Tripartite Evolutionary Game Model of Financialization Governance: Based on Equity Pledge

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Abstract. In order to deal with the problem of excessive allocation of financial assets after equity pledge of controlling shareholders, this paper constructs a tripartite evolutionary game model of financial regulatory authorities, controlling shareholders and non-controlling major shareholders. The evolutionary stability of strategy selection of the three stakeholders is analyzed by using the replicated dynamic equation, and the relevant parameters are simulated. The research results can provide theoretical guidance for the financial governance after equity pledge.

Keywords: Financial governance · Evolutionary game · Equity pledge

1 Introduction

Excessive financialization is not conducive to the long-term development of industry. After pledging the controlling shareholder's equity, they may use their controlling position to excessively allocate financial assets to obtain private income. Non controlling major shareholders have greater patience and ability to participate in corporate governance due to their large shareholding ratio [1]. Non controlling major shareholders mainly play a governance role through participation in governance and active supervision [2]. They can use the appointment of directors to submit proposals to the management of listed companies [3, 4], management change [5], reporting to regulatory authorities to participate in governance. Financial regulatory authorities have noticed the risk of excessive allocation of financial assets after equity pledge, and actively introduced relevant policies to curb the stock market pledge boom.

Simon [6] pointed out that human beings are actually in a state of bounded rationality. Smith et al. [7] proposed evolutionary game theory. At present, a large number of scholars in the academic circle have proposed an evolutionary game model to regulate enterprise financialization from different perspectives [8, 9]. In view of this, it is of great practical significance to explore the systematic and effective governance mechanism of excessive allocation of financial assets by real enterprises under the background of the normalization of equity pledge behavior of controlling shareholders.

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2 Evolutionary Game Model of Corporate Financialization Regulation

2.1 Model Assumptions and Construction

Hypothesis 1: The strategies of the three stakeholders involved in the game are described as follows: For the financial regulatory authorities, there are two strategies: strict regulation and loose regulation. The probability of the financial regulatory authorities adopting strict regulation is x; the probability of adopting loose regulation is $1-x$; For the controlling shareholder, there are two strategies: positive guidance and negative guidance. The probability of the controlling shareholder choosing positive guidance is y, and the probability of choosing negative guidance is $1-y$. For non-controlling major shareholders, there are two strategies of negative guidance to controlling shareholders: participation in reporting and non-participation. The probability of non-controlling major shareholders choosing to participate is z, and the probability of choosing not to participate is $1-z$. And assume $0 < x < 1$, $0 < y < 1$, $0 < z < 1$. The remaining hypothesises and parameter descriptions are shown in Table 1.

2.2 Income Matrix

According to the above assumptions and the strategy combinations of each game party, the payoff matrix of the three game parties under different strategy combinations can be obtained, as shown in Table 2.

3 Stability Analysis of Evolutionary Game Model

3.1 Progressive Stability Analysis of Financial Regulatory Sector

The expected revenue of the financial regulatory authorities
Suppose that the expected return of financial regulatory authorities adopting strict supervision strategy is E_{11}, the expected return of loose supervision strategy is E_{12}, and the average expected return is $\overline{E}_1$.

According to the income matrix, the expected income under the strict supervision of the financial regulatory department can be calculated as follows:

$$\begin{aligned} E_{11} = {} & yrI_{m1} - y\alpha(I_0 - I_{m1}) - C_{g1} + rI_{m2} + \beta(I_{m2} - I_0) \\ & -C_m - yrI_{m2} - y\beta(I_{m2} - I_0) + yC_m \end{aligned}$$

Similarly, the expected earnings of financial supervision departments under lax supervision are:

$$\begin{aligned} E_{12} = {} & yrI_{m1} + z\varphi\beta(I_{m2} - I_0) - z\varphi B - yz\varphi B(I_{m2} - I_0) \\ & +yz\varphi B - C_{g2} + rI_{m2} + (y-1)L_s - yrI_{m2} \end{aligned}$$

The average expected income of the financial regulatory sector is: $\overline{E}_1 = xE_{11} + (1-x)E_{12}$.

Table 1. Setting and description of main parameters

Game party	parameter	paraphrase
Financial supervision department	C_{g1}	The cost of strict supervision by financial regulators
	C_{g2}	The cost of lax regulation by financial regulators
	α	Commendation coefficient of financial supervision department
	β	Penalty coefficient of financial supervision department
	r	tax rate
	C_m	The governance cost of enterprise environment
	L_s	Loss caused by negative guidance of controlling shareholder
	x	The probability of strict regulation by financial regulators
controlling shareholder	R_{m1}	Controlling shareholder positive guidance of psychological benefits
	R_{m2}	Controlling shareholders negative guidance of psychological benefits
	I_{m1}	Positive earnings from controlling shareholders
	I_{m2}	Controlling shareholder negative guided earnings
	I_0	Daily income of controlling shareholders
	C_t	The input cost of investigating the basic situation of the enterprise when the controlling shareholder gives positive guidance
	ε	The estimated coefficient of the increase of the surrounding environmental uncertainty and psychological income when the controlling shareholder is negatively guided
	y	Probability of positive guidance by the controlling shareholder
Noncontrolling majority shareholder	C_s	Participation reporting cost of non-controlling major shareholders

(*continued*)

Table 1. (*continued*)

Game party	parameter	paraphrase
	φ	Success rate of reporting by non-controlling major shareholders
	B	Reward from financial regulatory authorities after successful reporting by non-controlling major shareholders
	L_f	Loss caused by non-controlling major shareholders' non-participation after negative guidance by controlling shareholders
	S	After negative guidance from the controlling shareholder, the non-controlling major shareholder participates in reporting the income obtained from the controlling shareholder
	z	The probability of non-controlling major shareholders participating in supervision

Replication dynamic equation analysis of financial regulatory sector

The replication dynamic equation of financial regulatory department's strategy is: $F(x) = \frac{dx}{dt} = x\left(E_{11} - \overline{E}_1\right)$, The derivative of the replication dynamic equation of the financial regulatory sector is: $\frac{d(F(x))}{dx}$.

When $y = \frac{(1-z\varphi)\beta(I_{m2}-I_0)-C_m-C_{g1}+C_{g2}+L_s+z\varphi B}{(1-z\varphi)\beta(I_{m2}-I_0)+\alpha(I_0-I_{m1})-C_m+L_s+z\varphi B}$, $F(x) \equiv 0$. This means that x at any value is a stable strategy, that whatever strategy the financial regulator chooses will not change over time. When $y \neq \frac{(1-z\varphi)\beta(I_{m2}-I_0)-C_m-C_{g1}+C_{g2}+L_s+z\varphi B}{(1-z\varphi)\beta(I_{m2}-I_0)+\alpha(I_0-I_{m1})-C_m+L_s+z\varphi B}$, let $F(x) \equiv 0$ and We have two equilibrium points $x = 0$ and $x = 1$. This indicates that when financial regulators choose the strategy of strict supervision or loose supervision, if there is no sudden situation, the strategy will be in a stable state.

According to the stability theorem of differential equation, when the evolutionary game process reaches a stable state, the financial regulatory authorities need to select this strategy to meet the following conditions: $F(x) = 0$, $\frac{d(F(x))}{dx} < 0$.

When $C_m > (1 - z\varphi)\beta(I_{m2} - I_0) + \alpha(I_0 - I_{m1}) + L_s + z\varphi B$, and if $y_0 < \frac{(1-z\varphi)\beta(I_{m2}-I_0)-C_m-C_{g1}+C_{g2}+L_s+z\varphi B}{(1-z\varphi)\beta(I_{m2}-I_0)+\alpha(I_0-I_{m1})-C_m+L_s+z\varphi B}$, $\left.\frac{d(F(x))}{dx}\right|_{x=0} < 0$, $\left.\frac{d(F(x))}{dx}\right|_{x=1} > 0$. Therefore, $x = 0$ is the equilibrium point (ESS), financial regulators choose the loose regulation strategy. If $y_0 > \frac{(1-z\varphi)\beta(I_{m2}-I_0)-C_m-C_{g1}+C_{g2}+L_s+z\varphi B}{(1-z\varphi)\beta(I_{m2}-I_0)+\alpha(I_0-I_{m1})-C_m+L_s+z\varphi B}$, $\left.\frac{d(F(x))}{dx}\right|_{x=0} > 0$, $\left.\frac{d(F(x))}{dx}\right|_{x=1} < 0$. Therefore, $x = 1$ is ESS, and the financial regulatory authorities choose the strict supervision strategy. On the contrary, we can also draw the opposite conclusion.

Table 2. Income matrix among financial regulatory authorities, controlling shareholders and non-controlling shareholders

	controlling shareholder	Non-controlling majority shareholder	
		Participate in reporting z	nonparticipation $1-z$
stringent regulation x	Positive guidance y	$-C_{g1}+rI_{m1}-\alpha(I_0-I_{m1})$	$-C_{g1}+rI_{m1}-\alpha(I_0-I_{m1})$
		$R_{m1}-rI_{m1}+\alpha(I_0-I_{m1})-C_t$	$R_{m1}-rI_{m1}+\alpha(I_0-I_{m1})-C_t$
		$-C_s$	0
	Negative guidance $1-y$	$-C_{g1}+rI_{m2}+\beta(I_{m2}-I_0)-C_m$	$-C_{g1}+rI_{m2}+\beta(I_{m2}-I_0)-C_m$
		$(1+\varepsilon)R_{m2}-rI_{m2}-\beta(I_{m2}-I_0)-\varphi S$	$(1+\varepsilon)R_{m2}-rI_{m2}-\beta(I_{m2}-I_0)$
		$-C_S+\varphi S$	$-L_f$
Lax regulation $1-x$	Positive guidance y	$-C_{g2}+rI_{m1}$	$-C_{g2}+rI_{m1}$
		$R_{m1}-rI_{m1}-C_t$	$R_{m1}-rI_{m1}-C_t$
		$-C_s$	0
	Negative guidance $1-y$	$-C_{g2}+rI_{m2}+\varphi\beta(I_{m2}-I_0)-\varphi B-L_s$	$-C_{g2}+rI_{m2}-L_s$
		$(1+\varepsilon)R_{m2}-rI_{m2}-\varphi\beta(I_{m2}-I_0)-\varphi S$	$(1+\varepsilon)R_{m2}-rI_{m2}$
		$-C_s+\varphi B+\varphi S$	$-L_f$

Remember the three-dimensional space $A=\{M(x,y,z)|0\le x\le 1, 0\le y\le 1, 0\le z\le 1\}$, curved surface $y=y_0=\frac{(1-z\varphi)\beta(I_{m2}-I_0)-C_m-C_{g1}+C_{g2}+L_s+z\varphi B}{(1-z\varphi)\beta(I_{m2}-I_0)+\alpha(I_0-I_{m1})-C_m+L_s+z\varphi B}$. The phase diagram of the strategy evolution of the financial regulatory sector is shown in Fig. 1. The surface G_1 divides space A into two parts, which are respectively denoted as spaces S_{11} and S_{12}.

When the initial state of the game is in space, that is S_{11}, the final strategy of the financial regulatory sector choose the strict supervision strategy. Conversely, if the initial state is in the space S_{12}, at that time, the financial regulatory sector choose the loose regulation strategy.

According to the above method, the strategy evolution phase diagram of controlling shareholders and the strategy evolution phase diagram of non-controlling shareholders can be obtained.

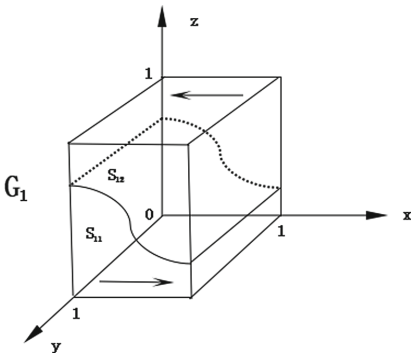

Fig. 1. The financial regulatory sector's strategy evolution phase diagram

3.2 Local Stability Analysis of Tripartite Evolutionary Game System

According to evolutionary game theory, the three evolutionary game equilibrium points of financial regulatory authorities, controlling shareholders and non-controlling shareholders must simultaneously satisfy: $F(x) = 0, F(y) = 0, F(z) = 0$. From this, the system equilibrium point can be obtained: $E_1(0, 0, 0)$, $E_2(0, 0, 1)$, $E_3(0, 1, 0)$, $E_4(0, 1, 1)$, $E_5(1, 0, 0)$, $E_6(1, 0, 1)$, $E_7(1, 1, 0)$ and $E_8(1, 1, 1)$. The Jacobian matrix of the tripartite evolutionary game system is: $A = \begin{pmatrix} \frac{\partial F(x)}{\partial x} & \frac{\partial F(x)}{\partial y} & \frac{\partial F(x)}{\partial z} \\ \frac{\partial F(y)}{\partial x} & \frac{\partial F(y)}{\partial y} & \frac{\partial F(y)}{\partial z} \\ \frac{\partial F(z)}{\partial x} & \frac{\partial F(z)}{\partial y} & \frac{\partial F(z)}{\partial z} \end{pmatrix}$.

The stability of the system can be determined by using the indirect method of Lyapunov [10]. In order to analyze the stability of each equilibrium point, the 8 equilibrium points are substituted into the Jacobian matrix A successively, and draw the following conclusion: when $\alpha(I_0 - I_{m1}) + C_{g1} - C_{g2} < 0$ and $-\alpha(I_0 - I_{m1}) - \beta(I_{m2} - I_0) - R_{m1} + (1 + \varepsilon)R_{m2} - r(I_{m2} - I_{m1}) + C_t < 0$, $E_7(1, 1, 0)$ is ESS.

4 Numerical Simulation

In order to study the influence of various parameters on the process of evolutionary game and verify the effectiveness of evolutionary stability analysis, this paper will assign numerical values to the model combined with the actual situation and use Matlab to conduct numerical simulation. The simulation results are shown in Figs. 2, 3 and 4.

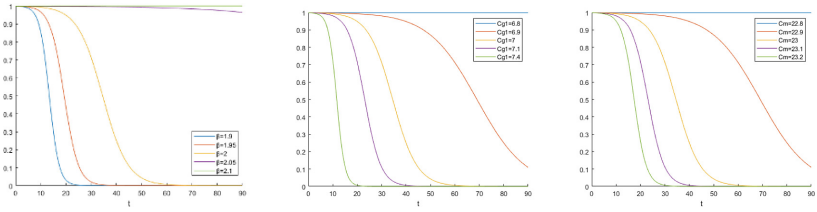

Fig. 2. Analysis of parameters affecting the strategy selection of financial regulatory departments

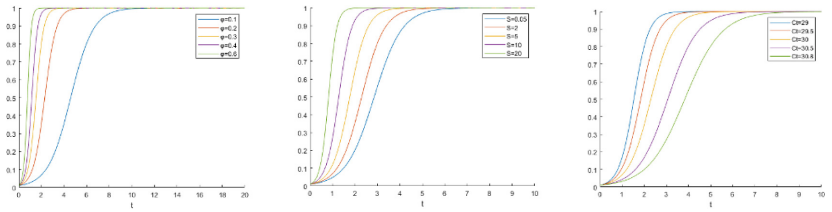

Fig. 3. Analysis of parameters affecting controlling shareholders' strategy selection

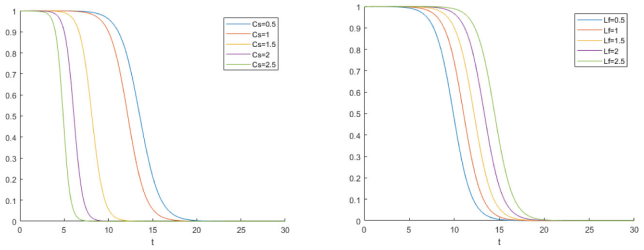

Fig. 4. Analysis of parameters affecting strategy selection of noncontrolling major shareholders

5 Conclusion

This paper constructs a tripartite evolutionary game model among financial regulatory authorities, controlling shareholders and non-controlling shareholders, and analyzes the stability of strategic choices of each party and the stability of the balanced strategy combination of the game system. The main conclusions include: Penalty coefficient of financial supervision department β, the difference between the cost of strict and lax regulation by financial regulators $\left(C_{g1} - C_{g2}\right)$, the cost of financial supervision department's governance of enterprise environment C_m has a significant impact on the strategy choice of financial supervision department; The regulatory success rate of non-controlling majority shareholders φ, non-controlling shareholders participate in reporting after negative guidance by controlling shareholders S, the input cost of information investigation when the controlling shareholder is positively guided C_t has a significant impact on the controlling shareholder's strategy choice; Whistleblowing costs for non-controlling shareholders C_s and the loss caused by the non-participation of the platform after the negative guidance of the controlling shareholder L_f has a significant impact on the strategy choice of the non-controlling shareholder.

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