
The Complexity of Cooperation between Shareholder and Manager: Computational Experiments Using Agent-based Modeling and Simulation

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Abstract:

This paper aims to study the complex cooperation between shareholder and manager on the basis of agent-based modeling and simulation. The shareholder and manager were in the prisoner's dilemma, then repeated game between them under bounded rationality assumption were simulated on computer, and their adaptive behaviors in the repeated game were studied. Results show shareholder and manager with equal status tend to cooperate with each other in repeated game. However, the betrayal and control still exist during the whole process, reflecting the complexity of cooperation. "Tit for tat" strategy is the optimal strategy. When shareholder and manager have unequal status and there is misunderstanding between them, shareholder with dominant position can obtain greater benefits. Manager can obtain some benefits in early period of repeated game if he/she chooses to betray shareholder, but loses more benefits in the long run. If shareholder uses "two tits for one tat" strategy and manager uses "one tit for two tats", they tend to cooperate with each other and a balance of interests between them can be achieved during repeated game, resulting in a win-win situation.

Keywords: Cooperation, Complexity, Misunderstanding, Agent-based modeling and simulation.

I. INTRODUCTION

In the development of Walt Disney company, professional managers were hired, who led to the separation of ownership and control. The full cooperation between the manager Michael Eisner and shareholders has created value for the company in the first decade of his term. However, he gradually violated the interests of Disney's shareholders over the next ten years. Finally, the California Public Employees' Retirement System and Disney's major shareholders cooperated to regain the control of the company. In addition, Gao and Guo pointed out that

there are frequent conflicts regarding control of the firm in the management practice of GOME Electrical Appliances. When the benefit goals of the founding shareholders and the professional managers are inconsistent, the rational managers will comprehensively weigh the control authority of founding shareholders and effect of sticking to professional ethics on their social capital, and then decide whether to compete for control [1]. Xu and Liu pointed out that the private benefits of control leads to power struggle and power defense, and finally competition for control in GOME Electrical Appliances [2]. Moreover, there is another case in Zheng Baiwen's company. Quite a number of subsidiary managers used the sales channels and investments of Zheng Baiwen Company to sell their own products and earned money for themselves. Thus, the control rights of local managers become a tool for serving their own interest. These cases show that among numerous stakeholders the shareholders and managers have the most obvious conflict of interest. There are both conflict and cooperation between shareholders and managers, which is a classic case of repeated game problem in economics. How to resolve the conflict of interest between shareholders and managers? How to achieve a balance of interests between them? How to turn the relationship between them from conflict to cooperation? Answering these questions is an important objective of corporate governance research.

Corporate governance theory puts special emphasis on the relationship between the shareholders and managers. Agency theory stresses the supervision and control over managers, whereas stewardship theory emphasizes the trust and cooperation between them. In this paper, on the basis of complexity science and complex adaptive system, the agent-based modeling and simulation (ABMS), which employed object-oriented programming, was adopted to study the complex control and cooperation between shareholders and managers. The shareholder and manager were in the prisoner's dilemma, and their adaptive behaviors were studied during repeated game under the bounded rationality assumption. Simulation experiment was carried out on the computer, and experimental results were obtained, which can be used to analyze the game process under variable conditions (What-if?). ABMS overcomes the limitation of the mathematical modeling of the principal-agent model by traditional game theory and has robust performance.

II. THEORETICAL ANALYSIS AND RESEARCH METHOD

2.1 Theoretical Analysis

In view of above problems, previous researchers have obtained significant achievements in agency theory, stewardship theory and game theory. However, they just studied these theories from certain aspects and failed to incorporate them into a framework to dynamically study the complex conflict and cooperation between shareholders and managers.

Agency theory originates from economic theory and financial theory. It supposes that managers exhibit opportunistic behavior and are driven by extrinsic motivation, and their goals are in conflict with those of shareholders. In addition, these managers hate risk and cannot be trusted, so they need to be supervised and controlled. Jensen and Meckling put forward the

agency theory, in which managers are self-interested, cannot bear the full responsibilities for the influence of their decisions on wealth [3]. Shleifer and Vishny pointed out that corporate governance mechanism provides some protection to shareholders, in which managers work hard to benefit the shareholders [4]. Walsh and Seward proposed that shareholders can make the interests of managers consistent with theirs with the help of internal and external governance mechanisms. Thus, listed companies can survive and prosper even if their managers have a tendency to be self-interested [5]. Dalton et al. proposed that the agency theory is dominant in corporate governance research. In almost all modern governance researches, the governance mechanism is defined as to prevent the self-interested behavior of the manager [6].

The stewardship theory originates from sociology and psychology. It supposes that managers have collective tendency toward cooperation and are driven by intrinsic motivation, and their objectives are consistent with those of shareholders. Thus, they have the courage to take risks because of the trust. Davis et al. pointed out that agency theory and stewardship theory are contradictory but also complementary to each other. Agency theorists view managers and directors as opportunists who serve for their own purpose. Stewardship theorists believe that the interests of managers are in line with those of shareholders, but this does not mean that managers or directors are selfless [7]. Lane et al. pointed out that managers serve not only the interests of shareholders but also their self-interest in many cases [8]. Baysinger and Hoskisson thought that the reputation of managers is associated with the financial performance of the company. In order to protect their reputation as decision-making experts, managers and directors tend to operate the company in a way of maximizing financial performance, including the return of shareholders [9]. Fama pointed out that directors and managers, as the organization expert, also manage their careers effectively [10].

In summary, it can be found that agency theory emphasizes the control while the stewardship theory stresses cooperation, representing two extreme and opposite theory. In fact, the relationship between shareholders and managers is between these two extremes; that is, there is regulation and control as well as trust and cooperation between shareholders and managers.

There are many mathematical modeling studies on the principal-agent problem in game theory, but most of them are based on the rational man hypothesis in economics and pay more attention to mathematical rigor. Therefore, they are unable to study the issue of bounded rationality in the real world. In addition, as human beings, shareholders and managers aim to achieve satisfaction but not the optimal solution. Adjusting the decision according to former experience, which is a kind of adaptive behavior, it cannot be studied by the traditional game theory. Li proposed that using Bryant's coordination game to describe trust may give an optimal Pareto coordination game result, which can better solve the problem of trust in agent. However, it is impossible or difficult for the familism trust to solve the problem of agent ability shortage with the increasing organization size or trading complexity, which is known as "Familism Dilemma" [11]. Zhang put forward that there is a trust game between entrepreneurs and professional managers, and he deeply analyzed the implementation

mechanism of the trust, the affection mechanism and the credit mechanism generated from the repeated game. Further, he analyzed how to establish the trust between entrepreneurs and professional managers from the internal system design and the external environment construction [12]. In addition, many scholars have recognized the complexity of the repeated game between large shareholders and professional managers. By using qualitative analysis and mathematical derivation, however, these scholars still cannot elaborate the complex dynamic evolution process of the repeated game between shareholders and managers, draw up a general rule and provide solutions to specific problems. In fact, problems that cannot be solved using qualitative analysis and mathematical modeling can be easily solved using a computer. Foster pointed out that science has developed in two directions: Various disciplines enter deeply into computer science, and computer science penetrates into each subject [13].

2.2 Agent-based Modeling and Simulation

Since case study is more suitable for the analysis of a single or a small number of enterprises, it is difficult to draw general conclusions from case study. In addition, it is also difficult to use econometric and experimental economics to find the law of long-term evolution formed during the development of enterprise. Therefore, Zheng thought that ABMS is a new method of management decision making and is suitable to solve complex and robustness problems. ABMS is based on the following assumptions: a. System is greater than the simple sum of its components. b. The system behavior is captured from bottom to top. c. The process from adaptive behavior of nonlinear interaction among micro individuals to the emergence of the macro phenomenon of the system is captured. The future trend of system is forecasted and scientific decision is made by controlling and regulating the behavior of agent [14]. Robert Axelrod thought ABMS is the main method for studying complexity problem and a third research method beside induction and deduction [15]. North and Michael [16] as well as Tesfatsion and Judd [17] thought that the assumptions underlying ABMS tend to be more loose, which allows for bounded rationality, adaptive adjustment and asymmetric information. Loose hypothesis is able to meet reality, but the overall result of nonlinear interaction among individuals is complex and is beyond the limits of human imagination, which necessitates the help of computers in research.

III. EXPERIMENTAL DESIGN OF REPEATED GAME BETWEEN SHAREHOLDERS AND MANAGERS

We proposed a basic problem regarding the conflict of interest between shareholders and managers from above cases and theoretical analysis. Whether there is a balance of interest between shareholders and managers determines competition for private benefits of control, cooperation based on trust or control based on distrust. The conflict of interest between shareholders and managers indicates the relationship between them is an interactive one, which is characterized by feedback, reciprocal causation and recursion. In fact, shareholders and managers are in a prisoner's dilemma raised by Rand Company, as shown in TABLE I.

If shareholder and manager cooperate with each other, each person will get three points; if

one person betrays the other one, he/she will get five points whereas the other one will get zero; if they betray each other at the same time, both of them will get one point. In a single game, almost everyone chooses to betray the other person in order to maximize their own interests. However, in repeated game, things are very different. Once the betrayal occurs, the betrayed person will revenge next time. Thus, both sides need to adopt the correct strategy during repeated game in order to obtain the highest score. Research of Robert Axelrod showed the best strategy is the "tit for tat" [18]. In our research, there are 4 situations in each game and thus 64 situations in three games ($4 \times 4 \times 4 = 64$). Human brain can still accurately analyze these situations. However, once the number of games reaches 100, there will be 4100 results, which is far beyond the limits of human imagination. Therefore, it is necessary to employ computer simulation techniques to study such complex problems. In this experiment, netlogo5.0 software was used [19]. In addition, on the basis of Two Person Iterated PD model developed by Wilensk, U [20], the conditions including interference (misunderstanding and misoperation) and status inequality were added to the software for further development and the simulation experiment was then carried out. The initial program interface is shown in Fig 1.

TABLE I. Prisoner's dilemma

		manager	
		cooperation	betrayal
Shareholder	cooperation	(3, 3)	(0, 5)
	betrayal	(5, 0)	(1, 1)

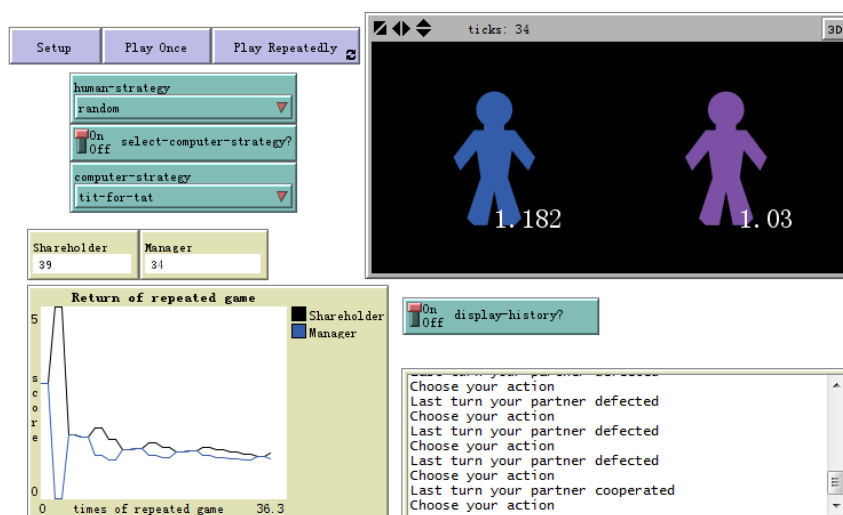


Fig 1: Operation interface of the repeated game between shareholder and manager with Netlogo5.0 software

IV. REPEATED GAME BETWEEN SHAREHOLDER AND MANAGER WITH EQUAL STATUS

The assumption is that there are only one major shareholder and one manager who have equal status and are able to make fair decisions. Each side of the game can adopt one of the following six strategies at first: random strategy, cooperation strategy, betrayal strategy, "tit for tat" strategy, "one tit for two tats" strategy and "countless tits for one tat" strategy. Random strategy means one person randomly choose cooperation or betrayal. Cooperation strategy means the shareholder cooperates with the manager from beginning to end. Betrayal strategy means one person always betray the other person. The "tit for tat" strategy means one person chooses cooperation in the first game, and then in following games he keeps using the same strategy used by the other person in last game. If the other person is cooperative last time, this person will use the cooperation strategy this time, too; if the other person uses betrayal strategy last time, this person will use the betrayal strategy this time, too. The "one tit for two tats" strategy means one person will revenge (that is, betray) the other person once after being betrayed twice. The "countless tits for one tat" strategy means one person keeps revenging the other person after being betrayed once. Shareholder and manager, at two sides of the game, both can use any of the six strategies at first. Thus, there are 36 possible situations in the first game, based on which 36 groups of experiments were carried out on computer. Then, we selected several representative experiments for dynamic analysis.

4.1 Repeated Game between Shareholder Using Betrayal Strategy and Manager Using Cooperation Strategy

As shown in Fig 2, the shareholder always uses the betrayal strategy, and the manager always uses the cooperation strategy. During the repeated game, the shareholder keep getting five points each time, whereas the manager keep getting zero. Thus, the benefit of shareholder's betrayal strategy is much higher than that of manager's cooperation strategy, which is consistent with previous studies. Shareholder can commit self-dealing by reducing the risk of company. He/she deprives managers, employees and other shareholders of wealth in order to maximize profit or make his/her interests better than those of other shareholders [21,22]. There is the result of the repeated game in which the shareholder uses the betrayal strategy and the manager uses cooperation strategy. In the real world, the manager will change his/her strategy after several games in order to punish the shareholder.

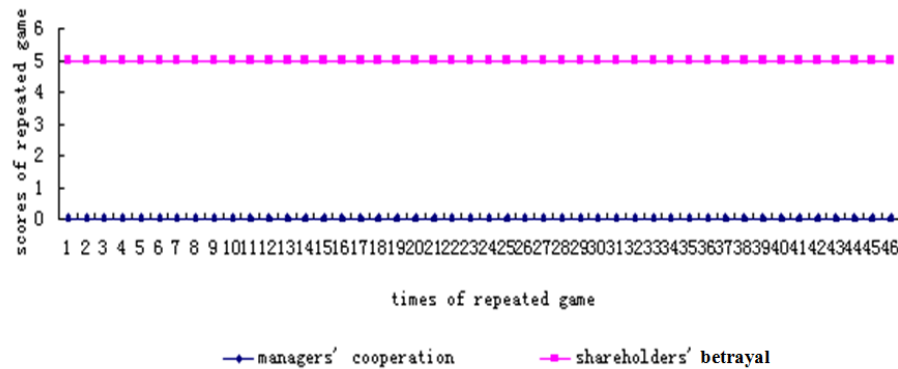


Fig 2: Benefit of shareholder's betrayal strategy and manager's cooperation strategy during the repeated game

4.2 Repeated Game between Shareholder Using Betrayal Strategy and Manager Using "One Tit for Two Tats" Strategy

As described above, shareholder using betrayal strategy means the shareholder always betray the manager, and manager using "one tit for two tats" strategy means the manager chooses cooperation first and will revenge once after being betrayed twice by the shareholder. This repeated game between shareholder and manager is different from that shown in Fig 2. When the manager realizes that his/her interests are violated by the shareholder in the long run, he/she will revenge the shareholder in an appropriate time. As shown in Fig 3, the benefit of shareholder's betrayal strategy is higher than that of manager's "one tit for two tats" strategy, meaning the shareholder usurps the benefit of the manager. Since the manager will revenge the shareholder once after being betrayed twice, his/her benefit increases gradually, which is different from the case shown in Fig 2 (The manager always gets zero).

The manager can betray the shareholder though many ways. For example, he/she might loaf on the job and never plans to make a contribution to the company. Besides, in a case where the shareholder is unable to fully understand the complex operation and management activities, the manager can use discretion to punish the shareholder, such as increasing on-the-job consumption, promoting his/her own cronies, cultivating his/her own power, investing in projects that may violate the interests of the shareholder but increase his/her own profit. Murphy Kevin proposed that managers have the incentive to make the company size larger than the optimal size. By increasing the resources that they control, the managers increase their power with increasing size of company [23]. This is also related to the increase in compensation for managers because the pay is positively related to the sales growth. Jensen put forward that the conflict of interest between shareholders and managers on the dividend payment policy is particularly intense when the organization produces a large amount of cash flow. The problem is how to motivate managers to "spit out" money rather than invest it in projects whose gains are lower than capital costs or waste it in the inefficient aspects of organizations [3]. These are consistent with results of simulation experiments.

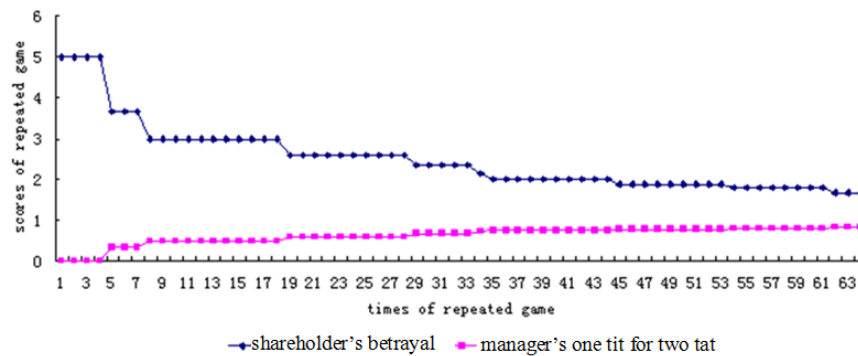


Fig 3: Benefit of shareholder's betrayal strategy and manager's "one tit for two tat" strategy during repeated game

4.3 Repeated Game between Shareholder Using Cooperation Strategy and Manager Using Random Strategy

When the manager is not satisfied with the shareholder's betrayal strategy and "two tits for one tat" strategy cannot make up for his/her loss of benefits, he/she might completely adopt the betrayal strategy without cooperation any more. In the prisoner's dilemma, the shareholder and the manager simultaneously using the betrayal strategy is the worst case. Both sides work for maximizing their own interests, but they obtain an unexpected counter-intuitive result; that is, both sides keep getting one point during repeated game, meaning that both of them suffer a loss of interests. When the shareholder and the manager realize this, they might change their strategies. If the shareholder chooses to use cooperation strategy, he/she will cooperate with the manager from beginning to end. However, the manager might decide to use random strategy, meaning he/she randomly choose cooperation or betrayal. As shown in Fig 4, the benefit of shareholder's cooperation strategy is lower than that of manager's random strategy. The manager acts treacherously and obtains more benefits. In contrast, the shareholder, who keep cooperating with the manager from beginning to end, obtains less benefits. Thus, the shareholder might decide that it is time to punish the manager.

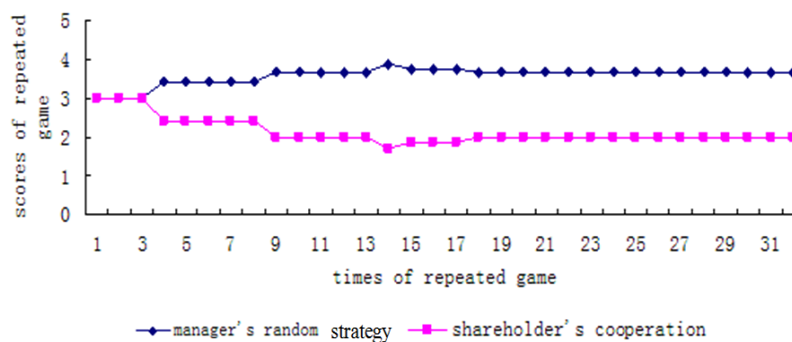


Fig 4: Benefit of shareholder's cooperation strategy and manager's random strategy during repeated game

4.4 Repeated Game between Shareholder Using "Tit for Tat" Strategy and Manager Using Cooperation Strategy

Since the manager uses a random strategy, he/she sometimes betray the shareholder and sometimes cooperate with the shareholder. Then, the shareholder might change his/her strategy. Fig 5 shows a case where the shareholder uses the strategy of "tit for tat" and the manager uses cooperation strategy. The shareholder and the manager cooperate with each other in the first game. Since the manager uses cooperation strategy and the shareholder uses the strategy of "tit for tat", two sides keep cooperating with each other during following games. On the basis of cooperation, the shareholder and the manager both get three points in each game and gain the same benefits from it. They recognize the importance of cooperation. These results are consistent with previous studies. Through the above five simulation experiments, it can be seen that the two sides of the repeated game have a tendency toward cooperation, but the process is accompanied by betrayal and control, showing the complexity of cooperation.

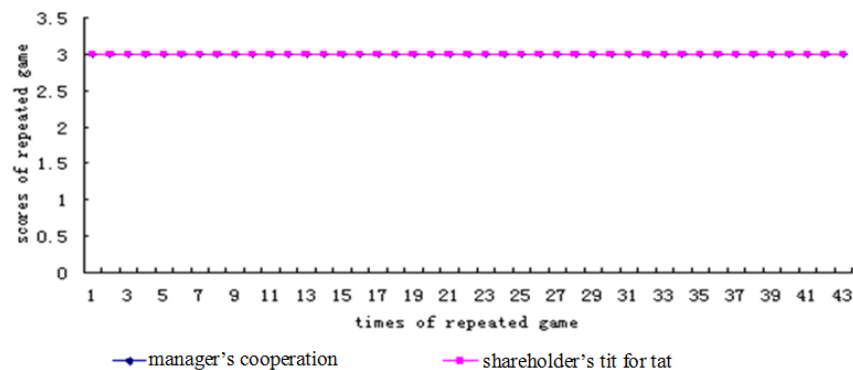


Fig 5: Benefit of manager's cooperation strategy and shareholder's "tit for tat" strategy during repeated game

4.5 The Optimal Strategy of Shareholder and Manager during Repeated Game

As shown in Fig 6, "tit for tat" strategy obtains the highest score after 45 games, which is consistent with study of Axelrod Robert [15], followed by betrayal strategy, "countless tits for one tat" strategy, random strategy and cooperation strategy. The experimental result will be the same for more games. A person using "tit for tat" strategy means that this person choose cooperation in the first game, and then in following games he keeps adopting the same strategy used by the other person in last game. If the other person is cooperative last time, he/she will use cooperation strategy this time, too. If the other person betrays him/her last time, he/she will use betrayal strategy this time, too. The agency theory emphasizes the supervision and restriction over managers, whereas the stewardship theory emphasizes that shareholders should trust and cooperate with managers. These two theories represent two opposite but complementary aspects, which is similar to the Yin and Yang of Tai Chi.

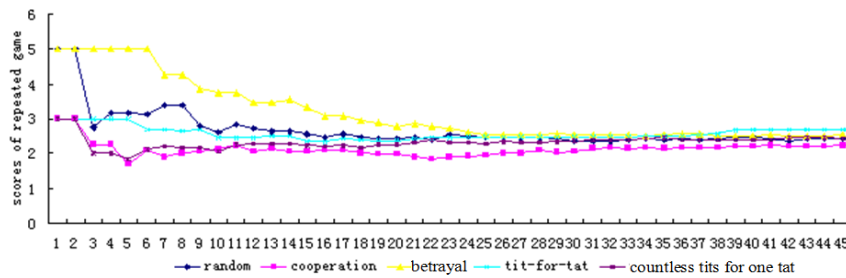


Fig 6: Benefits of five strategies used by shareholder and manager during repeated game

V. REPEATED GAME BETWEEN SHAREHOLDER AND MANAGER WITH UNEQUAL STATUS UNDER INTERFERENCE

Commonly, major shareholder and professional manager have unequal status. The position of a major shareholder in the enterprise is often more dominant. Manager is worried about being fired and subjected to more constraints and unequal treatment. In addition, there is interference including misoperation and misunderstanding in cooperation between shareholder and manager. Misoperation means the human error in operation, and misunderstanding is the opposite understanding of each other's behavior. The misoperation rate is set to 5%, and the misunderstanding rate is set to 10%. The results of repeated game between shareholder and manager with unequal status under interference are as follows.

5.1 Repeated Game between Shareholder Using "Three Tits for One Tat" Strategy and Manager Using "One Tit for Three Tats" Strategy

If major shareholder and professional manager have extremely unequal status, the conflict of interest between them tends to be less violent. Dominant shareholder tend to use "three tits for one tat" strategy, meaning that they would punish manager three times as a sign of discipline as long as the betrayal of manager occurs once. Manager tends to adopt "one tit for three tats" strategy, indicating that he/she will revenge shareholder once after being betrayed three times. As shown in Fig 7, the benefit of "three tits for one tat" strategy is significantly higher than that of "one tit for three tats" strategy after 58 games. More benefits are obtained by dominant shareholder.

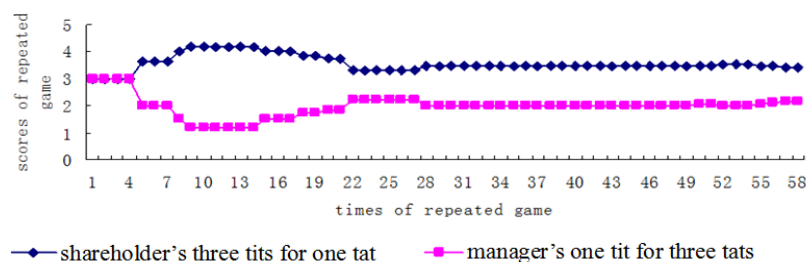


Fig 7: Benefit of shareholder's "three tits for one tat" strategy and manager's "one tit for three tats" strategy during repeated game

5.2 Repeated Game between Shareholder Using "Countless Tits for One Tat" Strategy and Manager Using Betrayal Strategy

As shown in Fig 8, major shareholder adopts the "countless tits for one tat" strategy. Once the betrayal of manager is found, the shareholder will never forgive him/her. Manager can betray shareholder through many ways, such as loafing on the job, avoiding risk and making no contribution. In early period of repeated game, the score of betrayal strategy is higher than that of "countless tits for one tat" strategy. Figs 7 and 8 show that benefit of the person using more betrayals is always higher in early period of repeated game. If the conflict of interest gets more violent, the weaker side is expelled from the repeated game. In addition, manager's long-term interests will be more severely violated if he/she betray the shareholder. Shareholder, who has dominant position, often does not give more chances to manager. For example, the probationary period of professional manager is set to only three months or six months. Thus, a focus on the analysis of early period of repeated game, such as the first 8 games (Fig 8), is important. In some extreme cases, major shareholder with dominant status, using "countless tits for one tat" strategy, will fire manager after finding the betrayal of manager, and the repeated game is ended.

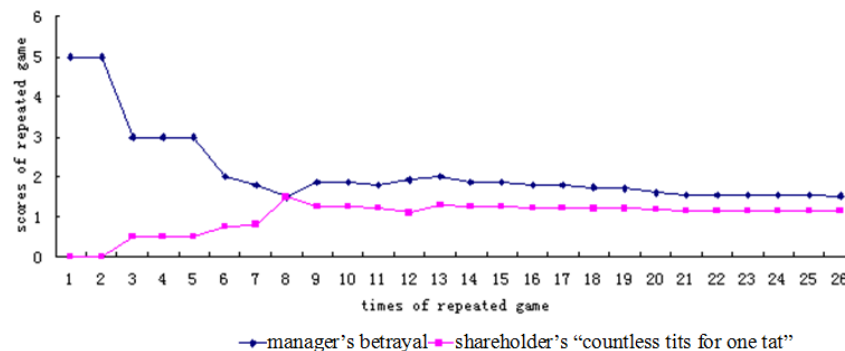


Fig 8: Benefit of shareholder's "countless tits for one tat" strategy and manager's betrayal strategy during repeated game

5.3 Repeated Game between Shareholder Using "Two Tits for One Tat" Strategy and Manager Using "One Tit for Two Tats" Strategy

The "one tit for two tats" strategy used by manager means that he/she will revenge the shareholder once if he/she is betrayed by the shareholder twice. This strategy is often adopted by the weak side. The "two tits for one tat" strategy used by shareholder indicates that he/she will revenge the manager twice if he/she is betrayed by the manager once. This strategy is often adopted by the strong side. The starting points of these two strategies are both cooperation. When there are interference including misunderstanding and misoperation in cooperation, two sides will have conflict with each other and obtain different profits in the short term, as shown in Fig 9. However, in the long run, there will be a balance between their profits, meaning a trend of cooperation between two sides. Major shareholder and professional manager with unequal status tend to cooperate with each other during repeated game and create a win-win

situation.

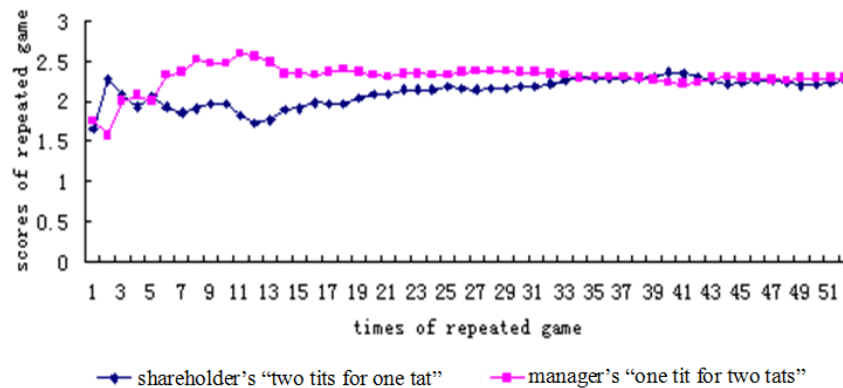


Fig 9: Benefit of shareholder's "two tits for one tat" strategy and manager's "one tit for two tats" strategy during repeated game

VI. VERIFICATION AND VALIDATION

Verification and validation is a key step of simulation experiment, which directly affects the scientificity, rigor and credibility of simulation experiment. ABMS consists of two main steps: modeling and simulation. The built computer model needs to be verified for correctness, and then the verified computer model needs to be validated for its effectiveness.

Verification of model correctness was performed using structural walkthrough. The program executed correctly, indicating the model does not have errors, omissions and defects. Then, the model was validated in terms of its input, output and operation process in order to study whether it reflects the behavior of real system. The model was compared with the case in real world in order to investigate whether it can solve real problems. In addition, we compared our simulation results to those in previous study and found they are consistent.

VII. CONCLUSIONS AND IMPLICATIONS

Conclusions of this study are as follows: If shareholder and manager have equal status, "tit for tat" is the optimal strategy in repeated game, followed by betrayal strategy, "countless tits for one tat" strategy, random strategy and cooperation strategy. If shareholder and manager have unequal status under interference including misoperation and misunderstanding, dominant shareholder tends to obtain greater benefits. Manager can obtain some benefits in early period of repeated game if he/she chooses to betray shareholder, but will lose more benefits in the long run. Manager using "one tit for two tats" strategy and shareholder using "two tits for one tat" strategy turn out to be a win-win situation. Although two sides have conflicts in early period of repeated game because of the influence of interference and unequal status, there will be a balance between their benefits in the long run, indicating both sides tend to cooperate with each other in order to create a win-win situation.

Implications of this study are as follows: There is a conflict of interest between shareholders

and managers, which is the basic cause of the complex phenomenon of control and cooperation. The goal of corporate governance is to achieve the balance of interests, a win-win situation, and cooperation in repeated game. When two sides of the repeated game have equal status, the optimal strategy is "tit for tat". If one side adopts this strategy, there will be a trend towards cooperation in the long run. When there is interference and two sides of the repeated game have unequal status, dominant shareholder will obtain greater benefits. Manager can obtain some benefits in early period of repeated game if he/she chooses to betray shareholder, but will lose more benefits in the long run. If shareholder uses "two tits for one tat" strategy and manager uses "one tit for two tats" strategy, two sides tend to cooperate with each other and a balance of interest between them can be achieved during repeated game, resulting in a win-win situation.

Contributions of this study are as follows: This paper is an interdisciplinary research, which integrates the complexity science, corporate governance theory and game theory, and allows for a deep understanding of complexity of cooperation between shareholders and managers. On the basis of agent-based modeling and simulation, the shareholders and managers were put in the prisoner's dilemma under bounded rationality assumption, then the repeated game between them was simulated on computer, and their adaptive behavior in the repeated game were studied. When two sides of the repeated game have equal status, the "tit for tat" strategy is the optimal strategy, which is consistent with the study of Robert Axelrod [15]. In addition, shareholder and manager have a tendency to cooperate with each other, solve the conflict of interests and achieve a balance of benefit during repeated game. However, there are still betrayal and control during the whole process, which reflects the complexity of cooperation.

The goal of future research is to study the adaptive behavior of shareholder and manager on the basis of evolutionary game theory and genetic algorithm. In addition, it is necessary to turn the two-player game into a multiplayer game and reveal the evolution of strategies used by multiplayer.

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