Cooperation Strategy of Intellectual Property Securitization in Supply Chain from Risk Perspective

Cheng Liu[1], Wenjing Xie[1], Qiuyuan Lei[1], and Xinzhong Bao[2(✉)]

[1] University of Science and Technology Beijing, Beijing, China
[2] Beijing Union University, Beijing, China
xinzhongbao@vip.sina.com

Abstract. This paper uses the evolutionary game method to study the strategic choice of SMEs, financial institutions and investors in the financing of intellectual property supply chain securitization from the perspective of risk governance, and discusses the influence of various risk factors on the stable equilibrium. The results show that no matter how the initial strategy is chosen, the final game will evolve to "SMEs repay the rent on time, financial institutions perform the contract, investors buy subordinated bonds". The credit risk of SMEs, intellectual property value evaluation risk and investor preference risk will affect the stable equilibrium of the game system.

Keywords: Intellectual property securitization · Supply chain · Tripartite evolutionary game · Risk governance

1 Introduction

The successful issuance of "Qiyi century supply chain intellectual property ABS" in 2018 indicates that China has begun to actively explore new ways of supply chain financing. The securitization of intellectual property supply chain helps to improve the capital turnover efficiency of the supply chain, promote the progress and scale of creation, and also provides greater development space and opportunities for enterprises in the supply chain, which is conducive to the development of the industry. However, the risks between supply chain enterprises and intellectual property seriously restrict the successful development of intellectual property supply chain securitization. Asset securitization creates a favorable market environment for the implementation of intellectual property supply chain securitization [1]. The timeliness and intangibility of intellectual property make its securitization not only complex but also risky [2]. The trust mechanism between enterprises in the supply chain and enterprise credit risk also seriously restrict the development of intellectual property supply chain Securitization [3]. The large scale of China's intellectual property assets and strong market demand for securitization are all favorable factors that support the smooth development of securitization in the intellectual property supply chain [4]. However, in the process of implementing

X. Shi et al. (Eds.): *LISS 2021*, LNOR, pp. 24–34, 2022.
https://doi.org/10.1007/978-981-16-8656-6_3

the securitization of the intellectual property supply chain, there are problems such as insufficient legal policies and protection mechanisms, large scale of intellectual property rights but low quality, imperfect intellectual property licensing trading market, lagging development of third-party intermediary service agencies, and some enterprises. Real problems and obstacles such as chaotic internal organization and management [5–7]. China should actively take advantage of the favorable conditions for the development of intellectual property securitization, overcome the unfavorable conditions that hinder its development, and develop the securitization model of the intellectual property supply chain.

To sum up, scholars' research on the securitization of intellectual property supply chain has the following deficiencies: (1) there are relatively few studies on the cooperation strategy of participants in the securitization of intellectual property supply chain. (2) In the existing research, few scholars use risk factors to measure the main income, and study the impact of risk factors on the stable equilibrium of the game.

2 The Construction of Evolutionary Game Model of Risk Sharing in Intellectual Property Supply Chain Securitization

This paper takes Qiyi century intellectual property supply chain financial asset support special plan, the first Securitization Product of intellectual property supply chain in China, as the research object, and studies the income balance of all parties from the perspective of risk sharing.

2.1 Introduction to the Securitization Process of the Intellectual Property Supply Chain

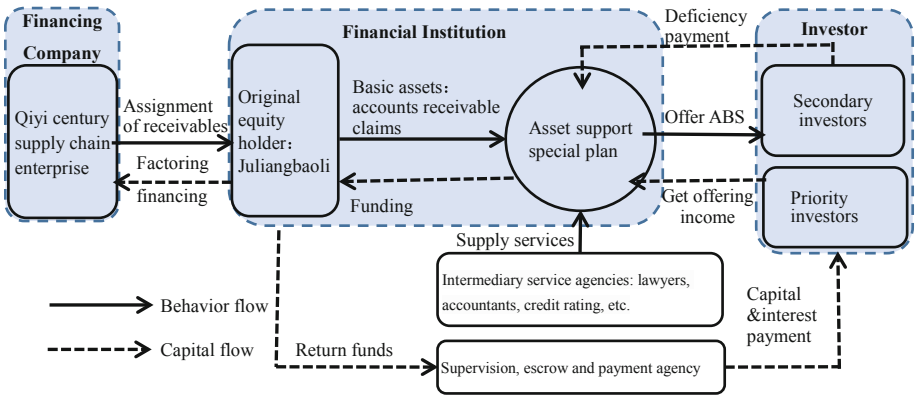


Fig. 1. Operation process of intellectual property supply chain ABS in Qiyi Century

The basic process of Qiyi century's intellectual property supply chain ABS is as follows: Qiyi century and its suppliers (enterprises in the supply chain) generate accounts

receivable claims due to intellectual property services, and Juliang factoring company transfers the accounts receivable claims to become the original owner of the intellectual property securitization project, and packages and transfers the factoring assets to the asset support special plan. Managers raise funds through asset-backed special plans, purchase accounts receivable and creditor's rights, and provide relevant services through intermediaries. The specific financing process is shown in Fig. 1.

In the start-up stage of intellectual property securitization, when the financing party transfers the accounts receivable of intellectual property to financial institutions, there is mainly the risk of intellectual property value evaluation; Financial institutions set up special asset plans with accounts receivable claims as basic assets, and entrust intermediary service agencies to carry out rating. This is the rating stage, and there are operational risks of intermediary service agencies; Then it enters the stage of design and issuance. The special asset-backed plan issues bonds, investors buy bonds, and the special asset-backed plan obtains issuance income. This stage mainly includes credit risk and investment preference risk; Then enter the duration, at this stage, enterprise credit risk, investment preference risk, intellectual property impairment risk is full of them, the above risks seriously restrict the strategy choice of game players. Facing the accounts receivable, the enterprise has the situation of paying or not paying; According to whether the financial institutions make up the balance of the special asset plan, the strategy choice is performance/nonperformance; Investors have the risk of investment preference and will make the decision to buy subordinated bonds or priority bonds. There are eight combination strategies of the three, and the decision meaning of each strategy is shown in Table 1.

Table 1. Strategy combination matrix

Serial number	Strategy combination	Meaning	Serial number	Strategy combination	Meaning
I	Payment, performance, purchase of subordinated bonds	Enterprises pay accounts, financial institutions perform contracts, and investors buy subordinated bonds	V	Nonpayment, performance, purchase of subordinated bonds	In the event of accelerated liquidation, the financial institutions make up the funds and cash the investors & apos; income in the order of liquidation. The investors buy the subordinated bonds and get part of the income, but less than the income when the cash flow is normal

(*continued*)

Table 1. (*continued*)

Serial number	Strategy combination	Meaning	Serial number	Strategy combination	Meaning
II	Pay, perform, buy priority bonds	Enterprises pay accounts, financial institutions perform contracts, and investors buy priority bonds	VI	Nonpayment, performance, purchase of senior bonds	When the accelerated liquidation event occurs, the financial institutions perform the contract, and the investors buy the priority bonds, the investors will get the interest income, which is less than the income when the cash flow is normal
III	Payment, default, purchase of subordinated bonds	Enterprises pay accounts, financial institutions default, may occur accelerated liquidation events, investors & apos; interest income is affected	VII	Nonpayment, default, purchase of subordinated bonds	If the enterprises do not pay the accounts, the financial institutions do not make up the difference and pay the corresponding price, and the investors buy the subordinated bonds, the income will be greatly reduced
IV	Pay, default, buy priority bonds	Enterprises pay accounts, financial institutions default, may occur accelerated liquidation events, investors & apos; income is affected	VIII	Nonpayment, default, purchase of senior bonds	Enterprises do not pay, financial institutions do not make up the difference, pay the price, investors buy priority bonds, the income is affected, but higher than the interest income of subordinated bond buyers

2.2 Parameter Setting

For the financing parties, the transfer of creditor's rights can obtain funds to meet the financing needs; For financial institutions, they undertake the collection of accounts receivable and interest payment of investors, entrust managers to manage basic assets, collect and transfer cash flow, and make up special funds. If they do not make up funds, they will pay a price; For investors, the risk of buying priority bonds is low. They pay interest on time and repay the principal by hand. If they choose to buy subordinated bonds, the risk is high and the yield is uncertain, but it is generally higher than that of priority bonds. In order to better reflect the income of the main game, the relevant parameters are set. The parameters and definitions are shown in Table 2.

Table 2. Parameter matrix

Variable	Parameter	Variable description	Variable	Parameter	Variable description
The cost of intellectual property securitization of the original owner	δ	All other costs of the business on behalf of the original owner	Intellectual property valuation	v	It is related to the level of risk
Investment amount of priority investors	B_1	The principal of a senior bond investor	Financing amount	$\gamma \varepsilon v$	ε Is the ratio of intellectual property fees, γ Assessing risk for intellectual property value
Investment amount of secondary investors	B_2	The principal of a subprime bond investor	Investment income of financial institutions	$\theta_1 r$	θ_1 For income risk, r Is the highest expected rate of return, $\theta_1 \in [0, 1]$
Expected yield of senior bond	i_{pn}	$n = 1, 2, 3$, It represents the yield of priority bonds in normal state, accelerated liquidation state and default state respectively	Balance payment	π	When the cash flow is abnormal, the difference payer needs to make up the expenses

(*continued*)

Table 2. (*continued*)

Variable	Parameter	Variable description	Variable	Parameter	Variable description
Expected total yield of subordinated bonds	i_{sm}	$m = 1, 3, 4$, They are the yields of subordinated bonds at maturity in normal state, accelerated liquidation state and default state	Loss of non-payment	D	If the enterprise does not pay the account, the right to use the intellectual property will be restricted, which will bring losses to the enterprise
Yield of subordinated bonds during holding period	i_{s2}	The yield of subordinated bonds during the holding period shall not exceed 1%/year	Losses from default of financial institutions	F	If a financial institution defaults, it should not inform the manager of the cash flow problem
Recovery ratio of accounts receivable	$\varphi\beta$	φ On behalf of enterprise credit risk, β Represents the highest recovery rate of accounts	Investment preference risk	μ_l	Represents the risk of the investor & apos earning, l The values are 1 and 2, which are the preference risk of priority and secondary investors respectively, $\mu_1 < \mu_2$

2.3 Model Assumptions

In order to establish a reasonable evolutionary game model, this paper makes the following assumptions.

- Hypothesis 1: the three subjects are bounded rationality and information asymmetry. In this paper, all yields do not consider the time value of funds, assuming that bonds issued at par.
- Hypothesis 2: when the enterprise does not pay the account, the balance made up by the difference payer can repay the interest and principal of the priority investor, and the investor and the original equity holder need to bear the credit risk of the enterprise and the impairment risk of intellectual property.
- Hypothesis 3: under normal conditions, the interest income of the investors purchasing the subordinated bonds is greater than that of the investors purchasing the priority bonds. However, when an accelerated liquidation event or a default event occurs, assuming that the interest income of the investors purchasing the subordinated bonds is less than that of the investors purchasing the priority bonds, the investors will guarantee the principal in any case. When the accounts receivable are abnormal, if the interest income of the investors purchasing the subordinated bonds is less than that of the investors purchasing the priority bonds, the investors will guarantee the principal. The cost of default of financial institutions is greater than the difference that needs to be made up. The probability of accounts receivable being paid is x and not being paid is $1 - x$; The performance probability is y and default probability of financial institutions is $1 - y$; The probability of investors investing in priority bonds is z, and the probability of investors investing in subordinated bonds is $1 - z$;

3 The Solution of Three Equilibrium Points and the Analysis of Stability Strategy of Three-Party Evolutionary Game

In this part, firstly, according to the hypothesis of the model and the setting of parameters, we get the income matrix of the three main bodies. Secondly, according to the income matrix, we get the replication dynamic equation of the three main bodies. Finally, we get the equilibrium point of the evolutionary game system, and explore the stability of the equilibrium point.

3.1 Income Matrix

According to the hypothesis and parameter matrix of the model, the capital asset pricing model is improved. The risk coefficient and income are multiplied to express the income of each participant, and the income matrix of each participant is determined. Table 3 reflects the income of each participant, and the results correspond to the financiers, financial institutions and investors respectively.

Table 3. The game income matrix of financiers, financial institutions and investors

Game participants		Supply chain enterprises			
		Payment of accounts receivable		Nonpayment of accounts receivable	
		Financial institution			
Investor	Purchase of subordinated bonds	Performance	Breach of contract	Performance	Breach of contract
		$\gamma\varepsilon v$	$\gamma\varepsilon v$	$\gamma\varepsilon v(1+\theta_1 r)-D$	$\gamma\varepsilon v(1+\theta_1 r)-D$
		$\varphi\beta\gamma\varepsilon v-\mu_1 i_{p1}B_1$ $-\mu_2 i_{s2}B_2-B_1$ $-B_2-\mu_2 i_{s1}B_2-\delta$ $-(1-\varphi\beta)\pi$	$\varphi\beta\gamma\varepsilon v-\mu_1 i_{p2}B_1-B_1$ $-B_2-\mu_2 i_{s3}B_2-\delta$ $-(1-\varphi\beta)F$	$\theta_2 v-\delta-\pi-\mathrm{B}_1$ $-\mu_1 i_{p2}\mathrm{B}_1-\mathrm{B}_2$ $-\mu_2 i_{s3}\mathrm{B}_2$	$\theta_2 v-\delta-\mathrm{B}_1$ $-\mu_1 i_{p3}\mathrm{B}_1-\mathrm{B}_2$ $-\mu_2 i_{s4}\mathrm{B}_2-F$
		$\mu_2 i_{s2}\mathrm{B}_2+\mu_2 i_{s1}\mathrm{B}_2$	$\mu_2 i_{s3}\mathrm{B}_2$	$\mu_2 i_{s3}\mathrm{B}_2$	$\mu_2 i_{s4}\mathrm{B}_2$
	Purchase of senior bonds	$\gamma\varepsilon v\times\theta_1 r$	$\gamma\varepsilon v\times\theta_1 r$	$\gamma\varepsilon v(1+\theta_1 r)-D$	$\gamma\varepsilon v(1+\theta_1 r)-D$
		$\varphi\beta\gamma\varepsilon v-\mu_1 i_{p1}\mathrm{B}_1$ $-\mu_2 i_{s2}\mathrm{B}_2-\mathrm{B}_1$ $-\mathrm{B}_2-\mu_2 i_{s1}\mathrm{B}_2-\delta$ $-(1-\varphi\beta)\pi$	$\varphi\beta\gamma\varepsilon v-\mu_1 i_{p2}\mathrm{B}_1-\mathrm{B}_1$ $-\mathrm{B}_2-\mu_2 i_{s3}\mathrm{B}_2-\delta$ $-(1-\varphi\beta)F$	$\theta_2 v-\delta-\pi-\mathrm{B}_1$ $-\mu_1 i_{p2}\mathrm{B}_1-\mathrm{B}_2$ $-\mu_2 i_{s3}\mathrm{B}_2$	$\theta_2 v-\delta-\mathrm{B}_1$ $-\mu_1 i_{p3}\mathrm{B}_1-\mathrm{B}_2$ $-\mu_2 i_{s4}\mathrm{B}_2-F$
		$\mu_1 i_{p1}B_1$	$\mu_1 i_{p2}B_1$	$\mu_1 i_{p2}B_1$	$\mu_1 i_{p3}B_1$

3.2 Copy Dynamic Equation

From the income matrix in Table 3, we can get the replication dynamic equation of financiers, financial institutions and investors:

$$F(x)=\frac{dx}{dt}=x\left(V_{E_1}-\overline{V_E}\right)=x(1-x)[D-\gamma\varepsilon v(K+1)] \tag{1}$$

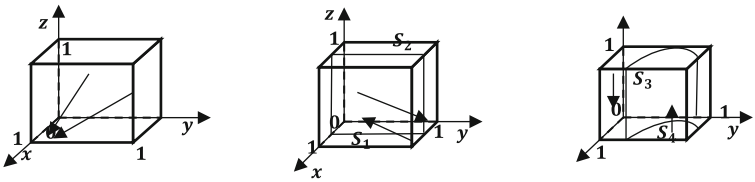
$$\begin{aligned}F(y)=\tfrac{\mathrm{d}y}{\mathrm{d}t}&=y\left(V_{B_1}-\overline{V_B}\right)=y(1-y)\{x\big[\left(\mu_1 i_{p2}B_1\right.\\&+\mu_2 i_{s3}B_2-\mu_1 i_{p1}B_1-\mu_2 i_{s2}B_2-\mu_2 i_{s1}B_2\big)+(1-\varphi\beta)\\&(F-\pi)]+(1-x)\left(\mu_2 i_{p3}B_1-\mu_2 i_{p2}B_1\right.\\&\left.+\mu_2 i_{s4}B_2-\mu_2 i_{s3}B_2+F-\pi\right)]\end{aligned} \tag{2}$$

$$\begin{aligned}F(Z)=\tfrac{\mathrm{d}Z}{\mathrm{d}t}&=Z\left(V_{I_1}-\overline{V_I}\right)=z(1-z)\{xy[(\mu_2 i_{s2}B_2\\&+\mu_2 i_{s1}B_2-\mu_1 i_{p1}B_1\big)+(x+y-2xy)(\mu_2 i_{s3}B_2\\&-\mu_1 i_{p2}B_1\big)+(1-x)(1-y)\left(\mu_2 i_{s4}B_2-\mu_1 i_{p3}B_1\right)\big]\end{aligned} \tag{3}$$

The equilibrium point of evolutionary game dynamic process can be generated by $\boldsymbol{F(x)}=\frac{\boldsymbol{dx}}{\boldsymbol{dt}}$, $\boldsymbol{F(y)}=\frac{\boldsymbol{dy}}{\boldsymbol{dt}}$, $\boldsymbol{F(z)}=\frac{\boldsymbol{dz}}{\boldsymbol{dt}}$ and E1 (0, 0, 0), E2 (0, 0, 1), E3 (0, 1, 0), E4 (0, 1, 1), E5 (1, 0, 0), E6 (1, 0, 1), E7 (1, 1, 0), E8 (1, 1, 1), E9 (p*, q*, m*), where E9 (p*, q*, m*) is the equilibrium point of mixed strategy).

3.3 Discussion on Stability of Equilibrium Point and Analysis on Stability Strategy of Evolutionary Game

In asymmetric game, mixed strategy equilibrium is not evolutionary stable equilibrium. Therefore, we only need to discuss the asymptotic stability of pure policy equilibrium. The asymptotic stability of the equilibrium point is determined by Lyapunov criterion (indirect method). According to the Lyapunov criterion[1], The equilibrium point is a stable point when the eigenvalue of J matrix $\boldsymbol{\lambda} \leq 0$. Business strategy "0" means that accounts receivable have not been paid, while business strategy "1" is the opposite; The strategy of financial institutions is "0" for default and "1" for performance; The investor strategy of "0" represents the purchase of priority bonds, and the investor strategy of "1" represents the purchase of subordinated bonds. According to the judgment of positive and negative eigenvalues it is found that the system has a unique evolutionary game equilibrium E8 (1,1,1). The evolutionary game phase diagram of the three subjects is shown in Fig. 2.



(a) Phase diagram of SMES (b) Phase diagram of financial institutions (b) Phase diagram of investors

Fig. 2. Phase diagram of evolutionary game

From the copy dynamic equation and Jacobian matrix of the three subjects, it can be seen that, because the assumption $\boldsymbol{D}-\boldsymbol{\gamma\varepsilon v}(\boldsymbol{K}+1)$ must be greater than 0, no matter what the initial strategy of the financing party is, it will eventually be stable at "1", that is, to pay the accounts receivable; When $x > \frac{\mu_1 B_1(i_{p2}-i_{p3})+\mu_2 B_2(i_{s3}-i_{s4})+\pi-F}{\mu_1 B_1(2i_{p2}-i_{p3}-i_{p1})+\mu_2 B_2(2i_{s3}-i_{s4}-i_{s2}-i_{s1})+\varphi\beta(\pi-F)}$ At that time, when the initial strategy is in $\boldsymbol{S}_1$, $\boldsymbol{y} = 0$ is the equilibrium point of evolutionary game, that is, financial institutions choose to "default"; when the initial strategy is in $\boldsymbol{S}_2$, $x < \frac{\mu_1 B_1(i_{p2}-i_{p3})+\mu_2 B_2(i_{s3}-i_{s4})+\pi-F}{\mu_1 B_1(2i_{p2}-i_{p3}-i_{p1})+\mu_2 B_2(2i_{s3}-i_{s4}-i_{s2}-i_{s1})+\varphi\beta(\pi-F)}$ $\mathrm{y} = 1$ is the equilibrium point of evolutionary game, that is, financial institutions choose to "perform"; It can be seen from the evolutionary game phase diagram of investors in Fig. 2 that when the initial game is in $\boldsymbol{S}_3$, $\boldsymbol{z} = 0$ is the equilibrium point of evolutionary game, that is, investors "buy priority bonds", when the initial game is in $\boldsymbol{S}_4$, $\boldsymbol{z} = 1$ is the equilibrium point of evolutionary game. According to the previous hypothesis, $x < \frac{\mu_1 B_1(i_{p2}-i_{p3})+\mu_2 B_2(i_{s3}-i_{s4})+\pi-F}{\mu_1 B_1(2i_{p2}-i_{p3}-i_{p1})+\mu_2 B_2(2i_{s3}-i_{s4}-i_{s2}-i_{s1})+\varphi\beta(\pi-F)}$ must be true, and the initial strategy choice of investors must be in $\boldsymbol{S}_4$, so the final evolutionary game is stable at E8 (1, 1, 1).

[1] It was established in 1892 by a.m. Lyapunov, a Russian mathematician and mechanic, to analyze the stability of the system.

4 Analysis of Factors Influencing the Stability Strategy of Tripartite Evolutionary Game

The stable equilibrium of the above three-party evolutionary game model is based on a series of assumptions, but if the assumptions change, it will seriously affect the behavior of the game players.

4.1 The Impact of Intellectual Property Valuation Risk on Evolutionary Game Equilibrium

The risk of intellectual property valuation γ mainly affects the amount of financing. When the risk of intellectual property valuation γ is very high, the financing party obtains a part of additional funds, which increases the amount of financing. When the risk of intellectual property valuation $\gamma > \frac{D}{\varepsilon v(k+1)}$, $D - \gamma \varepsilon v(k+1) < 0$, the stability point changes immediately, and E3 (0, 1, 0) is the stability point, In this case, financial institutions do not pay attention to the recovery of accounts after the game. However, because the default loss of financial institutions is greater than the difference that needs to be made up, financial institutions will not easily make default decisions. Financial institutions will choose to perform the contract after the game. For investors, the risk of intellectual property value assessment is high, After the game, they tend to buy priority bonds.

4.2 The Influence of Supply Chain Enterprise Credit Risk on Evolutionary Game Equilibrium

Enterprise credit risk φ mainly affects the recovery ratio of accounts, and then affects the amount that financial institutions need to spend. When the recovery ratio of accounts is relatively high, the difference between the default penalty and the payment is small. In the previous paper, it is assumed that the difference between the default loss and the difference payment can make up for the investor's loss, but if it cannot make up for the investor's loss, the stability point changes to E5 (1,0,0), When the credit risk of enterprises is relatively large, it mainly affects the strategic choice of financial institutions and investors. If the accounts are paid, if the accounts recovered by financial institutions cannot make up for the investment losses of investors, they will choose to default, and investors will also tend to buy priority bonds in order to avoid risks.

5 Conclusion

This paper constructs a risk sharing model of Intellectual Property Securitization Based on financiers, financial institutions and investors, and draws the following conclusions: (1) in order to promote the effective development of intellectual property supply chain securitization, through the game of its own income, the evolutionary equilibrium is finally stable at E8 (1,1,1). (2) Intellectual property value evaluation risk and enterprise credit risk affect the equilibrium of evolutionary game. When the risk of intellectual property valuation is high, the account is likely not to be paid, and investors will consider the

risk factors and choose to buy the low-risk priority bonds; The credit risk of enterprises mainly affects the strategic choice of financial institutions and investors. If the recovered accounts cannot make up for the investment losses of investors, financial institutions will choose to default, and investors will also tend to buy priority bonds in order to avoid risks.

Acknowledgements. This research is partially supported by Major projects of Beijing Social Science Foundation (no. 20ZDA03).

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