Economic Evolution Game Study on the integration of informatization and intelligentization in manufacturing enterprises

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Abstract: At present, the new generation of information technologies such as blockchain and artificial intelligence ,big data, cloud computing, are endogenous driving forces to promote the intelligent transformation and upgrading of China's manufacturing industry. "Made in China 2025" proposes to take intelligent manufacturing as the main direction of manufacturing development, and the integration of informatization and industrialization is gradually transformed into the integration of informatization and intelligence. In this paper, an evolutionary game model of the integration of manufacturing information unit and intelligent unit is constructed, and the influence and evolution process of the integration of information and intelligence are analyzed from the aspects of the level of intelligent transformation strategy, the maturity of knowledge engineering, the risk of the integration of information and intelligence, information technology resources and capabilities. Results show that the intelligent transformation strategy level, knowledge engineering maturity has a positive impact on informatization and intelligent integration, and intelligence information fusion of risk has a negative influence on informatization and intelligent integration, information technology resources and capabilities as the sum of the benefit of the other three different influence on informatization and intelligent integration, Based on this, some suggestions are put forward to promote the integration process of information and intelligence.

1. INTRODUCTION

Intelligent manufacturing has been the main power point of intelligent manufacturing in developed countries and China [1]. The manufacturing industry is the foundation of a strong country. Especially at present, the new generation of information technology is penetrating into the manufacturing industry at an excessive speed. The deep integration of informatization and industrialization gradually has new opportunities, and the integration of informatization and intelligence has become a new trend. Informatization is to make full use of information technology and information resources, achieve full sharing and interaction of information, and finally achieve the purpose of promoting social transformation [2]. The intelligent transformation of enterprises is mainly manifested by the application of new technologies in the whole process of design, production and sales [3], that is, the integration of informatization and intelligence.

In "Made in China 2025", intelligent manufacturing is the focus of integration of industrialization and information technology and the foundation of the development of manufacturing industry [4-5]. Informatization is the premise and basis of intelligence [6]. Taking informatization as the starting point and combining it with intelligence is the most important new research focus. However, the mechanism of the integration of information and intelligence is still relatively fuzzy, which is the task to be explored and solved now.

2. LITERATURE REVIEW

(1) The relationship between informatization and industrialization. China has pioneered the simultaneous development of informatization and industrialization, with industrialization driving informatization and informatization promoting industrialization [7]. The integration of informatization and industrialization is a complex systematic project, involving the integration of production factors [8], production mode, management mode, industrial system and social and economic operation mode [9]. Domestic and foreign research on the integration of the two from three perspectives, the first is the description and analysis of the integration of the two. Second, the realization mechanism and connotation of the fusion of the two are analyzed. Third, the evaluation index of the integration level of the two is constructed [10]. From the above point of view, there are many literatures on the integration of informatization and industrialization, including current situation and problems of the integration

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[11], level of integration [12], influencing factors and integration path [13], etc.

(2) The relationship between informatization and intelligentization. Some scholars believe that informatization has a direct impact on intellectualization [14]. Another scholar believes that manufacturing enterprise intelligence mainly relies on the development of new technologies or the improvement of existing technologies [10], that is, informatization can only really promote the intelligent transformation through technological innovation [5]. As for the influencing factors of intelligent transformation, digital ability [15], intelligent platform [16], intelligent management system [16], intelligent technology [16-17] and intelligent interaction ability [16] are put forward as the main factors. Therefore, it is necessary to expand the perspective and choose new means to reveal the mechanism of the integration of information and intelligence.

Therefore, this paper will choose evolutionary game as a perspective, select different variable parameters and calculate and analyze each parameter, so as to provide an explanation for the internal mechanism of informatization and intelligent fusion selection. Information technology resources are the material capital, human capital and organizational capital for enterprises to conceive and implement information technology strategies [15], while the application ability of information technology refers to the ability to successfully develop and effectively use information systems by using resources [10], which is called information technology resources and capabilities. The selection of the maturity index of knowledge engineering is aimed at the establishment of the system of knowledge absorption and knowledge transformation ability of enterprises in the integration process of informatization and intelligentization[16]. The integration risk of intelligence and information technology is the integration risk faced by enterprises after entering the market[17]. The strategic level of intelligent transformation refers to the level of understanding of knowledge and strategy related to intelligent transformation in the development process of an enterprise [5], which determines the general direction of enterprise development.

3. INTEGRATED EVOLUTIONARY GAME MODEL OF INFORMATIZATION AND INTELLIGENTIZATION

Evolutionary game theory is a method of dynamic game, and the integration of informatization and intelligence is a general direction of future development. The choice of cooperation between two types of enterprises is a process of dynamic change and stable state at last, which is in line with the relevant requirements of evolutionary game theory.

3.1Model Assumptions

(1) Under the premise of "integration of informatization and intelligence", it is assumed that there are only two kinds of units in the market: information unit and intelligent unit, and there are only two strategies: "cooperation" and "non-cooperation" when playing games with each other;

(2) It is assumed that the thinking prospect of enterprises in the market is limited, and enterprises do not have enough resources and channels to collect all the information resources related to decision-making, so that they make decisions from their own perspective according to the limited information, that is, enterprises with information units and enterprises with intelligent units have bounded rationality;

3.2Description of Model symbols

The initial income of the information unit and intelligent manufacturing unit of the two sides of the game is r_1 and r_2 respectively, and the assets are f_1 and f_2 respectively. Due to the different types of enterprises, the risks of integration, the maturity of knowledge engineering, the strategic level of intelligent transformation of the two kinds of enterprises, and the information technology resources and capabilities are different. Therefore, it is assumed that the information technology coefficients of the information unit and the intelligent manufacturing unit are I_1 and I_2, the risk coefficients are m_1 and m_2, the knowledge engineering maturity coefficients are t_1 and t_2, and the strategic levels of the intelligent transformation of the two types of enterprises are η_1 and η_2, as shown in Table 1.

Table 1 Description of model symbols

	Information unit	Intelligent unit
benefits	r_1	r_2
assets	f_1	f_2
Information technology coefficient	I_1	I_2
Intelligence and information integration risk	m_1	m_2
Knowledge engineering maturity	t_1	t_2

Strategic level of intelligent transformation	η_1	η_2

3.3Construction of evolutionary game model of integration of the two processes

We analyze the corresponding actual income according to the specific situation.

(1) When both the information unit and the intelligent unit choose not to cooperate, they maintain their original benefits, namely r_1 and r_2;

(2) When the information unit chooses not to cooperate, and the intelligent unit chooses to cooperate, the intelligent manufacturing unit will face the technical risks and market risks of the integration of informatization and intelligence due to the non-cooperation of the information unit. This is because the intelligent unit that chooses cooperation will be published due to its strategy, market strategy and technical preference of the integration of informatization and intelligence. When there is a certain risk loss, the size of the risk loss is proportional to the enterprise assets of the intelligent unit. Because the other party chooses not to cooperate, the information unit also fails to enjoy and absorb the information technology resources and information technology capabilities of the other party, and the size of the loss caused by information technology is proportional to the assets of the intelligent unit. Therefore, the income of information unit and intelligent unit is r_1 and r_2-m_2f_2-I_2f_1 respectively.

(3) When the information unit chooses cooperation while the intelligent unit chooses non-cooperation, the result is the same as above. Therefore, the income of information unit and intelligent unit is r_1-m_1f_1-I_1f_2 and r_2 respectively.

(4) When the information unit chooses cooperation, the intelligent unit also chooses cooperation. In this case, the cooperation between the two parties will promote the corresponding harvest of both parties. When the coefficient of information technology is larger, the spillover benefit of information technology is proportional to the other party's assets. When the maturity coefficient of knowledge engineering is larger, the spillover benefit of knowledge engineering maturity is proportional to the assets of the other side of the game. When two enterprises cooperate, they can make positive and effective use of each other's enterprise resources and gain benefits, so the benefits of intelligent transformation strategy are proportional to the assets of the other side. In addition, since both sides choose to cooperate, we believe that both sides will reduce the risk of integration in the integration process of informatization and intelligence. At this time, the income obtained by the information unit and the intelligent unit is $r_1+I_1f_2+t_1f_2+\eta_1f_2$ and $r_2+I_2f_1+t_2f_1+\eta_2f_1$ respectively.

According to the above, the income matrix is obtained (as shown in Table 2).

Table 2 Game income matrix of both sides

		Intelligent unit	
		cooperation	non-cooperation
Information unit	cooperation	$(r_1+I_1f_2+t_1f_2+\eta_1f_2,\ r_2+I_2f_1+t_2f_1+\eta_2f_1)$	$(r_1-m_1f_1-I_1f_2,\ r_2)$
	non-cooperation	$(r_1,\ r_2-m_2f_2-I_2f_1)$	(r_1,r_2)

Suppose that in the initial stage of the game between the intelligent unit and the information unit, the proportion of the information unit choosing cooperative strategy is x, then the proportion of the information unit choosing non-cooperative strategy is 1-x, and the proportion of the intelligent unit choosing cooperative strategy is y, then the proportion of the intelligent unit choosing non-cooperative strategy is 1-y, then

The benefits of the information unit in selecting the cooperation strategy are: $E_{1a}=y(r_1+I_1f_2+t_1f_2+\eta_1f_2)+(1-y)(r_1-m_1f_1-I_1f_2)$

The benefits of the information unit when choosing the non-cooperation strategy is: $E_{1b}=yr_1+(1-y)r_1$

Then, the expected income of the strategy selected by the information unit is: $\overline{E}_1=xE_{1a}+(1-x)E_{1b}$

$=x[y(r_1+I_1f_2+t_1f_2+\eta_1f_2)+(1-y)(r_1-m_1f_1-I_1f_2)]+(1-x)[yr_1+(1-y)r_1]$

The benefits of intelligent unit when choosing cooperation strategy are: $E_{2a}=x(r_2+I_2f_1+t_2f_1+\eta_2f_1)+(1-x)(r_2-m_2f_2-I_2f_1)$

The benefits of intelligent manufacturing unit when choosing non-cooperation strategy are as follows: $E_{2b}=xr_2+(1-x)r_2$

Then, the expected income of the strategy chosen by the intelligent unit is: $\overline{E}_2=yE_{2a}+(1-y)E_{2b}$

$=y[x(r_2+I_2f_1+t_2f_1+\eta_2f_1)+(1-x)(r_2-m_2f_2-I_2f_1)]+(1-y)[xr_2+(1-x)r_2]$

$=xy(2I_2f_1+t_2f_1+\eta_2f_1+m_2f_2)-y(m_2f_2+I_2f_1)+r_2$

According to the above formula, the replication dynamic equations of two types of enterprises are constructed:

$$F_1(x)=\frac{\partial x}{\partial t}=x(E_{1a}-E_1)$$
$$=x[y(r_1+I_1f_2+t_1f_2+\eta_1f_2)+(1-y)(r_1-m_1f_1-I_1f_2)-xy(2I_1f_2+t_1f_2+\eta_1f_2+m_1f_1)+x(m_1f_1+I_1f_2)-r_1]=x(1-y)[y(2I_1f_2+t_1f_2+\eta_1f_2+m_1f_1)-m_1f_1-I_1f_2]$$

$$F_2(y)=\frac{\partial y}{\partial t}=y(E_{2a}-E_2)$$
$$=y[x(r_2+I_2f_1+t_2f_1+\eta_2f_1)+(1-x)(r_2-m_2f_2-I_2f_1)-xy(2I_2f_1+t_2f_1+\eta_2f_1+m_2f_2)+y(m_2f_2+I_2f_1)-r_2]=y(1-y)[x(2I_2f_1+t_2f_1+\eta_2f_1+m_2f_2)-m_2f_2-I_2f_1]$$

For the convenience of the following analysis, let $x_*=\frac{m_2f_2+I_2f_1}{2I_2f_1+t_2f_1+\eta_2f_1+m_2f_2}, y_*=\frac{m_1f_1+I_1f_2}{2I_1f_2+t_1f_2+\eta_1f_2+m_1f_1}$，obviously $0<x_*<1, 0<y_*<1$。

4. ANALYSIS OF EVOLUTIONARY GAME MODEL INTEGRATING INFORMATIZATION AND INTELLIGENTIZATION

4.1 Stability analysis of equilibrium points

According to the theory of differential equations, let $\frac{\partial x}{\partial t}=0$，$\frac{\partial y}{\partial t}=0$，The stable point can be obtained, being (0,0)，(0,1)，(1,0)，(1,1)，$(x_*，y_*)$。The Jacobian matrix is

$$J=\begin{bmatrix}(1-2x)[y(2I_1f_2+t_1f_2+\eta_1f_2+m_1f_1)-m_1f_1-I_1f_2] & x(1-x)(2I_1f_2+t_1f_2+\eta_1f_2+m_1f_1)\\ y(1-y)(2I_2f_1+t_2f_1+\eta_2f_1+m_2f_2) & (1-2y)[x(2I_2f_1+t_2f_1+\eta_2f_1+m_2f_2)-m_2f_2-I_2f_1]\end{bmatrix}$$

According to the local stability analysis method of the Jacobian matrix, the stability analysis of the above equilibrium points is performed, and the results are shown in Table 3:

Table 3 Local stability analysis results

Equilibrium point	The determinant of J	Det J symbol	Value of Tra J	Tra J symbol	result
(0,0)	$(m_1f_1+I_1f_2)\cdot(m_2f_2+I_2f_1)$	+	$-(m_1f_1+I_1f_2)-(m_2f_2+I_2f_1)$	-	ESS
(0,1)	$(t_1f_2+\eta_1f_2+I_1f_2)\cdot(m_2f_2+I_2f_1)$	+	$t_1f_2+\eta_1f_2+I_1f_2+m_2f_2+I_2f_1$	+	unsound
(1,0)	$(t_2f_1+\eta_2f_1+I_2f_1)\cdot(m_1f_1+I_1f_2)$	+	$t_2f_1+\eta_2f_1+I_2f_1+m_1f_1+I_1f_2$	+	unsound
(1,1)	$(t_1f_2+\eta_1f_2+I_1f_2)(t_2f_1+\eta_2f_1+I_2f_1)$	+	$-(t_1f_2+\eta_1f_2+I_1f_2)-(t_2f_1+\eta_2f_1+I_2f_1)$	-	ESS
(x_*,y_*)	$-x_*(1-x_*)(t_1f_2+\eta_1f_2+m_1f_1+2I_1f_2)y_*(1-y_*)(t_2f_1+\eta_2f_1+m_2f_2+2I_2f_1)$	-	0	0	Saddle point

When (Det J)>0, (Tra J)<0, the equilibrium points (0, 0) and (1,1) are stable; When (Det J)>0, (Tra J)>0, the equilibrium points (0, 1) and (1,0) are unstable; When (Det J)>0, (Tra J)=0,the equilibrium point (x_*,y_*) is the saddle point.

The dynamic phase diagram of group replication is shown in Figure 1. The whole system is composed of two parts. The line formed by A, D and C in the figure is the critical line of dynamic evolution for the integration of informatization and intelligence in the enterprise. The evolution of informatization and intelligent integration between manufacturing enterprises will eventually converge to O (0,0), that is, the information unit and intelligent unit will choose not to cooperate, and the informatization and intelligent integration will fail. However, when the initial state of the system is located in the upper right region I (BADCB) of the phase diagram, the evolution of fusion between manufacturing enterprises will eventually converge to B (1,1), that is, all objects in the system choose cooperation strategy, and the fusion of the two becomes successful. O (0,0) and B (1,1) are both stable points, that is, there is no cooperation between one firm and the other firm chooses not to cooperate. The choice of the firm can only be between (cooperation, cooperation) and (non-cooperation, non-cooperation).

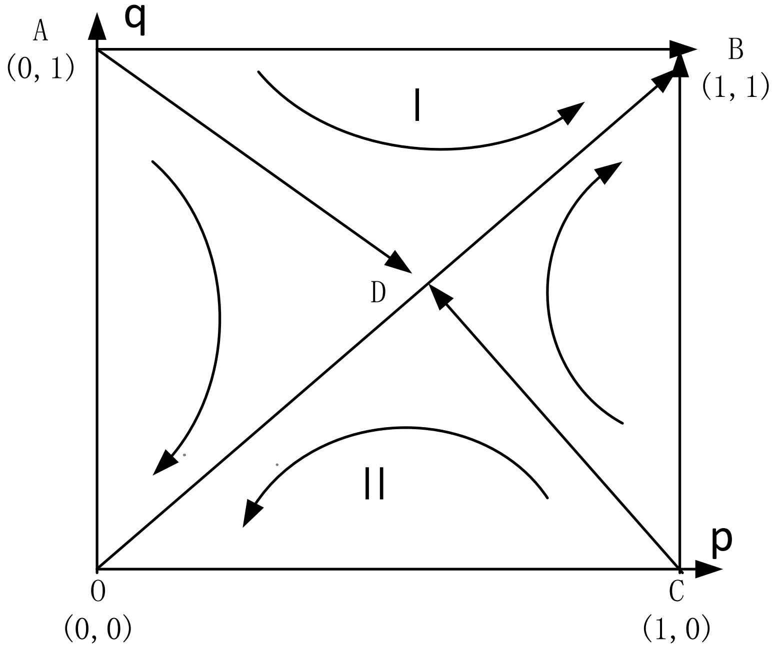

Figure 1 Dynamic phase diagram of game group replication

4.2 Impact of parameter changes on system status

As can be seen from the above, the equilibrium state of the system is (no cooperation, no cooperation) or (cooperation, cooperation), but the initial state determines the final orientation of the system, and the size of each variable parameter determines the initial state of the system. When $S_I > S_{II}$,the probability of successful fusion is higher. When $S_I < S_{II}$, the probability of fusion failure is higher. When $S_I = S_{II}$, the two possibilities are equal. Since S_I is determined by the size of each variable, each parameter will be analyzed to discover its influence on the mutual integration of information unit and intelligence unit.

According to the position coordinates of saddle point (x_*, y_*), it is easy to obtain:

$$S_I = \frac{1}{2}\left(1-\frac{m_2f_2+I_2f_1}{2I_2f_1+t_2f_1+\eta_2f_1+m_2f_2}\right)\cdot 1+\frac{1}{2}\left(1-\frac{m_1f_1+I_1f_2}{2I_1f_2+t_1f_2+\eta_1f_2+m_1f_1}\right)\cdot 1$$
$$=\frac{1}{2}\left(\frac{t_2f_1+\eta_2f_1+I_2f_1}{2I_2f_1+t_2f_1+\eta_2f_1+m_2f_2}+\frac{t_1f_2+\eta_1f_2+I_1f_2}{2I_1f_2+t_1f_2+\eta_1f_2+m_1f_1}\right)$$

As can be seen from the above equation, there are 8 parameters affecting the size of S_I, and propositions can be obtained through analysis.

Proposition 1: The larger the information unit knowledge engineering maturity coefficient t_1 is, the larger the intelligent unit knowledge engineering maturity coefficient t_2 is, the greater the probability of informationization and intelligentization integration is; conversely, the smaller the information unit knowledge engineering maturity coefficient t_1 is, the smaller the intelligent unit enterprise knowledge engineering maturity coefficient t_2 is, the smaller the probability of informationization and intelligentization integration is.

Proof: partial derivative of S_I with respect to t_1, $\frac{\partial S_I}{\partial t_1} = \frac{1}{2}\left(\frac{t_2f_1+\eta_2f_1+I_2f_1}{2I_2f_1+t_2f_1+\eta_2f_1+m_2f_2}+\frac{t_1f_2+\eta_1f_2+I_1f_2}{2I_1f_2+t_1f_2+\eta_1f_2+m_1f_1}\right)|\partial t_1 = \frac{1}{2}\frac{f_2m_1f_1+I_1f_2f_2}{(t_1f_2+\eta_1f_2+m_1f_1+2I_1f_2)^2}$

The partial derivative of S_I with respect to t_2, $\frac{\partial S_I}{\partial t_2} = \frac{1}{2}\left(\frac{t_2f_1+\eta_2f_1+I_2f_1}{2I_2f_1+t_2f_1+\eta_2f_1+m_2f_2}+\frac{t_1f_2+\eta_1f_2+I_1f_2}{2I_1f_2+t_1f_2+\eta_1f_2+m_1f_1}\right)|\partial t_2 = \frac{1}{2}\frac{f_1m_2f_2+I_2f_1f_1}{(t_2f_1+\eta_2f_1+m_2f_2+2I_2f_1)^2}$

By type available $\frac{\partial S_I}{\partial t_i} = \frac{m_if_if_j+i_if_jf_j}{2(t_if_j+\eta_if_j+m_if_i+2I_if_j)^2} > 0$, where $\begin{Bmatrix} i=1, j=2 \\ i=2, j=1 \end{Bmatrix}$, SI is the monotonically increasing function of t_1 and t_2 in the interval (0,1). When the maturity coefficient of knowledge engineering increases, the saddle point will shift to the lower left, and the possibility of the system state shifting to the direction of (cooperation, cooperation) will increase. Because $t_i \in (0,1)$, the existence of $(x_x, y_y) \in \left(\frac{m_if_i}{f_j+\eta_if_j+m_if_i}, \frac{m_if_i}{\eta_if_j+m_if_i}\right)$, including $\begin{Bmatrix} i=1, j=2 \\ i=2, j=1 \end{Bmatrix}$, With the change of the maturity of knowledge engineering, this deviation towards (cooperation, cooperation) direction can be stopped. The enhancement of the maturity of knowledge engineering can promote the integration of informatization and intelligence, but the influence degree is limited, as shown in the figure 2. When the limit value is reached, the probability of the integration of the two will no longer increase.

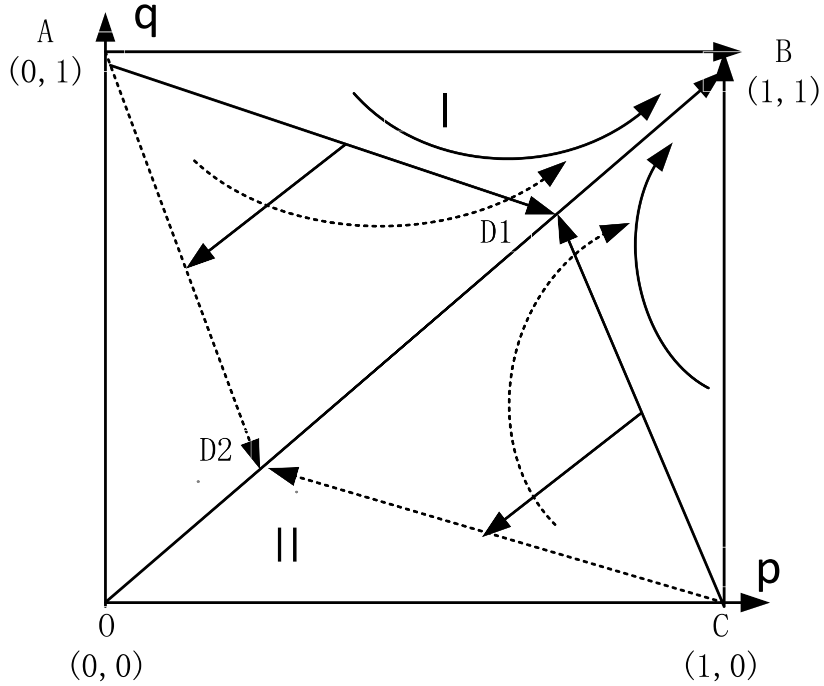

Figure 2 Replication dynamic phase diagram of knowledge engineering maturity change

Proposition 2: The greater the strategic level η_1 of the intelligent transformation of the information unit, the greater the strategic level η_2 of the intelligent transformation of the intelligent unit, the greater the probability of the integration of informatization and intelligence. Conversely, the smaller the strategic level η_1 of the intelligent transformation of the information unit, the smaller the strategic level η_2 of the intelligent transformation of the intelligent unit, the smaller the probability of the integration of informatization and intelligence.

Proof: partial derivative of S_I with η_1, $\frac{\partial S_I}{\partial \eta_1} = \frac{1}{2}\left(\frac{t_2 f_1+\eta_2 f_1+I_2 f_1}{2I_2 f_1+t_2 f_1+\eta_2 f_1+m_2 f_2}+\frac{t_1 f_2+\eta_1 f_2+I_1 f_2}{2I_1 f_2+t_1 f_2+\eta_1 f_2+m_1 f_1}\right)|_{\partial\eta_1} = \frac{1}{2}\frac{f_1 m_1 f_2+I_1 f_2 f_2}{(t_1 f_2+\eta_1 f_2+m_1 f_1+2I_1 f_2)^2}$

Partial derivative of S_I with respect to η_2, $\frac{\partial S_I}{\partial \eta_2} = \frac{1}{2}\left(\frac{t_2 f_1+\eta_2 f_1+I_2 f_1}{2I_2 f_1+t_2 f_1+\eta_2 f_1+m_2 f_2}+\frac{t_1 f_2+\eta_1 f_2+I_1 f_2}{2I_1 f_2+t_1 f_2+\eta_1 f_2+m_1 f_1}\right)|_{\partial\eta_2} = \frac{1}{2}\frac{f_1 m_2 f_2+I_2 f_1 f_1}{(t_2 f_1+\eta_2 f_1+m_2 f_2+2I_2 f_1)^2}$

By type available $\frac{\partial S_I}{\partial \eta_i} = \frac{m_i f_i f_j+I_i f_j f_j}{2(t_i f_j+\eta_i f_j+m_i f_i)^2} > 0$, where $\begin{cases} i=1, j=2 \\ i=2, j=1 \end{cases}$, S_I is the monotonically increasing function of η_1 and η_2 in the interval (0,1). When the intelligent transformation strategy level of the two types of enterprises is improved, the saddle point will shift to the lower left. The larger the S_I area in the phase diagram, the more likely the two types of enterprises will move towards the integration direction of informatization and intelligence. Because $\eta \in (0, 1)$, $x_x \in \left(\frac{m_2 f_2+I_2 f_1}{t_2 f_1+f_1+m_2 f_2+2I_2 f_1}, \frac{m_2 f_2+I_2 f_1}{t_2 f_1+m_2 f_2+2I_2 f_1}\right)$, $y_y \in \left(\frac{m_1 f_1+I_1 f_2}{t_1 f_2+f_2+m_1 f_1+2I_1 f_2}, \frac{m_1 f_1+I_1 f_2}{t_1 f_2+m_1 f_1+2I_1 f_2}\right)$, With the improvement of intelligent transformation strategy of the two kinds of enterprises, the saddle point has a limit value $\left(\frac{m_1 f_1}{t_1 f_2+f_2+m_1 f_1}, \frac{m_2 f_2}{t_2 f_1+f_1+m_2 f_2}\right)$, and the area of S_I reaches the maximum, which indicates that, Although the strategic level of enterprise intelligent transformation plays a positive role in promoting the integration of informatization and intelligence, this role is limited, as shown in the figure 3.

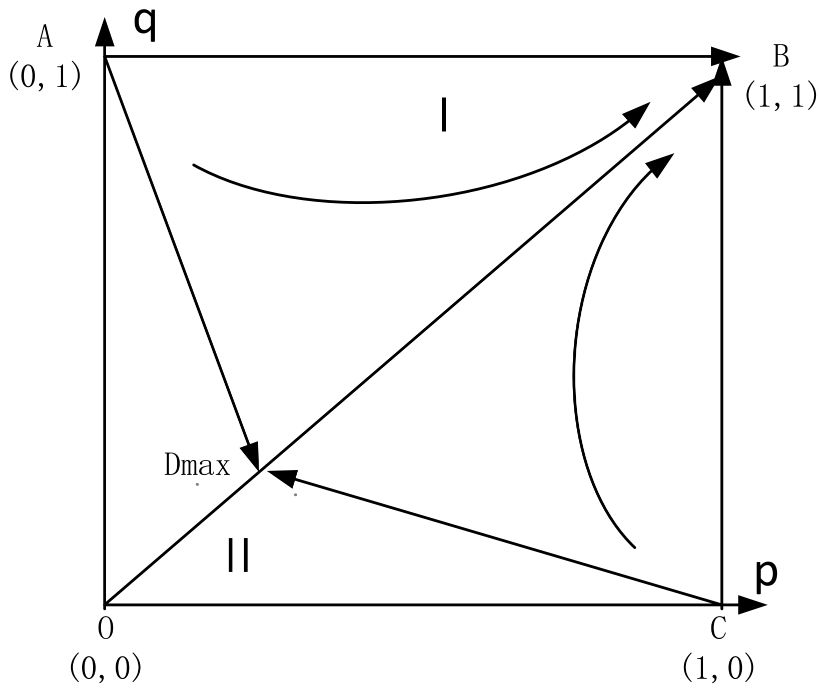

Figure3 Replication dynamic phase diagram of the maximum level of enterprise intelligent transformation awareness

Proposition 3: The greater the risk coefficient m_1 of information unit integration, the greater the risk coefficient m_2 of intelligent unit integration, the smaller the probability of informationization and intelligent integration; conversely, the smaller the risk coefficient m_1 of information unit integration, the smaller the risk coefficient m_2 of intelligent unit integration, the greater the probability of informationization and intelligent integration.

Proof: partial derivative of S_I with respect to m_1, $\frac{\partial S_I}{\partial m_1} = \frac{1}{2}\left(\frac{t_2f_1+\eta_2f_1+I_2f_1}{2I_2f_1+t_2f_1+\eta_2f_1+m_2f_2} + \frac{t_1f_2+\eta_1f_2+I_1f_2}{2I_1f_2+t_1f_2+\eta_1f_2+m_1f_1}\right)|_{\partial m_1} = \frac{1}{2}\frac{-f_1(t_1f_2+\eta_1f_2+I_1f_2)}{(t_1f_2+\eta_1f_2+m_1f_1+2I_1f_2)^2}$

The partial derivative of S_I with respect to m_2, $\frac{\partial S_I}{\partial m_1} = \frac{1}{2}\left(\frac{t_2f_1+\eta_2f_1+I_2f_1}{2I_2f_1+t_2f_1+\eta_2f_1+m_2f_2} + \frac{t_1f_2+\eta_1f_2+I_1f_2}{2I_1f_2+t_1f_2+\eta_1f_2+m_1f_1}\right)|_{\partial m_2} = \frac{1}{2}\frac{-f_2(t_2f_1+\eta_2f_1+I_2f_1)}{(t_2f_1+\eta_2f_1+m_2f_2+2I_2f_1)^2}$

By type available $\frac{\partial S_I}{\partial m_i} = \frac{-f_i(t_if_j+\eta_if_j+I_if_j)}{2(t_if_j+\eta_if_j+m_if_i+2I_if_j)^2} < 0$, where $\begin{Bmatrix} i=1, j=2 \\ i=2, j=1 \end{Bmatrix}$, it can be obtained from the above equation that S_I is the monotone decreasing function of m_i in the interval (0, 1). Due to $m_i \in (0,1)$, $x_x \in \left(\frac{I_2f_1}{t_2f_1+\eta_2f_1+2I_2f_1}, \frac{I_2f_1+f_2}{t_2f_1+\eta_2f_1+2I_2f_1+f_2}\right)$, $y_y \in \left(\frac{I_1f_2}{t_1f_2+\eta_1f_2+2i_1f_2}, \frac{f_1+I_1f_2}{t_1f_2+\eta_1f_2+2I_1f_2+f_1}\right)$, with the increase of m_i, Limit value of $\left(\frac{I_2f_1+f_2}{t_2f_1+\eta_2f_1+2I_2f_1+f_2}, \frac{f_1+I_1f_2}{t_1f_2+\eta_1f_2+2I_1f_2+f_1}\right)$, when the saddle point more to the upper right deviation, The smaller the area of SI in the replication phase diagram, it means that the two types of enterprises, information enterprises and manufacturing enterprises, are less likely to shift to the direction of integration of informatization and intelligence, but there is still the possibility of integration of informatization and intelligence, as shown in the figure 4.

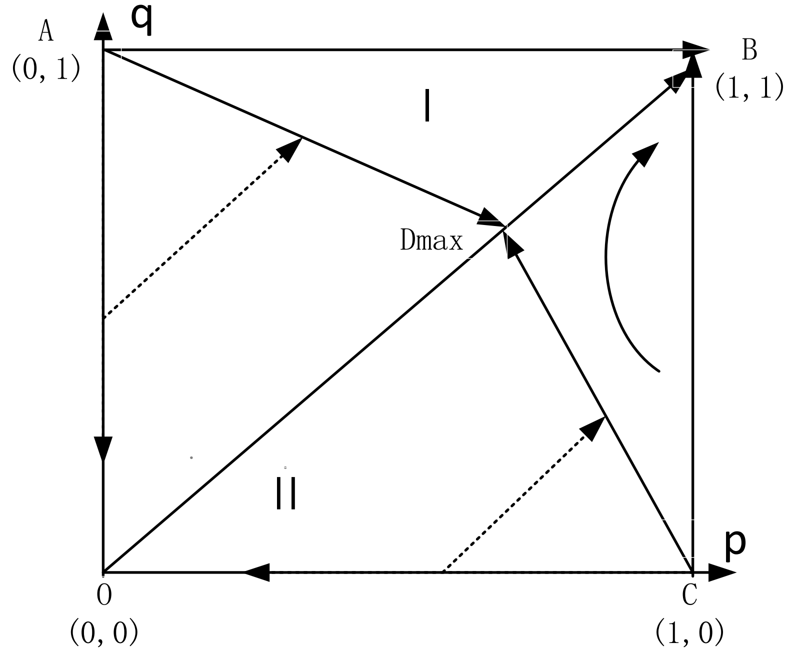

Figure 4 Replication dynamic phase diagram of integration risk changes of informatization and intelligence

Proposition 4: The greater the information technology coefficient i_1 of the information unit, the greater the information technology coefficient i_2 of the intelligent manufacturing unit, the greater the probability of the integration of informatization and intelligence; conversely, the smaller the information technology coefficient i_1 of the information unit, the smaller the information technology coefficient i_2 of the intelligent manufacturing unit, the smaller the probability of the integration of informatization and intelligence.

Proof: partial derivative of S_I with respect to i_1, $\frac{\partial S_I}{\partial i_1} = \frac{1}{2}\left(\frac{t_2 f_1+\eta_2 f_1+I_2 f_1}{2I_2 f_1+t_2 f_1+\eta_2 f_1+m_2 f_2}+\frac{t_1 f_2+\eta_1 f_2+I_1 f_2}{2I_1 f_2+t_1 f_2+\eta_1 f_2+m_1 f_1}\right)|_{\partial i_1} = \frac{1}{2}\frac{f_2(m_1 f_1-t_1 f_2-\eta_1 f_2)}{(t_1 f_2+\eta_1 f_2+m_1 f_1+2I_1 f_2)^2}$

The partial derivative of S_I with respect to i_2, $\frac{\partial S_I}{\partial i_1} = \frac{1}{2}\left(\frac{t_2 f_1+\eta_2 f_1+I_2 f_1}{2I_2 f_1+t_2 f_1+\eta_2 f_1+m_2 f_2}+\frac{t_1 f_2+\eta_1 f_2+I_1 f_2}{2I_1 f_2+t_1 f_2+\eta_1 f_2+m_1 f_1}\right)|_{\partial i_2} = \frac{1}{2}\frac{f_1(m_2 f_2-t_2 f_1-\eta_2 f_1)}{(t_2 f_1+\eta_2 f_1+m_2 f_2+2I_2 f_1)^2}$,

It can be obtained from the above equation $\frac{\partial S_I}{\partial i_i} = \frac{1}{2}\frac{f_i(m_i f_i-t_i f_j-\eta_i f_j)}{(t_i f_j+\eta_i f_j+m_i f_i+2I_i f_j)^2}$,

When $m_i f_i > t_i f_j + \eta_i f_j$, $\frac{\partial S_I}{\partial i_i} > 0$ 0, that is, when the loss benefit brought by the enterprise's own risks is greater than the sum of benefits brought by the knowledge engineering maturity and intelligent transformation strategy level in the integration of informatization and intelligence, S_I is the monotone increasing function of Ii in the interval (0,1). Because Ii∈（0, 1）,（x_*, y_*）has a limit value. That is, when the informatization technology of the two types of enterprises is improved, the saddle point will shift to the lower left. The larger the S_I area in the phase diagram, the more likely the two types of enterprises are to convert to the integration direction of informatization and intelligence.

When $m_i f_i = t_i f_j + \eta_i f_j$, $\frac{\partial S_I}{\partial i_i} = 0$, that is, when the loss benefit brought by the enterprise's own risks is equal to the sum of the benefits brought by the knowledge engineering maturity and intelligent transformation strategy level in the integration of informatization and intelligence, The probability of the two types of enterprises choosing to integrate informatization and intelligence is equal to the probability of not integrating informatization and intelligence.

When $m_i f_i < t_i f_j + \eta_i f_j$, $\frac{\partial S_I}{\partial i_i} < 0$, that is when the loss benefit brought by the enterprise's own risks is less than the sum of benefits brought by the knowledge engineering maturity and intelligent transformation strategy level in the integration of informatization and intelligence, S_I is the monotone decreasing function of I_i in the interval (0,1). Because I_i∈（0, 1）,（x_*, y_*）has a limit value. That is, when the informatization technology of the two types of enterprises is improved, the saddle point will shift to the upper right. The smaller the S_I area in the phase diagram is, the less likely the two types of enterprises are to convert to the integration direction of informatization and intelligence.

Through the analysis of the above three situations, it can be seen that the impact of enterprise information technology resources and capabilities on the integration of informatization and intelligence is related to the benefits brought by the maturity of enterprise knowledge engineering and the strategic level of intelligent transformation as well as the losses brought by the integration risk of intelligence and information. Only when the maturity of knowledge engineering, the strategic level of intelligent transformation and the integration risk of intelligence and information meet certain conditions, the enterprise information technology resources and capabilities can effectively promote the integration of information and intelligence.

5. CONCLUSION

This paper studies the internal mechanism of information unit and intelligent enterprise in the process of integration. The results show that the higher the maturity of knowledge engineering, the higher the strategic level of enterprise informatization and intelligent integration, the more likely the enterprise is to shift to the direction of informatization and intelligent integration, which is conducive to promoting the process of informatization and intelligent integration. The greater the risk coefficient of informationization and intelligentization integration, the enterprise is not easy to deviate from the direction of informationization and intelligentization integration. And it is only when the two kinds of enterprises change together that the system is strongly affected. In addition, it is worth noting that the information technology resources and capabilities have a great impact on the integration, but the degree and direction of their impact are subject to other factors such as the maturity of knowledge engineering. Only when these factors meet certain conditions, can they have a positive effect on the integration of informatization and intelligence.

In view of this, we propose the following policy suggestions to promote the integration of information technology and intelligence in the manufacturing industry. First, encourage absorption and re-innovation, build enterprise knowledge engineering system, and advocate learning organization. In terms of technology, technology utilization and technology innovation should be combined to build knowledge base and make the enterprise become a learning organization. Second, upgrade the strategic level and promote the integration of information technology and intelligence. Accelerate the formation of enterprise intelligent strategy cognition, to ensure that employees at all levels of enterprises completely as far as possible to maintain the same attitude towards the integration of information and intelligent. Third, we need to reduce integration risks and ensure steady progress in the integration of information technology and intelligence. On the one hand, we will improve the construction of intelligent infrastructure. On the other hand, do a good job of intelligent transformation policy guarantee. Fourthly, manufacturing enterprises should not only focus on one informatization or intelligence, but should pay full attention to the role of knowledge engineering maturity, intelligent transformation strategy and integration risk of informatization and intelligence in promoting the integration of informatization and intelligence.

Only from the perspective of evolutionary game, this paper builds a model for the integration of informatization and intelligence in manufacturing enterprises. In addition to the maturity of knowledge engineering, the strategic level of intelligent transformation, information technology resources and capabilities, and the integration risk of informatization and intelligence, there are other important factors that will have a unique impact on the integration of the two, such as policy changes. The introduction of the third party in the process of the integration of the two will be a new direction of future research.

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