

Application of Game Theory in M&A Decision of Listed Manufacturing Companies

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Abstract: This study investigates the tripartite game mechanism in mergers and acquisitions (M&A) between state-owned enterprises (SOEs) and listed companies in the manufacturing sector. A dynamic evolutionary game model involving the government, SOEs, and listed companies is constructed based on evolutionary game theory. Python-based simulations and case validation are employed to analyze equilibrium stability. Key findings include: 1) Narrowing M&A price differentials increases the likelihood of SOEs adopting high-price strategies and government support; 2) Rising transaction costs drive SOEs to raise acquisition prices while enhancing listed companies' acceptance rates; 3) Widening income gaps boost listed companies' acceptance but reduce government incentives; 4) Government capital assistance directly influences strategic choices—greater capital disparities between parties promote high-price acquisitions and transaction success. The research provides a game-theoretic framework to optimize M&A decision-making, revealing how institutional dynamics and resource allocation shape cross-ownership restructuring outcomes.

Keywords: Merger; Evolutionary Game; Listed Companies; State-Owned Enterprises; Government.

1. Introduction

Manufacturing serves as the cornerstone of China's economy, where mergers and acquisitions (M&A) act as pivotal drivers of industrial upgrading, resource optimization, and high-quality development. While M&A transactions appear as bilateral deals, they inherently involve intricate multi-party games balancing psychological expectations and strategic interests. Achieving mutually beneficial outcomes in this complex landscape necessitates addressing critical challenges: listed firms must evaluate the trade-offs of acquisition decisions, SOEs face strategic dilemmas between cost control through price suppression and value-driven bids, and governments must balance fiscal impacts with socially optimal M&A policies. These interdependent decisions underscore the need for a tripartite game framework to analyze interactions among SOEs, listed firms, and regulatory bodies.

Existing research predominantly employs risk assessments, case studies, and empirical analyses to explore M&A behavior, often overlooking dynamic strategic interactions. Evolutionary game theory (EGT), however, offers a robust lens to study bounded rationality and long-term equilibrium in multi-agent systems. For instance, studies by Zhu et al. [2] and Wei et al. [3] applied EGT and Lyapunov's stability analysis to model regulatory dynamics in pharmaceutical and

public governance contexts, respectively. Similarly, He et al. [4] dissected supply chain coordination in live-streaming e-commerce using EGT, highlighting the method's versatility in complex systems. Despite these advances, gaps persist in applying EGT to SOE-listed firm M&A scenarios, particularly in quantifying policy impacts and strategic equilibria.

This paper bridges these gaps through three innovations: First, it constructs a tripartite evolutionary game model involving SOEs, listed firms, and governments, elucidating strategic stability and influencing factors. Second, leveraging Lyapunov's first method, it rigorously analyzes equilibrium stability under pure and mixed strategies, proposing context-specific policy recommendations. Third, Python-based simulations validate the model's robustness across initial conditions, offering actionable insights for stakeholders.

2. Model Construction

2.1. Players and Strategies

A tripartite evolutionary game model is developed involving state-owned enterprises (SOEs), listed manufacturing firms, and the government. Key elements of M&A processes are quantified under defined assumptions to establish a mixed-strategy game matrix.

The interplay among stakeholders is structured as follows:

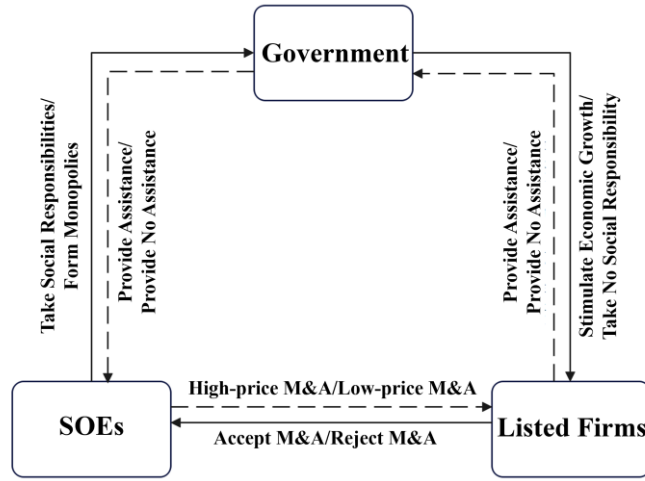


Figure 1 Logical Relationships among the Three Evolutionary Game Players

Government: Chooses to encourage (via financial/policy support to SOEs and firms) or not encourage M&A. Encouragement aims to balance dual outcomes: (1) Pros: Enhanced social responsibility fulfillment by SOEs. (2) Cons: Risk of market monopolization.

State-owned enterprises: Select between high-price M&A (premium bids) or low-price M&A (cost suppression tactics).

Listed Firms: Decide to accept or reject SOEs' bids. Rejection triggers trade-offs: (1) Pros: Potential economic growth stimulation. (2) Cons: Reduced alignment with public welfare goals compared to SOEs.

This framework captures strategic interdependencies, policy trade-offs, and behavioral incentives driving M&A outcomes.

2.2. Model Assumptions

To construct the game model, analyze the stability of the strategies and equilibrium points of all parties, and the influencing relationships of various elements [5], the following assumptions are made:

Assumption 1: The state-owned enterprise is Player 1, the listed company is Player 2, and the government is Player 3. All three parties are bounded - rational participants, and their strategic choices gradually evolve and stabilize to the optimal strategy over time.

Assumption 2: The strategy space of the state-owned enterprise is $\alpha = (\alpha_1, \alpha_2) = (\text{High-price, Low-price and suppress})$, and it chooses α_1 with a probability of x and α_2 with a probability of $(1 - x)$, where $x \in [0, 1]$; the strategy space of the listed company is $\beta = (\beta_1, \beta_2) = (\text{Accept M&A, Reject M&A})$, and it chooses β_1 with a probability of y and β_2 with a probability of $(1 - y)$, where $y \in [0, 1]$; the strategy space of the

government is $\gamma = (\gamma_1, \gamma_2) = (\text{Encourage M&A, Do not encourage M&A})$, and it chooses γ_1 with a probability of z and γ_2 with a probability of $(1 - z)$, where $z \in [0, 1]$.

Assumption 3: For state-owned enterprises, the M&A revenue is R_p , the high-price cost is C_{ph} , the low-price cost is C_{pl} , the cost of seeking other M&A methods is B_t . If the M&A fails, the high-price cost is C'_{ph} and the low-price cost is C'_{pl} . And $C_{ph} > C_{pl} + B_t$, $C'_{ph} > C'_{pl} + B_t$, $\frac{C_{ph}}{C'_{ph}} = \frac{C_{pl}}{C'_{pl}}$.

Assumption 4: For listed companies, the revenue from being acquired is V_t , and the revenue from not being acquired is V'_t . When the state-owned enterprise offers a low price and suppresses, it causes a loss of C_r to the listed company.

Assumption 5: For the government, if it encourages M&A: the high-price assistance provided to state-owned enterprises is M_p , the low-price assistance is M'_p , the assistance to listed companies is M_t , and in case of M&A failure, it is M'_t ; if a high-price M&A is successful, compared with when the government does not encourage, the government can obtain an additional revenue of A_g , and if a low-price M&A is successful, the additional revenue is A'_g . And $M_p > M'_p$, $M_t > M'_t$, $A_g > A'_g$. If M&A is encouraged and successful, there is a social-prestige revenue of A_{gs} ; if M&A is encouraged but fails, there is a social-prestige loss of A'_{gs} .

Assumption 6: For the government, if the M&A is successful, it brings a revenue of M_r , and if it fails, there is a loss of T_g .

Based on the above assumptions, the mixed - strategy game matrix of state - owned enterprises, listed companies, and the government is constructed, as shown in Table 1.

Table 1. Mixed-Strategy Game Matrix

SOEs	Listed Firms\Government	Encourage (z)	Not Encourage ($1 - z$)
High-price (x)	Accept (y)	$R_p - C_{ph} + M_p, V_t + M_t, -M_p - M_t + A_g + M_r + A_{gs}$	$R_p - C_{ph}, V_t, M_r$
	Reject ($1 - y$)	$-C'_{ph} + M_p, V'_t + M'_t, -M_p - M'_t - T_g - A'_{gs}$	$-C'_{ph}, V'_t, -T_g$
Low-price ($1 - x$)	Accept (y)	$R_p - C_{pl} - B_t + M'_p, -C_r + V_t + M_t, -M'_p - M_t + A'_g + M_r + A_g$	$R_p - C_{pl} - B_t, -C_r + V_t, M_r$
	Reject ($1 - y$)	$-C'_{pl} - B_t + M'_p, -C_r + V'_t + M'_t, -M'_p - M'_t - T_g - A'_{gs}$	$-C'_{pl} - B_t, -C_r + V'_t, -T_g$

3. Stability Analysis

From Table 1, we define the expected revenues E_{11} and E_{12} for state- owned enterprises when choosing high-price

$$\bar{E}_1 = xE_{11} + (1 - x)E_{12}. \quad (1)$$

Then the replication-dynamic equation for the state-owned enterprise's strategy choice is:

$$F_1(x, y, z) = x(x - 1)[C'_{ph} - B_t - C'_{pl} + (C_{ph} - C'_{ph} - C_{pl} + C'_{pl})y + (M'_p - M_p)z]. \quad (2)$$

Similarly, the replication-dynamic equation of the listed company's strategy choice is:

$$F_2(x, y, z) = y(y - 1)[-V_t + V'_t + (M'_t - M_t)z]. \quad (3)$$

And the replication-dynamic equation of the government's strategy choice is:

$$F_3(x, y, z) = z(z - 1)[(A'_g - A_g)xy + (M_p - M'_p)x + (M_t - A'_{gs} - M'_t - A'_g - A_{gs})y + (M'_t + M'_p + A'_{gs})] \quad (4)$$

From $F(x) = 0$, $F(y) = 0$, and $F(z) = 0$, the equilibrium points of the system can be obtained as $E_1(0,0,0)$, $E_2(1,0,0)$, $E_3(0,1,0)$, $E_4(0,0,1)$, $E_5(0,1,1)$, $E_6(1,0,1)$, $E_7(1,1,0)$, $E_8(1,1,1)$, $E_9(0, \frac{M_p + M'_t + A'_{gs}}{A'_g + A_{gs} + M'_t - M_t + A'_{gs}}, \frac{V'_t - V_t}{M_t - M'_t})$, $E_{10}(1, \frac{M_p + M'_t + A'_{gs}}{A_g + A_{gs} + M'_t - M_t + A'_{gs}}, \frac{V'_t - V_t}{M_t - M'_t})$, $E_{11}(\frac{M'_p + M'_t + A'_{gs}}{M'_p - M_p}, 0, \frac{C'_{ph} - B_t - C'_{pl}}{M_p - M'_p})$, $E_{12}(\frac{M_t + M'_p - A'_g - A_{gs}}{A_g + M'_p - M_p - A'_g}, 1, \frac{C_{ph} - B_t - C_{pl}}{M_p - M'_p})$.

Since $x, y, z \in [0,1]$, $E_9 - E_{12}$ are meaningful under certain conditions. Because $M'_p - M_p < 0$, E_{11} is meaningful. Since $A_g + A_{gs} > M_p + M_t$, so $\frac{M_t + M'_p - A'_g - A_{gs}}{A_g + M'_p - M_p - A'_g} > 1$ or $\frac{M_t + M'_p - A'_g - A_{gs}}{A_g + M'_p - M_p - A'_g} < 0$, then E_{12} is meaningless.

The Jacobian matrix of the three-party evolutionary game system is:

$$J = \begin{bmatrix} \frac{\partial F_1(x,y,z)}{\partial x} & \frac{\partial F_1(x,y,z)}{\partial y} & \frac{\partial F_1(x,y,z)}{\partial z} \\ \frac{\partial F_2(x,y,z)}{\partial x} & \frac{\partial F_2(x,y,z)}{\partial y} & \frac{\partial F_2(x,y,z)}{\partial z} \\ \frac{\partial F_3(x,y,z)}{\partial x} & \frac{\partial F_3(x,y,z)}{\partial y} & \frac{\partial F_3(x,y,z)}{\partial z} \end{bmatrix} =$$

$$\begin{bmatrix} (2x - 1)[C'_{ph} - B_t - C'_{pl} + (C_{ph} - C'_{ph} - C_{pl} + C'_{pl})y + (M'_p - M_p)z] & x(x - 1)(C_{ph} - C'_{ph} - C_{pl} + C'_{pl}) & x(x - 1)(M'_p - M_p)z \\ 0 & (2y - 1)[-V_t + V'_t + (M'_t - M_t)z] & y(y - 1)(M'_t - M_t)z \\ z(z - 1)[(A'_g - A_g)xy + (M_p - M'_p)x + (M_t - A'_{gs} - M'_t - A'_g - A_{gs})y + (M'_t + M'_p + A'_{gs})] & z(z - 1)[(A'_g - A_g)x + (M_t - A'_{gs} - M'_t - A'_g - A_{gs})] & (2z - 1)[(A'_g - A_g)xy + (M_p - M'_p)x + (M_t - A'_{gs} - M'_t - A'_g - A_{gs})y + (M'_t + M'_p + A'_{gs})] \end{bmatrix} \quad (5)$$

Using Lyapunov's first method: If all the eigenvalues of the Jacobian matrix have negative real parts, the equilibrium point is an asymptotically stable point; if at least one eigenvalue of the Jacobian matrix has a positive real part, the equilibrium point is an unstable point; if the Jacobian matrix

has eigenvalues with zero real parts and the rest have negative real parts, the equilibrium point is in a critical state, and its stability cannot be determined by the signs of the eigenvalues. The stability of each equilibrium point is analyzed as shown in Table 2.

Table 2. Stability Analysis of Equilibrium Points

Equilibrium Points	Eigenvalues: $\lambda_1, \lambda_2, \lambda_3$	Sign of Real Part	Stability Conclusion	Condition
$E_1(0,0,0)$	$B_t + C'_{pl} - C'_{ph}V_t - V'_t - M'_t - M'_p - A'_{gs}$	(-,×,-)	Uncertain	①
$E_2(1,0,0)$	$C'_{ph} - B_t - C'_{pl}V_t - V'_t - M'_t - M_p - A'_{gs}$	(+,×,-)	Unstable	\
$E_3(0,1,0)$	$B_t + C'_{pl} - C'_{ph}V'_t - V_t - A'_g + A_{gs} - M_t - M'_p$	(-,×,+)	Unstable	\
$E_4(0,0,1)$	$M_p - M'_p + B_t + C'_{pl} - C'_{ph}V_t - V'_t + M_t - M'_t - M'_p + A'_{gs}$	(×,×,+)	Unstable	\
$E_5(0,1,1)$	$M_p - M'_p + B_t + C'_{pl} - C'_{ph}V'_t - V_t + M'_t - M_t - M'_t + M'_p - A'_g - A_{gs}$	(×,×,-)	Uncertain	②
$E_6(1,0,1)$	$C'_{ph} - B_t - C'_{pl} + M'_p - M_p - V_t - V'_t + M_t - M'_t - M'_t + M_p + A'_{gs}$	(×,×,+)	Unstable	\
$E_7(1,1,0)$	$C'_{ph} - B_t - C'_{pl}V'_t - V_t - A_g + A_{gs} - M_p - M_t$	(+,×,+)	Unstable	\
$E_8(1,1,1)$	$M'_p - M_p + C'_{ph} - B_t - C'_{pl}V'_t - V_t + M'_t - M_t - M_p + M_t - A_g - A_{gs}$	(-,×,-)	Uncertain	③
$E_9(0, y_1, z_1)$	$B_t + C'_{pl} - C'_{ph} + (C'_{ph} - C'_{ph} + C'_{pl} - C'_{pl})y_1 + (M_p - M'_p)z_1,$ $\sqrt{y_1(y_1 - 1)(V_t - V'_t)z_1(z_1 - 1)(M_t - A'_{gs} - M'_t - A'_g - A_{gs})},$ $-\sqrt{y_1(y_1 - 1)(V_t - V'_t)z_1(z_1 - 1)(M_t - A'_{gs} - M'_t - A'_g - A_{gs})}$	(×,+,-)	Unstable	④
$E_{10}(1, y_2, z_2)$	$C'_{ph} - B_t - C'_{pl} + (C'_{ph} - C'_{ph} - C'_{pl} + C'_{pl})y_2 + (M'_p - M_p)z_2,$ $\sqrt{y_2(y_2 - 1)(V_t - V'_t)z_2(z_2 - 1)(M_t - A'_{gs} - M'_t - A'_g - A_{gs})},$ $-\sqrt{y_2(y_2 - 1)(V_t - V'_t)z_2(z_2 - 1)(M_t - A'_{gs} - M'_t - A'_g - A_{gs})}$	(×,+,-)	Unstable	④

Note: × represents an uncertain sign. y_1, y_2, z_1, z_2 are the coordinates of the corresponding equilibrium points respectively. If the conditions corresponding to the equilibrium point are not satisfied, the equilibrium point is unstable or meaningless. ① $V'_t - V_t < 0$; ② $M_p - M'_p + B_t + C'_{pl} - C'_{ph} < 0, V'_t - V_t + M'_t - M_t < 0$; ③ $M'_p - M_p + C'_{ph} - B_t - C'_{pl} < 0, V'_t - V_t + M'_t - M_t < 0$; ④ $0 < V'_t - V_t < M_t - M'_t$.

4. Simulation

To verify the effectiveness of the evolutionary stability analysis, the model is assigned numerical values in combination with the actual situation, and numerical simulations are carried out using Python.

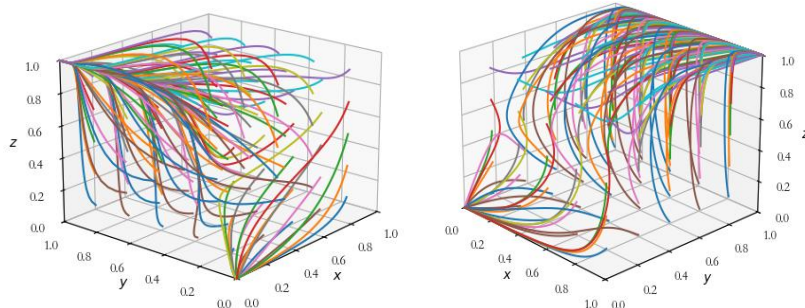
Array 1: $C_{ph} = 100, C_{pl} = 4, B_t = 20, C'_{ph} = 25, C'_{pl} = 1, V_t = 50, V'_t = 10, M_p = 20, M'_p = 10, M_t = 20, M'_t = 10, A_g = 50, A'_g = 0, A_{gs} = 100, A'_{gs} = 10$.

Array 2: $C_{ph} = 30, C_{pl} = 6, B_t = 15, C'_{ph} = 25, C'_{pl} = 5, V_t = 20, V'_t = 25, M_p = 20, M'_p = 10, M_t = 20, M'_t = 10, A_g = 50, A'_g = 0, A_{gs} = 50, A'_{gs} = 15$.

Array 3: $C_{ph} = 100, C_{pl} = 4, B_t = 20, C'_{ph} = 25, C'_{pl} = 1, V_t = 20, V'_t = 10, M_p = 20, M'_p = 10, M_t = 20, M'_t = 10, A_g = 50, A'_g = 0, A_{gs} = 100, A'_{gs} = 10$.

Array 4: $C_{ph} = 50, C_{pl} = 2, B_t = 60, C'_{ph} = 25, C'_{pl} = 1, V_t = 20, V'_t = 10, M_p = 20, M'_p = 10, M_t = 20, M'_t = 10, A_g = 50, A'_g = 0, A_{gs} = 100, A'_{gs} = 10$.

Figure 2 shows that under the conditions of satisfying Conditions ①, ②, and ④, the system has two stable points (0,0,0) and (0,1,1), that is, the strategy combinations of the state-owned enterprise, listed company, and government (low-price and suppression, reject M&A, do not encourage M&A) and (low-price and suppression, accept M&A, encourage M&A) are two evolutionary stable strategy combinations. Under the conditions of satisfying Conditions ①, ②, ③, and ④, the system also has two stable points (0,0,0) and (1,1,1), that is, the strategy combinations of the state-owned enterprise, listed company, and government (low-price and suppression, reject M&A, do not encourage M&A) and (high-price, accept M&A, encourage M&A) are two evolutionary stable strategy combinations.



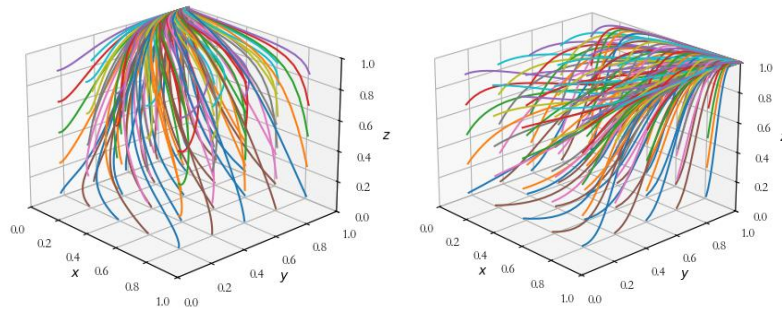


Figure 2 Results of Array 1(upper left), Array 2(upper right), Array 3(bottom left), Array 4(bottom right) Evolving for 50 Times

When Condition ① is not satisfied and Condition ④ is satisfied, the system has only one stable point (0,1,1), that is, the strategy combination of the state-owned enterprise, listed company, and government (low-price and suppression, accept M&A, encourage M&A) is an evolutionary stable strategy combination. When Condition ① is not satisfied and Condition ③ is satisfied, the system also has only one stable point (1,1,1), that is, the strategy combination of the state-owned enterprise, listed company, and government (high-price, accept M&A, encourage M&A) is an evolutionary stable strategy combination. Therefore, the government should actively encourage M&A plans to promote listed companies to accept M&A, lay the foundation for optimizing resource allocation and industrial integration and innovation, and thus promote the rapid development of the social economy and improve people's livelihood and well-being. It can be seen that the simulation analysis is consistent with the conclusions of the stability analysis of each party's strategies and is effective, which has practical guiding significance for the strategic choices of the three-party game.

5. Summary

The main conclusions of this paper are as follows:

First, regardless of the success or failure of the M&A, the smaller the M&A price difference of state-owned enterprises, the greater the probability that they offer a high price, and the greater the probability that the government encourages.

Second, as other costs increase, the probability that state-owned enterprises choose high-price M&A increases, and the probability that listed companies accept also increases.

Third, as the revenue gap increases (that is, the advantage of accepting the M&A increases), the probability that listed companies accept the M&A increases, and the probability that the government encourages decreases.

Fourth, regardless of the success or failure of the M&A, the greater the difference in capital investment of the government's assistance to state-owned enterprises or listed companies, the greater the probability that state-owned enterprises offer a high price, and the probability that listed companies accept also increases.

We believe that with the help of this model, we can help enterprises in need predict the trends of the three parties more accurately and make further decisions. Perhaps this is just the tip of the iceberg for now, but based on this, by changing and adding parameters according to needs and updating data in real-time, the potential of this model will be limitless.

Acknowledgements

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