



A study on cross-border e-commerce partner selection in B2B mode

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Abstract

The emergence of cross-border e-commerce has brought new opportunities to traditional enterprises. This paper discusses the partner selection of cross-border e-commerce companies in the B2B mode. It constructs a theoretical model of partner selection of cross-border e-commerce enterprises based on literature review. Through the mathematical analysis of an asymmetric evolutionary game model, it is considered that the model has an evolutionarily stable strategy. Based on it, a multi-agent model is constructed. The results of the simulation reveal the mediation role of trust between corporate reputation and enterprise cooperation. Simultaneously, it verified the moderation effect of information sharing between the trust and cooperation of cross-border e-commerce companies. It also provides explanations for the inconsistency in the relationship between trust and cooperative behavior. From both mathematical and data perspectives, this paper attempts to test the theoretical model proposed, which enriches the methodology to test the theory.

Keywords Cross-border e-commerce enterprises · Cooperation · Partner selection · Evolutionary game · Multi-agent simulation

1 Introduction

Cross-border e-commerce refers to an international trade activity in which two individuals or enterprises in different countries make transactions and deliver goods through cross-border logistics [1]. The emergence and development of

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cross-border e-commerce have promoted the development of international trade, which greatly increases the volume of international trade and enables better development of a country's economy. At the same time, it produces a knowledge spillover effect and obtains more benefits [2, 3]. Although cross-border e-commerce is currently booming, it still faces problems such as uneven development of cross-border platforms, incomplete logistics, and lack of consumer trust [4, 5]. Many enterprises are unable to cope with these problems based on their own resources and service capabilities, so they will choose partners to expand the international market when developing cross-border business. How to quickly and accurately select a suitable partner is often key to the success of transactions.

There is a consensus in the theoretical and industrial circles that enterprises are linked to each other due to business transactions. Moreover, enterprises try to develop and maintain competitive advantages in the market through cooperation [6, 7]. Generally speaking, enterprises should cooperate mainly based on their own interests. If both sides believe that cooperation will bring more benefits or values, they will tend to cooperate [8]. Compared with general enterprises, cross-border e-commerce enterprises have different customs, geographical locations, cultural characteristics, and economic and trade environment. Each cross-border e-commerce enterprise is a particular individual with differences. In this context, the issues these enterprises consider will be more complicated. Cross-border e-commerce partnership is a kind of partnership between e-commerce enterprises. E-commerce enterprises with such a relationship will share information and risks and make profits together within a certain period of time [9]. This kind of partnership is formed between enterprises with specific goals and interests in cross-border e-commerce. Two different enterprises work together to seek resources conducive to their development and strive for survival through common goals.

With the development of economy, more and more enterprises are aware of the importance of reputation and begin to pay attention to it. Corporate reputation sometimes may affect cooperation among enterprises. A good reputation of an enterprise is beneficial to the realization of cooperation. For example, Fama [10] posited that reputation was an implicit incentive mechanism which could motivate actors to abandon short-term interests and maintain long-term cooperative relationships; Fombrun and Riel [11] held that "good reputation" and "improvement of the relationship between enterprises and stakeholders" mutually reinforced each other; Ngowi [12] proposed the indicators for cooperative partner selection such as reputation. And many scholars agree with this view. Some scholars believed that the reputation of cooperative partners was positively correlated with cooperation performance. At the same time, scholars Chang et al. [13] believed that reputation is an effective mechanism to promote trust and cooperation between partners, and is an important factor in partner selection. However, cross-border e-commerce trade is still in its initial stage of development. In many cases, when e-commerce enterprises choose its partners, because it is the first time to cooperate and often has no direct contact experience, studies have shown that the level of reputation of enterprises and the good behaviors such as keeping the faith and taking social responsibility in cooperation are strongly positively correlated [14, 15]. Therefore, when a

cross-border e-commerce enterprise choosing the desired partner, it often makes a decision based on the reputation of the candidate enterprise.

Inter-firm trust is key to successful cooperation [16]. Some scholars believed that the establishment of organizational trust could reduce the opportunistic tendency of enterprises to a certain extent, helped them learn from each other, and made use of complementary resources and sensitive information. Open communication can improve cooperation performance and stimulate cooperation willingness [17–20]. The mutual trust among partners can also help to form stable inter-organizational relationships. The cooperation and coordination of partners, as well as the maintenance of the network, can ensure the results of alliance cooperation. Thereby, it improves the willingness of enterprises to participate in cooperation and reduces the barriers and transactional costs in cooperation [21, 22]. Vangen and Huxham [23] emphasized the importance of trust in the process of continuous cultivation of cooperative relationships. Other scholars have confirmed that trust between enterprises had a positive impact on cooperation from the empirical point of view [24]. Therefore, trust is a very important indicator in the selection of cross-border e-commerce partners.

Information exchange and sharing are necessary means for enterprises to cooperate [25]. At present, the world is in the era of an information economy, enterprises may find that they have more channels to choose partners but obviously enterprises can't evaluate every partner on the Internet [26]. Especially in the transnational context, the information sharing of candidate partners can help enterprises to better evaluate various factors and make better judgments. Thus, a corresponding evaluation mechanism should be established [27]. At the same time, the degree of information sharing will affect the communication between enterprises and thus affect the cooperation between the two sides. For example, GM and its suppliers shortened their vehicle development cycle from 4 years to 18 months by sharing a large amount of information about operations, logistics, strategic plans and so on during their cooperation [28]. Chiesa [29] built an information-sharing cooperation model and pointed out that this cooperation model would improve the R&D capabilities of enterprises and benefit the enterprises. Usually, when two sides realize benefits through initial information sharing and establish a certain degree of the trust relationship, they may further share information [30] and promote a higher degree of trust and better cooperation as well [31]. From this, we can see that, especially for cross-border e-commerce enterprises, due to the different social environments of both sides, the asymmetry of information between cross-border e-commerce enterprises will lead to communication blockage. Therefore, this paper takes information sharing as an important factor and takes it into consideration when choosing cross-border e-commerce partners.

Cross-border e-commerce cooperation has its particularity compared with traditional domestic enterprise cooperation. In addition to the difficulties faced by general domestic traditional enterprises, cross-border e-commerce cooperation is more complex. Under the transnational background, the degree of information asymmetry of cross-border e-commerce cooperation is more obvious than that of traditional enterprise cooperation; most enterprises rely on the reputation of the other side to make a preliminary judgment. They establish a preliminary trust so as to conduct

in-depth information exchange and build a reasonable cost and benefit-sharing mechanism for both sides to achieve equilibrium and stability. By comprehensively analyzing the similarities and differences of cross-border e-commerce in B2B mode and ordinary enterprises, apart from the profit and cost factors, this paper selects three most important factors affecting cross-border e-commerce partner selection, which are trust, reputation and information sharing.

2 Previous research

In the existing studies, Herzi et al. [32] have studied the logical framework of reputation and trust. They proposed that the definition of trust was similar to that of reputation. As an implicit mechanism to ensure the implementation of contracts, corporate reputation often plays the role of transmission of trustworthy information. Such a role can promote the partners' respect and trust towards the enterprises and therefore effectively stimulate the extra-role altruistic behaviors [33]. So, a good corporate reputation can promote the formation of trust between enterprises. Castro et al. [34] divided corporate reputation into a social reputation and business reputation. When an enterprise has a good reputation for social responsibility, it shows that the enterprise has a high degree of social assessment. It may prompt the other party to choose to build a trustworthy relationship with it [35]. When an enterprise has a commercial reputation such as a good reputation for business innovation, the other party will believe that the enterprise has strong innovation ability and can provide highly cost-effective and customized products or services. As a result, the other party will develop the perception of trust in it [36]; when an enterprise has a good reputation for fair trade in the industry, it shows that the enterprise is concerned about the interests of the other party and will not undermine the relationship. Thereby, such a reputation can increase the trust of the two enterprises [35]. In a word, when the candidate cooperative enterprise has a certain reputation, the enterprise will transform the reputation value into a certain trust value, that is, reputation has a positive impact on trust.

Reputation has a positive impact on promoting cooperation [37]. A good reputation of an enterprise is beneficial to the realization of cooperation. Reputation can not only urge actors to maintain long-term cooperative relationships [10], but also improve the relationship between enterprises and stakeholders [38]. Researchers have confirmed that in the market, enterprises maintain their competitiveness in the market by constantly building a reputation to improve cooperation performance [39]. The existing studies showed how reputation promoted cooperation [40, 41] and proved that reputation worked best particularly when enterprises were in initial cooperation. In the context of cross-border e-commerce, enterprises in different countries lack communication and interaction. In initial cooperation, reputation plays a significant positive role in promoting cooperation.

In the past decade, the relationship between trust and cooperation has become the focus of research. As transnational cooperation is vulnerable to political fluctuations and diplomatic crises, the social capital involved in transnational transactions is more dependent on cooperation between trusted partners. Effective cross-border

cooperation and “trust” between actors are closely related [42]. At the same time, trust has a positive effect on the efficiency of cooperation [43]. Since trust refers to the positive recognition of the relevant attributes of partners, in the presence of uncertainty and risk, this positive recognition helps to mitigate such uncertainty and risk and thereby promote cooperation [44]. Other researchers have confirmed that in some small and medium-sized enterprises, social factors such as trust, common values, and communication commitment are the key factors to promote cooperation [45]. In a word, we can conclude that trust has a positive impact on promoting cooperation.

Information sharing is crucial to cooperation between enterprises. In the globalized market, the high level of information sharing is conducive for enterprises to have cooperation willingness [46]. With the increase of the application of e-commerce in enterprises, information exchange between business partners in the supply chain becomes more and more important. The higher the information sharing of manufacturing enterprises is, the closer the relationship between trust and cooperation is [47]. In a cross-border context, enterprises constantly update their cognition towards other enterprises through information integration and learning to reduce cultural differences and cooperation barriers caused by distance factors [46]. The degree of information sharing has increased, and the more alternating the exchanges between enterprises, the more conducive to the trust between partners. After the partners have realized the benefits of initial information sharing and established a certain degree of the trust relationship, they can further share information [48]. Therefore, information sharing can moderate the relationship between trust and cooperation.

The selection of cross-border e-commerce partners is a complicated problem. Based on the reference to literature on the determinants of cooperative partner selection, this paper selects 3 factors that influence the selection of cross-border partners: the trust of a cooperative partner, the reputation of cooperative partner and the information sharing. Based on it, combining the discussion above, we introduce a moderated mediating conceptual model. Please see Fig. 1.

The selection of cross-border e-commerce partners may be more complicated and difficult because of the differences in culture, values, management mode, knowledge spillover, geographical location and policy background among enterprises. In this paper, an evolutionary game method is applied to study the selection of cross-border

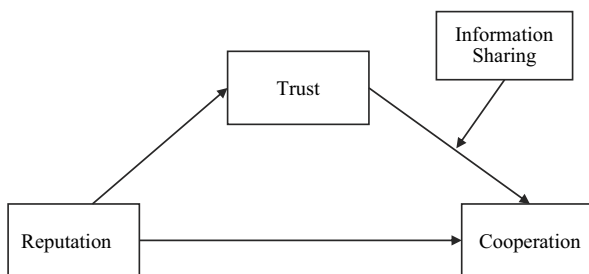


Fig. 1 Conceptual model of cross-border e-commerce cooperation

e-commerce partners from the perspective of trust, reputation and information sharing. Firstly, based on the literature review, we build a conceptual model of cross-border e-commerce partner selection. Based on it, we build a payoff matrix and calculate the equilibrium points of the evolutionary game. Then, we simulate and model the selection of cross-border e-commerce partners by analyzing the influence of trust, reputation and information sharing.

The structure of this paper is as follows: Sect. 1 introduces the article research background and analyses the factors affecting the selection of cross-border e-commerce partners. Section 2 reviews previous research and establishes a conceptual model of cross-border e-commerce cooperation; Sect. 3 establishes an asymmetric evolutionary game for the selection of cross-border e-commerce partners; Sect. 4 builds a multi-agent model to simulate the selection of cross-border e-commerce partners; Sect. 5 is intervention analysis of the cooperative behaviors; Sect. 6 finds new findings and implications for future research and practice; Sect. 7 summarizes the whole paper.

3 Construction of the evolutionary game model of cross-border partner selection

3.1 Assumptions and symbols

Cross-border e-commerce cooperation is a business setting. The selection of its partners must be based on profit. When choosing partners to cooperate, enterprises will take into account the reputation, trust and information sharing of partners. Because of the differences between cross-border e-commerce enterprises, conflicts and resistances will inevitably occur between the two sides in the process of cooperation, resulting in a sense of distrust and affecting cooperation. It may even lead to a breach of a cooperative relationship. Based on the existing literature and the conceptual framework in Fig. 1, the author proposed 3 factors affecting the selection of cross-border e-commerce partners and they are enterprise reputation, trust and information sharing. Combining other factors such as benefits, cooperative cost, and risky cost, we propose the following assumptions [49].

The modeling of this paper satisfies the following hypotheses:

H1 Suppose there are cross-border e-commerce enterprises conducting strategy gaming in partner selection. In the cross-border e-commerce environment, there are two categories of enterprises, the domestic enterprises A and the foreign enterprises B. $A = \{a_1, a_2, \dots, a_n\}$ $B = \{b_1, b_2, \dots, b_n\}$, where a_i , $b_i (i = 1, 2, \dots, n)$ denotes respectively the individual member of domestic enterprises A and foreign enterprises B. The strategy selection set of each side is {cooperation, noncooperation}.

H2 The degree of the reputation of e-commerce enterprises is $r_i (0 \leq r_i \leq 1)$, the degree of trust of e-commerce enterprises is $t_i (0 \leq t_i \leq 1)$. Generally, the reputation of e-commerce enterprises is different. The degree of the reputation of domestic enterprises A is r_1 . The degree of the reputation of foreign enterprises B is r_2 . The

profit margins brought by the cooperation based on the reputation of each other are respectively $t_2r_2\pi_1, t_1r_1\pi_2$, where $0 \leq t_i \leq 1, 0 \leq r_i \leq 1, 0 \leq \pi_i \leq 1$. Due to the difference of each e-commerce enterprise's reputation, the cost coefficients from the examination of the other party while selecting cooperative strategies are respectively $(1 - r_2)c_1, (1 - r_1)c_2$. c denotes the cost rate of surveys and communication with other companies involved before cooperating. f denotes the rate of failure loss. When both parties adopt the cooperative strategies, the rates of failure loss are respectively f_1 and f_2 , where $0 \leq c_1 \leq 1, 0 \leq c_2 \leq 1, 0 \leq f_1 \leq 1, 0 \leq f_2 \leq 1$.

H3 The degree of information sharing of e-commerce enterprises is s_i . In most cases, the degree of information sharing of e-commerce enterprises are different. The degree of information sharing of domestic enterprises A is s_1 while the degree of information sharing of foreign enterprises B is s_2 . The profit margins brought by the cooperation of information sharing of both sides respectively are $s_1\pi_2, s_2\pi_1$, where $0 \leq s_1 \leq 1, 0 \leq s_2 \leq 1$.

H4 According to the previous analysis, the moderation of information sharing of e-commerce enterprises on the degree of trust will affect cooperation. Considering the information sharing of the other party, the profits brought by cooperation while both sides trust each other are respectively $s_2t_2\pi_1, s_1t_1\pi_2$.

H5 Suppose that when only the foreign enterprises adopt a non-cooperative strategy, the cost coefficient of domestic enterprises' inspection of the partners is $(1 - r_2)c_1$. Suppose that when only the domestic enterprises adopt a non-cooperative strategy, the cost coefficient of foreign enterprises' inspection of the partners is $(1 - r_1)c_2$.

We can get the payoff matrix of the cooperation game of cross-border e-commerce enterprises in the B2B mode (Table 1).

3.2 Construction and solution of the evolutionary game model

According to the payoff matrix of the evolutionary game of e-commerce enterprises, we can get the expected payoff of domestic enterprise A adopting "cooperative strategy" and it is

Table 1 The payoff matrix of selection game of cross-border e-commerce partners in B2B mode

Domestic enterprises 1	Foreign enterprise 2	
	Cooperation y	Non-cooperation 1 - y
Cooperation x	$t_2r_2\pi_1 + s_2t_2\pi_1 + s_2\pi_1 - (1 - r_2)c_1 - f_1$	$-(1 - r_2)c_1$
	$t_1r_1\pi_2 + s_1t_1\pi_2 + s_1\pi_2 - (1 - r_1)c_2 - f_2$	0
Non-cooperation 1 - x	0	0
	$-(1 - r_1)c_2$	0

$$E_{11} = y[t_2r_2\pi_1 + s_2t_2\pi_1 + s_2\pi_1 - (1 - r_2)c_1 - f_1] - (1 - y)c_1(1 - r_2) \quad (1)$$

The expected payoff of domestic enterprise A adopting “noncooperative strategy” is

$$E_{12} = y * 0 + (1 - y) * 0 = 0 \quad (2)$$

The average payoff of enterprise A is

$$E_1 = xE_{11} + (1 - x)E_{12} = xE_{11} \quad (3)$$

The replicator dynamics equation of domestic enterprise A adopting cooperative strategy is

$$\begin{aligned} F(x) &= dx/dt = x(E_{11} - E_1) = x(1 - x)E_{11} \\ &= x(1 - x)[y(t_2r_2\pi_1 + s_2t_2\pi_1 + s_2\pi_1 - f_1) - c_1(1 - r_2)] \end{aligned} \quad (4)$$

The expected payoff of foreign enterprise B adopting “cooperative strategy” is

$$E_{21} = x[t_1r_1\pi_2 + s_1t_1\pi_2 + s_1\pi_2 - (1 - r_1)c_2 - f_2] - (1 - x)c_2(1 - r_1) \quad (5)$$

The expected payoff of foreign enterprise B adopting “noncooperative strategy” is

$$E_{22} = x * 0 + (1 - x) * 0 = 0 \quad (6)$$

The average payoff of enterprise B is

$$E_2 = yE_{21} + (1 - y)E_{22} = yE_{21} \quad (7)$$

The replicator dynamics equation of domestic enterprise B adopting “cooperative strategy” is

$$\begin{aligned} F(y) &= dy/dt = y(E_{21} - E_2) = (1 - y)E_{21} \\ &= y(1 - y)[x(t_1r_1\pi_2 + s_1t_1\pi_2 + s_1\pi_2 - f_2) - (1 - r_1)c_2] \end{aligned} \quad (8)$$

Make $F(x) = dx/dt$, $F(y) = dy/dt$ and get derivative with respect to x and y

$$F_1(x) = (1 - 2x)[y(t_2r_2\pi_1 + s_2t_2\pi_1 + s_2\pi_1 - f_1) - c_1(1 - r_2)] \quad (9)$$

$$F_2(x) = x(1 - x)(t_2r_2\pi_1 + s_2t_2\pi_1 + s_2\pi_1 - f_1) \quad (10)$$

$$F_1(y) = y(1 - y)(t_1r_1\pi_2 + s_1t_1\pi_2 + s_1\pi_2 - f_2) \quad (11)$$

$$F_2(y) = (1 - 2y)[x(t_1r_1\pi_2 + s_1t_1\pi_2 + s_1\pi_2 - f_2) - c_2(1 - r_1)] \quad (12)$$

In the above replicator dynamics equation, make $F(x) = 0, F(x) = 0$ and we can get 5 dynamic equilibrium point and they are $(0, 1), (0, 0), (1, 0), (1, 1)$ $\left(\frac{c_2(1-r_1)}{t_1r_1\pi_2+s_1t_1\pi_2+s_1\pi_2-f_2}, \frac{c_1(1-r_2)}{t_2r_2\pi_1+s_2t_2\pi_1+s_2\pi_1-f_1} \right)$.

Based on the method proposed by Friedman [50], the stability of the equilibrium points can be analyzed by the local stability of the Jacobian matrix. The Jacobian matrix of the system is:

$$J = \begin{pmatrix} (1-2x)[y(t_2r_2\pi_1 + s_2t_2\pi_1 + s_2\pi_1 - f_1) - c_1(1-r_2)] & x(1-x)(t_2r_2\pi_1 + s_2t_2\pi_1 + s_2\pi_1 - f_1) \\ y(1-y)(t_1r_1\pi_2 + s_1t_1\pi_2 + s_1\pi_2 - f_2) & [x(t_1r_1\pi_2 + s_1t_1\pi_2 + s_1\pi_2 - f_2) - c_2(1-r_1)] \end{pmatrix} \tag{13}$$

The determinant of the matrix is:

$$\begin{aligned} det &= (1-2x)(1-2y)[y(\pi_1t_2s_2 + \pi_1t_2r_2 + s_2\pi_1 - f_1) - c_1(1-r_2)] \\ &\quad [x(\pi_2t_1s_1 + t_1\pi_2s_1 + s_1\pi_2 - f_2) - c_2(1-r_1)] \\ &\quad - xy(1-x)(1-y)(\pi_1t_2s_2 + \pi_1t_2r_2 + s_2\pi_1 - f_1)(t_1\pi_2r_1 + t_1\pi_2s_1 + s_1\pi_2 - f_2) \end{aligned} \tag{14}$$

The trace of the matrix is

$$\begin{aligned} tr &= (1-2x)[y(\pi_1t_2s_2 + \pi_1t_2r_2 + s_2\pi_1 - f_1) - c_1(1-r_2)] \\ &\quad + (1-2y)[x(\pi_2t_1s_1 + t_1\pi_2s_1 + s_1\pi_2 - f_2) - c_2(1-r_1)] \end{aligned} \tag{15}$$

Discussion 1 Equilibrium point $E_1 = (0, 0)$. When $x = 0, y = 0$, $\begin{cases} det = c_1c_2(1-r_1)(1-r_2) \\ tr = -c_1(1-r_2) - c_2(1-r_1) \end{cases}$

And because $c_1 \geq 0, c_2 \geq 0, 1-r_1 \geq 0, 1-r_2 \geq 0, det > 0, tr < 0$. Thus, $E_1 = (0, 0)$ is the stable strategy of the evolutionary game.

Discussion 2 Equilibrium point $E_2 = (0, 1)$. When $x = 0, y = 1$, $\begin{cases} det = c_2(1-r_1)[(\pi_1t_2s_2 + \pi_1t_2r_2 + s_2\pi_1 - f_1) - c_1(1-r_2)] \\ tr = [(\pi_1t_2s_2 + \pi_1t_2r_2 + s_2\pi_1 - f_1) - c_1(1-r_2)] + c_2(1-r_1) \end{cases}$ To make $det > 0, tr < 0$, we should make $\pi_1t_2s_2 + \pi_1t_2r_2 + s_2\pi_1 - f_1 > c_1(1-r_2)$ and $\pi_1t_2s_2 + \pi_1t_2r_2 + s_2\pi_1 - c_1(1-r_2) < 0$. But the two inequalities contradict each other. So $E_2 = (0, 1)$ is not a stable strategy of the evolutionary game.

Discussion 3 Equilibrium point $E_3 = (1, 0)$. When $x = 1, y = 0$, $\begin{cases} det = c_1(1-r_2)[\pi_2t_1s_1 + \pi_2t_1s_1 + s_1\pi_2 - f_2 - c_2(1-r_1)] \\ tr = c_1(1-r_2) + \pi_2t_1s_1 + t_1s_1\pi_2 + s_1\pi_2 - f_2 - c_2(1-r_1) \end{cases}$ To make $det > 0, tr < 0$, we should make $\pi_2t_1s_1 + \pi_2t_1s_1 + s_1\pi_2 - f_2 > c_2(1-r_1)$ and $(\pi_2t_1s_1 + \pi_2t_1s_1 + s_1\pi_2 - f_2) - c_2(1-r_1) < 0$. However, the two inequalities contradict each other. So $E_3 = (1, 0)$ is not a stable strategy of the evolutionary game.

Discussion 4 Equilibrium point $E_4 = (1, 1)$. When $x = 1, y = 1$,

$$\begin{cases} \det = [(\pi_1 t_2 s_2 + \pi_1 t_2 r_2 + s_2 \pi_1 - f_1) - c_1(1 - r_2)][(\pi_2 t_1 s_1 + t_1 \pi_2 s_1 + s_1 \pi_2 - f_2) - c_2(1 - r_1)] \\ tr = c_1(1 - r_2) - (\pi_1 t_2 s_2 + \pi_1 t_2 r_2 + s_2 \pi_1 - f_1) - (\pi_2 t_1 s_1 + t_1 \pi_2 s_1 + s_1 \pi_2 - f_2) + c_2(1 - r_1) \end{cases}$$

To make $\det > 0, tr < 0$, then we should make $\pi_1 t_2 s_2 + \pi_1 t_2 r_2 + s_2 \pi_1 - f_1 > c_1(1 - r_2)$ and $(1 - r_2)\pi_2 t_1 s_1 + t_1 \pi_2 s_1 + s_1 \pi_2 - f_2 > c_2(1 - r_1)$. That is, when $\pi_1 > \frac{c_1(1-r_2)+f_1}{t_2(r_2+s_2)+s_2}$ and $\pi_2 > \frac{c_2(1-r_1)+f_2}{t_1(r_1+s_1)+s_1}$, $E_4 = (1, 1)$ is a stable strategy of the evolutionary game.

Discussion 5 Equilibrium point $E_5 = \left(\frac{c_2(1-r_1)}{(\pi_2 t_1(r_1+s_1)+s_1 \pi_2 - f_2)}, \frac{c_1(1-r_2)}{(\pi_1 t_2(r_2+s_2)+s_2 \pi_1 - f_1)} \right)$.

When $x = \frac{c_2(1-r_1)}{(\pi_2 t_1(r_1+s_1)+s_1 \pi_2 - f_2)}$ and $y = \frac{c_1(1-r_2)}{(\pi_1 t_2(r_2+s_2)+s_2 \pi_1 - f_1)}, tr = 0$.

So we cannot make a judgement about the stable strategy of the evolutionary game based on the local stability of the Jacobian matrix. Based on the above calculation, $(0, 0)$ and $(1, 1)$ are ESS. And the other points are not ESS.

4 Simulation analysis of the cooperative behaviors of cross-border e-commerce enterprises based on multi-agent modelling

4.1 Model description

According to the analysis of the above section, this paper simulates the dynamic evolution of the cooperative behaviors of the cross-border e-commerce enterprises based on multi-agent modeling. We use Agent to describe the domestic and foreign e-commerce enterprises which will cooperate. And we use the constraint sets to describe the cooperation conditions. The parameters of the basic model are defined as

1. A is a set of domestic e-commerce enterprises. $A = \{A_1, A_2, \dots, A_i\}$, where i denotes the number of domestic e-commerce enterprises.
2. B is a set of foreign e-commerce enterprises. $B = \{B_1, B_2, \dots, B_j\}$, where j denotes the number of foreign e-commerce enterprises.
3. F is a set of the cooperation condition for domestic and foreign enterprises. From the above analysis, we can know $F = (x, y, \pi, c, f)$, where x, y respectively denotes the possibility of domestic and foreign enterprises to choose to cooperate. π denotes the profit margin of e-commerce enterprises, c denotes the cost rate and f denotes the failure loss rate.

4.2 Rule description

1. Initial rules.

We suppose there are 30 domestic and foreign enterprises in the world. In the initial state, the domestic enterprise has x possibility to cooperate and the $1-x$ possibility to refuse to cooperate. The foreign enterprise has y possibility to choose to cooperate and the $1-y$ possibility to refuse to cooperate. It is emphasized in the simulation that there was only cooperation of cross-border e-commerce enterprises and we didn't consider the cooperation of domestic e-commerce enterprises.

2. Rules of cooperative selection.

For other factors influencing the selection of cross-border e-commerce enterprises as cost rate, risky cost rate, risky rate, and profit margin, we control them at certain values. The reputation value r , trust value t , and information sharing value s are all randomly distributed between 0 and 1. By controlling the initial values of r , t , and s . we discuss the partner selection of cross-border e-commerce enterprises at different values of r , t , s . The r value is between 0 and 1, where 0 denotes there is no reputation while 1 denotes the highest value of reputation. The values of t and s are similar to r .

3. Rules of e-commerce enterprises to choose cooperation.

There are four strategy combinations (C, C), (C, D), (D, C), (D, D), where C denotes cooperation and D denotes not to cooperate. The rules for each e-commerce enterprise to make a decision is when $U_1(C) > U_1(D)$, $U_2(C) > U_2(D)$, then we choose the strategy combination (C, C) and build a cooperation chain. If the condition is not satisfied, then both sides will not cooperate and not establish the cooperation chain.

4.3 Model simulation

This paper uses NetLogo as a simulation tool. Netlogo is a programmable modeling environment used to simulate natural and social phenomena. And it is one of the

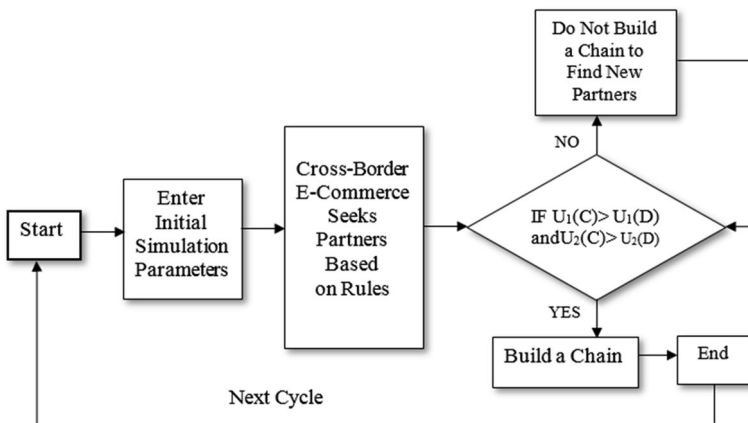


Fig. 2 The overall logic of simulation

most widely used simulation tools at present. The version used in this paper is Net-Logo 6.0.3.

Figure 2 shows the overall logic of the simulation. This paper assumes that the domestic and foreign political contextual factors are moderate and there are no other force majeure factors. Through the analysis of “2018 China Cross-border E-Commerce Market Data Monitoring Report” [51], the questionnaires of more than 900 cross-border e-commerce sellers show that more than one-third of respondents (39%) have a pre-tax profit margin of between 11 and 25, 35% have a profit margin of 10% or less, and the remaining 26% have a higher profit margin. So we set the average $\pi=0.33$ and $f=0.15$ for enterprises. For other parameters, we set up a questionnaire and asked 200 cross-border e-commerce partners for their willingness to cooperate. Using this value as the initial parameter setting, under the assumption that x, y, π, c, f are all greater than 0 and smaller than 1, the average value of each parameter is as follows $F=(0.6, 0.4, 0.33, 0.12, 0.15)$. For the other three factors considered in this paper, the values of $r, t,$ and s are respectively controlled within a certain range. For instance, if the r value is 0.6, it denotes that the reputation values of all cross-border e-commerce enterprises are randomly distributed between 0 and 0.6. The purpose is to better control the impact of parameters, and at the same time to be consistent with the real world. Firstly, we set the values of $r, t,$ and s is 1 respectively. The simulation results are shown in Fig. 3. The red line is the proportion of the number of cross-border e-commerce enterprises choosing to cooperate while the blue line is the proportion of the number of cross-border e-commerce enterprises choosing not to cooperate.

From the simulation results of Fig. 3, we can see that when the values of $r, t,$ and s are respectively equal to 1, the final equilibrium is that the proportion of cross-border e-commerce enterprises to choose C is approaching to 1, which is highly bigger than the proportion to choose D. And the simulation results are consistent with

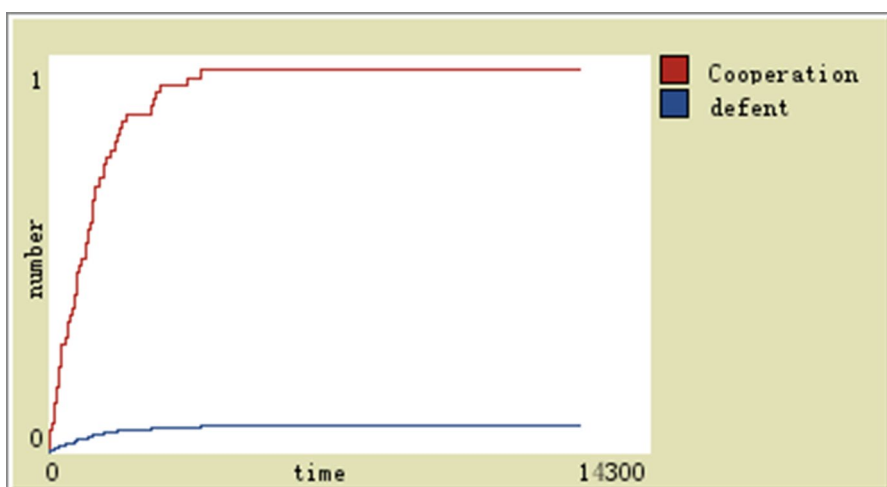


Fig. 3 Evolutionary simulation of cross-border e-commerce enterprises

the mathematical deduction of the evolutionary game. It is mainly because there are two equilibrium points (C, C) and (D, D). When $t_2r_2\pi_1 + t_2s_2\pi_1 + s_2\pi_1 - f_1 > 0$ the e-commerce enterprises will choose to cooperate because they have profit to make. Even when the macro situation is very optimistic, it is inevitable that some enterprises with poor individual conditions or fear of risk choose not to cooperate, which is in line with reality.

5 The intervention analysis of cooperative behaviors of e-commerce enterprises

From the above analysis, we can know there are many factors influencing the selection of e-commerce partners. In this paper, we mainly consider the influence of the three factors as reputation, trust, and information sharing on cooperative behaviors of e-commerce enterprises. And the three factors are in the relationships presented in the conceptual model. Next, we will further discuss it.

5.1 The influence of reputation on cooperative behaviors of e-commerce enterprises

Firstly, we assume the average values of the reputation of e-commerce enterprises in the two countries are both below 0.5. We set $F=(0.6,0.4,0.33,0.12,0.15)$ and the initial values of trust and information sharing are between 0 and 1. The simulation results please see Fig. 4.

From the above figure, we can see that when the reputation value is reduced by about 50%, the cooperation choice of cross-border e-commerce enterprises has

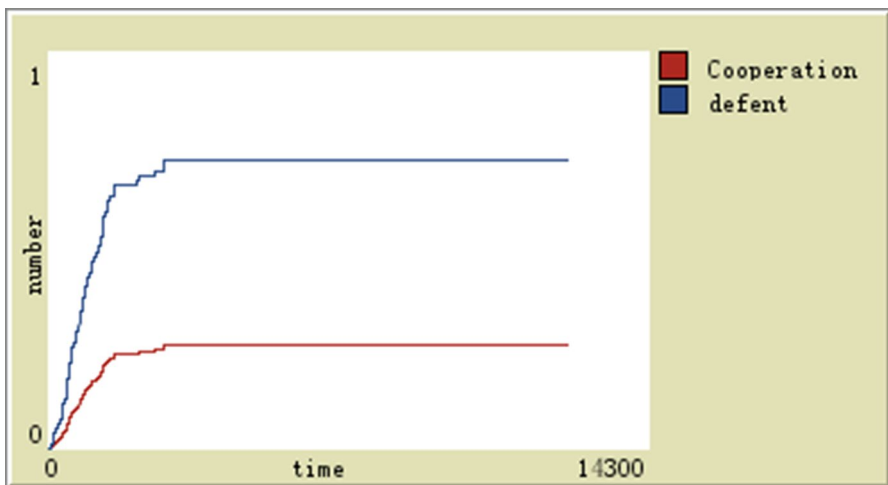


Fig. 4 Simulation of the evolution of cross-border e-commerce enterprises at the level of r being 0.5

changed dramatically. Initially, the original number of cooperation far exceeds the number of non-cooperation. Then it turns to that the present number of non-cooperation far exceeds the number of cooperation. This shows the impact of reputation on the choice of cross-border e-commerce partners. It also confirms why many enterprises hope to improve their reputation through various channels to attract investment and cooperation. But we know that some enterprises have a bad reputation, especially those who had a bad reputation previously. So this time we adjust the r value to a relatively low level of 0.1, that is to say, these enterprises have basically no reputation. Let's see the simulation results.

From Fig. 5, we find that when the reputation of the whole industry drops to a certain value, there is no enterprise in the world choosing to cooperate. It indicates that when the reputation of an enterprise is very low, it will directly affect the others' trust in him. No matter how high the degree of information sharing at this time is, no one will choose to cooperate with it. This proves that some profiteers in real life suffer from reputation decline after producing counterfeit and inferior products or tax evasion. And as a result, it is difficult for enterprises to be willing to cooperate with them.

5.2 The influence of trust on cooperative behaviors of cross-border e-commerce enterprises

According to the literature review of Sect. 2, the cooperative behaviors of cross-border e-commerce enterprises are affected by mutual trust between them. Trust between enterprises is constantly accumulating and changing. When the enterprises successfully cooperate, their trust values are often increasing and vice versa. But generally speaking, for enterprises that never cooperate, the degree of trust between them depends on the factors like reputation and policy support and so forth.

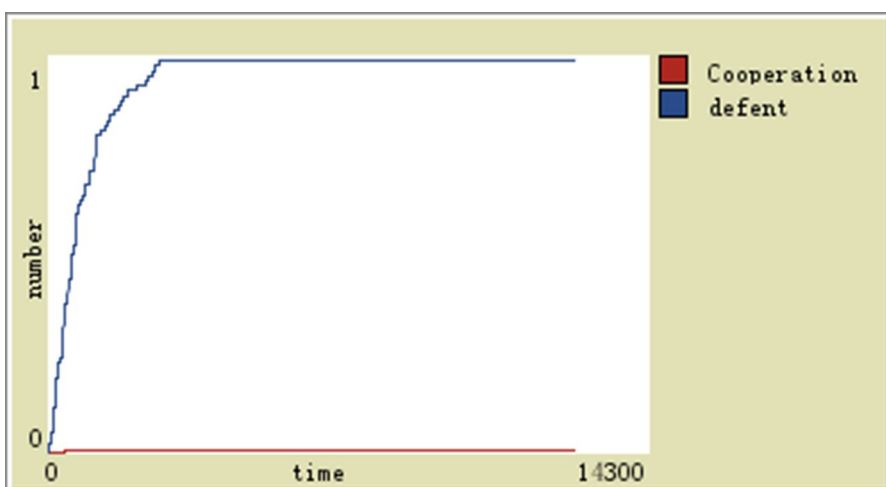


Fig. 5 Simulation of the evolution of cross-border e-commerce enterprises at the level of r being 0.1

To control the influence of reputation value on trust value, we set the reputation value of enterprises a fixed value of 0.5. And we directly consider the impact of different trust values on cross-border e-commerce cooperation, that is, setting $F=(0.6, 0.4, 0.33, 0.12, 0.15)$ and $r=0.5$. We also suppose s is a random value between 0 and 1 and t is between 0 and 0.2, 0 and 0.5, 0 and 0.8, respectively. To make the experimental results more intuitive, we directly compare the total number of chains in the evolutionary equilibrium, that is, the number of successful cooperation of cross-border e-commerce enterprises. The simulation results are shown in Fig. 6.

From the figure above, we can see the total number of cooperation between e-commerce enterprises at three different levels. When t is at the level of 0.8, the total number of cooperation reached nearly 66, while at the level of 0.5, only about 20. At the level of 0.2, there was little cooperation between the two sides. The higher the degree of trust between the two enterprises is, the more cooperative the enterprises will be. In addition, the simulation results also show that the marginal benefit of trust cooperation is increasing in a certain range, that is to say, the higher the degree of trust in a certain range is, compared with low trust, the higher the benefit of trust increased by the high trust. This explains why it's hard for some enterprises to cooperate with each other even if they have little trust in each other.

5.3 The influence of information sharing on cooperative behaviors of cross-border e-commerce enterprises

Through a literature review, we find that cross-border e-commerce cooperation is closely related to the degree of information sharing. With the rapid development of the Internet and the continuous advancement of trade policy, some enterprises begin to publish some research and development results of their own on their websites for other people to learn and study. In the conceptual model established in Sect. 3, we

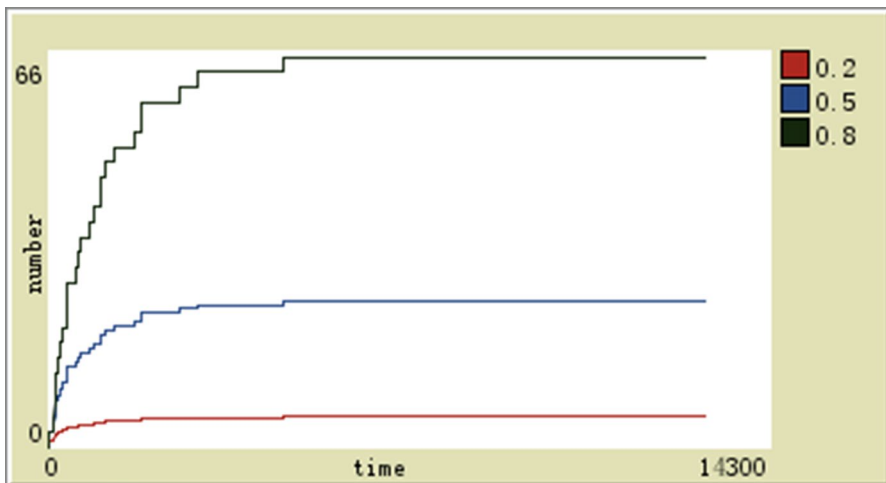


Fig. 6 Simulation of the number of cooperation of cross-border e-commerce enterprises at different levels of t

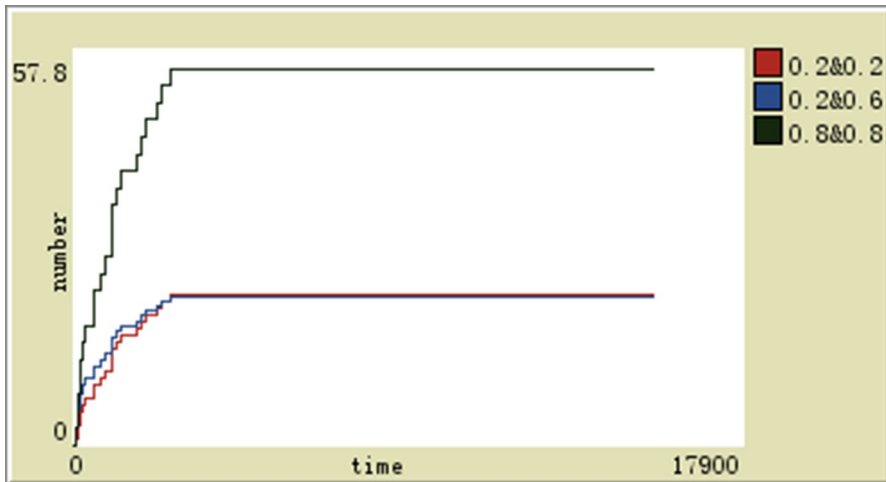


Fig. 7 Simulation of the number of cooperation of cross-border e-commerce enterprises at the different levels of f

assume that information sharing plays a moderating role. So we verify the impact of information sharing on cross-border e-commerce cooperation by controlling the degree of information sharing of domestic and foreign enterprises respectively. We set $F=(0.6, 0.4, 0.33, 0.12, 0.15)$ unchanged and t and r are randomly distributed between 0 and 1. The degree of information sharing at home and abroad is set at 0.2, 0.2 and 0.6, 0.8 and 0.8 respectively. The simulation results are shown in Fig. 7.

From Fig. 7, we can see that when the values of information sharing of domestic and foreign enterprises are both 0.8, the number of cross-border e-commerce cooperation is as high as 57 times while the number of cross-border e-commerce cooperation is basically stable at 20 times at the level of 0.2 & 0.2 and 0.2 & 0.6. This fully illustrates the antagonism of information sharing at home and abroad. Only when both sides share the same level of information can their willingness to cooperate be maximized. Therefore, when choosing cooperation, most enterprises prefer to choose enterprises with the same degree of information as to their own. The less asymmetric the degree of information sharing among enterprises is and the higher the degree of information sharing is, the more cooperation among enterprises can be promoted.

6 Discussions

6.1 New contributions

Firstly, based on the literature review, this paper constructs a theoretical model of partner selection for cross-border e-commerce enterprises. Existing literature discusses the impact of reputation and trust in promoting e-commerce cooperation [10,

36, 37, 42, 52], and analyze the role of information sharing in e-commerce cooperation [46, 47]. But are these conclusions applicable to the context of cross-border e-commerce? Previous research has not fully discussed it. Some researchers have reasonably assumed such relationships but there is no definite study to test these assumptions. Through literature review, this paper establishes a moderated mediation model, which posits that trust mediates the relationship between reputation and e-commerce cooperation and information sharing moderates the relationship between trust and cooperation.

Secondly, according to the hypotheses of the theoretical model, the payoff matrix of each actor in the game is established. Unlike ordinary e-commerce cooperation, the reputation and trust of cross-border e-commerce enterprises are more fragile [53]. Due to the uncertainty of trade relations between countries (such as the recent Sino-US trade relations), it is difficult for the cross-border e-commerce enterprises to have a long-term cooperation. As a result, their cooperative behaviors are more likely to be affected by the results of the previous transaction. The main consideration of the traditional game model is the long-term benefits based on the assumption of rational economic man. What is more, their way to find out the equilibrium points is not suitable for cross-border e-commerce enterprises.

Thirdly, this paper establishes an evolutionary game model. It analyses the decision maker's choice of different decision-making strategies according to the benefit they get in the last time. Based on the analysis, we can get the equilibrium stable strategy (ESS) of cross-border e-commerce cooperation. In doing so, from the game perspective, this paper explores the mechanism of reputation, trust, and information sharing on cooperation, which deeply analyses the evolutionary mechanism of cross-border e-commerce partner selection in B2B mode.

6.2 Implications for future research and practice

This paper constructs a multi-agent simulation model. Based on the investigation of a large number of cross-border e-commerce enterprises, empirical data are obtained and used as the initial value of the simulation model [54]. Besides, based on the results of the investigation, the range of parameters of the model is defined. Then this paper simulates the influence of factors on ESS of both sides with different parameter changes. From the simulation results, we can see that the basis for cross-border e-commerce cooperation is that the net profit should be bigger than 0. Apart from that, enterprises may have all kinds of worries when expanding the abroad market. Without experiences with the enterprises in other countries, at this time, reputation may strongly affect the initial cooperation willingness. And better reputation often indicates more trust while trust can promote cooperation. Furthermore, information sharing can moderate the relationship between trust and cooperation. When both sides have a certain trust basis, the higher the information sharing level is, the more the cross-border e-commerce enterprises tend to choose cooperation. And the degree of asymmetry of information sharing will also influence the cooperation. The smaller the asymmetry is, the easier enterprises are to cooperate.

Previous studies often first put forward hypotheses and then established corresponding theoretical models [55]. By questionnaires and data collection, they test and modify these models. These are the commonly used methodology to test the model. Different from previous studies, this paper combines the mathematical deduction of evolutionary game analysis with a simulation method to test the theoretical model. From these two perspectives, this paper respectively verifies the model. In so doing, this paper provides a new way to test the model. It enriches the theory test methodologies, especially when it is hard to get the data. But this method is only a simulation test. So the conclusions still need to be further tested empirically.

7 Conclusions

At present, due to the development of information technology [56], cross-border e-commerce is in rapid growth. Based on the analysis of the current situation of cross-border e-commerce development under B2B mode, this paper studies the selection of cross-border e-commerce partners. In view of cross-border scenarios, the main factors affecting cross-border enterprise cooperation are identified through the literature review. This paper argues that in order to effectively improve the cooperation opportunities between cross-border e-commerce enterprises and promote the sustainable development of cross-border e-commerce [57], the following points need to be paid attention to:

1. E-commerce enterprises should pay attention to their own reputation and establish a sound reputation evaluation index system. The world economy continues to grow, but multinational e-commerce companies generally have a low reputation overseas and weak competitiveness. Corporate reputation has become a measure of corporate trust, which directly affects the cooperation with other enterprises. Therefore, we should pay attention to the construction of the reputation of e-commerce enterprises, and actively manage the reputation of enterprises according to the historical performance of previous cooperation and the strength of enterprises themselves. In doing so, enterprises can effectively improve their reputation. When selecting a partner, a sound reputation evaluation index system should be established to properly evaluate the reputation of the candidate enterprise.
2. Strengthen trust mechanism. Strengthening trust mechanism can reduce the transactional cost of e-commerce enterprises, enhance information exchange, and realize the growth of the value of e-commerce enterprises. The results of empirical studies show that as a mediator of cooperative partner selection, trust should be emphasized by the e-commerce enterprises. Today's international market environment is quite competitive. Only mutual trust can guarantee the overall advantage of enterprises in cross-border e-commerce businesses. Therefore, strengthening trust in cross-border e-commerce cooperation can enhance the overall level of cooperation among enterprises. Otherwise, the stability of the overall cooperation will be difficult to maintain.

3. Pay attention to the asymmetry of information sharing. From the simulation results, we can see that the higher the degree of information sharing between enterprises is, the higher the possibility is for enterprises to cooperate. In the selection of partner-enterprises, if the degree of information sharing of both sides is not matched, then both sides need to make a decision under the premise of reducing their own costs and risks. This is a long-term and repeated game. Therefore, when choosing partners, under the precondition of protecting their own interests, enterprises should choose partners with a similar degree of information sharing as far as possible because it will often lead to long-term strategic cooperation between the two sides.
4. Cooperative behaviors among enterprises are generated to achieve common goals and are affected by various factors. When cooperating between enterprises, the interaction of reputation, trust, and information sharing should be considered comprehensively, that is, the impact of different combinations on cooperative behaviors among partners should be considered. Enterprises maintain trust and enhance their reputation to increase inter-organizational trust, thereby promoting the willingness to cooperate.

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Compliance with ethical standards

Conflict of interest The author declares no conflict of interest.

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