failure The rate will also be affected by its own factors, such as the enterprise's own logistics level and the degree of importance the enterprise attaches to logistics service innovation. Therefore, the system has two equilibrium states (1, 0) and (0, 1).

In this chapter, the influence of various parameters on the choice of innovation mode of manufacturing enterprises is discussed. The following conclusions are obtained through analysis:

(1) Manufacturing companies with high levels of logistics knowledge are more inclined to choose continuous logistics service innovation models. However, if the success rate of continuous logistics service innovation is low, manufacturing companies will switch to a breakthrough logistics service innovation model.

(2) The importance of manufacturing enterprises to the innovation mode of logistics services has a greater impact on enterprises. Regarding the importance of the breakthrough logistics service innovation model, enterprises are promoting breakthrough logistics service innovation for enterprises with low logistics knowledge level. However, if the emphasis is too low, enterprises with low logistics knowledge level will choose continuous logistics services. Innovative model; the importance of enterprises on the continuous logistics service innovation model is promoting continuous logistics service innovation for enterprises with high logistics knowledge level. However, if the emphasis is too low, enterprises with high logistics knowledge level will choose a breakthrough logistics service innovation model.

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