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A Study on the Potential Application of Parrondo's Paradox in Industrial Clusters, Business Strategy and Public Affairs

Wei-Wei Xie[1], Yang Wang[2] and Qi-Wen Wang[2,*]
[1]School of Management, Northwest Minzu University, Gansu, 730030;
[2]School of Business, Shanghai DianJi University, Shanghai, 201306
*Correspondent Author: firstlovewen@163.com

ABSTRACT

The Parrondo's Paradox is described as two individually losing games can be combined in producing winning expectations. To date, Parrondo's Paradox has wide applications on biology, heuristic effect, evolution, investment, but there are few researches focus on the business and public. There are two versions of Parrondo's Paradox, which is termed as capital-dependent Parrondo's Paradox and history-dependent Parrondo's Paradox. Initial application of the Parrondo's Paradox in investment discipline includes the mixed individual-losing investment strategies leading to the winning outcomes. Subsequently, the heuristic effect of Parrondo's Paradox also demonstrate that information exchange can make market participants choosing corresponding investment strategies in a more rational way by reducing the potential risk of financial assets and mitigating the potential losses. Lastly, the application of Parrondo's Paradox will be extended into the other business disciplines, some potential applications will be addressed in this paper including business strategy, cluster effect and public management.

keywords: Parrondo's Paradox, business strategy, competition

INTRODUCTION

The Parrondo's Paradox was initially proposed by Spanish physicist, J.M.R. Parrondo. Then the original capital-dependent version of Parrondo's Paradox was expanded to the history-dependent Parrondo's Paradox by Parrondo, Harmer and Abbott (Harmer and Abbott 1999, Parrondo *et. al.*2000). Later, the Parrondian effect can be further altered by modifying the related parameters in the probability space (Harmer and Abbott 2002). Moreover, two winning games may also lead to the undesired outcomes (Percus 2002, Hammer *et. al.* 1999). After that, the original Parrondian effect was deliberately expended in the formation of strong Parrondian effect (Shu and Wang 2014).

In addition to the initial modification applied to the original version of Parrondo's Paradox, the Parrondo's game might also extend in many disciplines such as species coexistence and persistence, evolution, species diversity (Williams and Hastings 2011). For instance, in the environment of limited resources, the designated experiment proved that species can coexist by evolving according to the multi-resource model (Huang *et. al.* 2016, Armstrong & McGehee 1976). Moreover, high modularity and hierarchical level will increase the stability of species in the fluctuating environment (Pan and Sinha 2009). Intriguingly, in a specified environment, natural selection prefers to favor the organism with sensor of low accuracy instead of more accurate sensor (Kang Hao Cheong *et. al.* 2016) which means bacteria clones in a state known as random phrase variation can realize stable evolution. In addition, if combining the nomadism and colonialism can increase the population and take these two measures individually will lead to the maladaptive (Tan and Cheong 2017) and territory also can be expanded because of the population growth and habitat expansion (Tan and Cheong 2019).

In-so-far, majority of mentioned contributions have no straightforward relationship with the discipline of business. In reality, the framework of Parrondo's Paradox can be adopted in investment, which means two losing strategies may lead to the winning outcomes by combining these business strategies together (Ho Fai Ma *et. al.* 2017, Chakrabarti A. 2014). It can be demonstrated as follows: market participants can take two strategies, the first one is taking the same strategy as the nearest neighbor who obtain return from the

specified financial assets. The second strategy is avoiding to practice the losing strategies, whereas market participants know his nearest neighbors lose money from this respectively financial instrument. The participant will not adopt such losing strategy and shift its strategy into alternative version. If the market participants choose these two strategies independently, the capital gain from each individual strategy will be a negative amount (*i.e.*, a losing game for certain), a wining outcome can be produced via combining these two isolatedly losing strategies. Inspired from the application as specified above, market participants can exchange information to determine which assets can be profitable and simply invest on it. In addition, market participants can choose the specified strategy to obtain positive return on investment if they know the winning probability for both strategies. The cluster effect addressed in this example cannot be simply neglected, that is, it is essential for market participants know the entity which profits by investing on specified assets, and then follow such winning strategy.

2 ORIGINAL PARRONDO'S PARADOX

The definition of Parrondo's Paradox is that two individual losing games can be combined to obtain the winning expectations. The original Parrondo's Paradox includes two versions, namely, capital-dependent and history-dependent Parrondo's Paradox. These two versions of Parrondo's Paradox will be conclusively summarized in the following two sub-sections.

2.1 Capital-dependent Parrondo's Paradox

The capital-dependent Parrondo's Paradox includes two separate games, namely, game A and game B. Game A is simple coin-tossing game, a winning result will provide the player one unit of capital, and losing result will deduct one unit of capital from the player. The winning probability of game A is controlled by a biased coin 1 which offers winning probability of $P_A = 0.5 - \varepsilon$, and its losing probability is 1-P_A = 0.5 + ε . Game B is slightly complicated in contrast to game A, which consists of two separate scenarios, namely, scenario 1 and scenario 2, each scenario is associated with a biased coin offers different winning probabilities – for scenario 1, the winning probability is $P_{W1} = 0.1 - \varepsilon$; for scenario 2, the winning probability is $P_{W2} = 0.75 - \varepsilon$. Deciding which scenario to be selected and played is depending on whether instantaneous capital of the player can or cannot be divisible by a predefined integer M. In initial case, M = 3 is deliberately specified, suppose the capital is divisible by M, scenario 1 will be selected, otherwise, scenario 2 will be chosen. The outcome of game B is identical to that of game A, that is, a winning outcome will enable the player a gain one unit of capital, and conversely, a losing outcome will deduct one unit of the capital from the player. Game A and game B can be mathematically illustrated by using the following probability transition matrix:

$$g(A) = \begin{bmatrix} 0 & P_A & 1-P_A \\ 1-P_A & 0 & P_A \\ P_A & 1-P_A & 0 \end{bmatrix} \quad (1)$$

$$g(B) = \begin{bmatrix} 0 & P_{W1} & 1-P_{W1} \\ 1-P_{W2} & 0 & P_{W2} \\ P_{W2} & 1-P_{W2} & 0 \end{bmatrix} \quad (2)$$

Obviously, game A is a fair game when ε = 0, which means P_A = 0.5. When ε > 0, coin-tossing will entitle game A with a losing outcome in the long-run. Game A will be a winning game if ε < 0. Moreover, the winning probability of scenario 1 of game B is P_{W1} = 0.1 - ε and winning probability of scenario 2 is P_{W2} = 0.75 - ε .

The long-term effect of game B can be described by discrete-time Markov chain, which means the probability of each state (*i.e.*,$C_t \bmod M$ = 0, 1, 2) should be corrected as $\frac{5}{13}$, $\frac{2}{13}$ and $\frac{6}{13}$ instead of $\frac{1}{3}$. The derived state probability is illustrated in (3):

$$N_1 = \frac{1}{10}\cdot\frac{5}{13} + \frac{3}{4}\cdot\frac{2}{13} + \frac{3}{4}\cdot\frac{6}{13} = \frac{1}{2} \quad (3)$$

As specified in (3), game B is a fair game by using the corrected state probability. When ε ≠ 0, in order to explore whether game B of Parrondo's paradox will produce a winning or losing outcome individually, placing all the probabilities in the same probability space may result in equation (4) as stated below:

$$P_{W1}{P_{W2}}^{M-1} = (1-P_{W1})(1-P_{W2})^{M-1} \quad (4)$$

This equation implies the probability of winning is identical to its losing probability. Predefined integer M equals 3 in capital-dependent version of Parrondo's Paradox, the resulting equation should be described as (5):

$$\frac{P_{W1}{P_{W2}}^2}{(1-P_{W1})(1-P_{W2})^2} = 1 \quad (5)$$

Equation (5) can be modified to express the

relationship between P_{W1} and P_{W2}, which results in equation (6) as stated below:

$$P_{W1} = \frac{(1-P_{W2})^2}{{P_{W2}}^2 + (1-P_{W2})^2} \quad (6)$$

By referring to the equation (5), the entire probability space can be expressed as shown in Figure 1. As indicated in Figure 1, the probability space can be separated into two regions which can be mathematically described as equation (7) and (8).

$$P_{W1}{P_{W2}}^2 > (1-P_{W1})(1-P_{W2})^2 \quad (7)$$

$$P_{W1}{P_{W2}}^2 < (1-P_{W1})(1-P_{W2})^2 \quad (8)$$

By setting the probability $P_A = P_{W1} = P_{W2}$, the equation (5) can be transferred into the equation (9) as stated below:

$${P_A}^3 = (1-P_A)^3 \quad (9)$$

It is possible to obtain one real number solution $P_A = \frac{1}{2}$ and two imaginary number solutions $P_A = \frac{1}{2} - \frac{\sqrt{3}}{2}i$ and $P_A = \frac{1}{2} + \frac{\sqrt{3}}{2}i$. If $P_A > 1/2$, game A is a winning game, the selected probability is located in the winning region as specified in Figure 1, if < 1/2, it implies that game A is a losing game, the selected probability is located in the losing region. The real solution is = 1/2, this solution implies that winning probability equals to the losing probability, which means game A is a fair game. The similar analytical method can be employed in the analysis of game B.

2.2 History- Dependent Parrondo's Paradox

The second version of Parrondo's Paradox is history-dependent. Game A is identical to the capital-dependent Parrondo's Paradox. But the game B is much more complicated in contrast to that of capital-dependent version, game B is dependent of the outcomes of previous two games, the selected scenario in time t depends on the result of the time $t-1$, and $t-2$. Such that, game B includes 4 scenarios, namely, scenario 1 implies the outcome of previous two games is {lose, lose}, scenario 2 implies that the outcome of previous two games is {lose, win}, scenario 3 implies the outcome of previous two games is {win, lose}, scenario 4 specifies the outcome of previous two games is {win, win}. The associated probabilities of $P_{S1}, P_{S2}, P_{S3}, P_{S4}$ are specified in (10):

$$P_A = \frac{1}{2} - \varepsilon, \quad P_{S1} = \frac{9}{10} - \varepsilon, \; P_{S2} = P_{S3} = \frac{1}{4} - \varepsilon, \; P_{S4} = \frac{7}{10} - \varepsilon \quad (10)$$

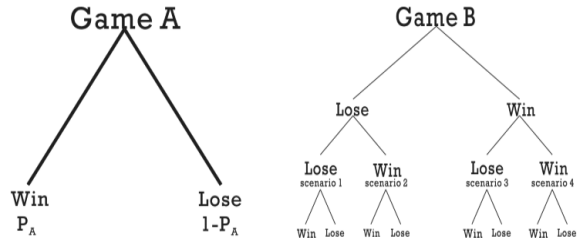

Figure 2 (a). Game of History-dependent Parrondo's Paradox.

The same analytical methods, which employed in capital-dependent Parrondo's paradox, can be utilized in history-dependent version. The probability transition matrix can be expressed in terms of a matrix, as shown in equation (11) and (12).

$$\mathrm{P(A)} = \begin{bmatrix} 0 & P_A & 1-P_A \\ 1-P_A & 0 & P_A \\ P_A & 1-P_A & 0 \end{bmatrix} \quad (11)$$

$$\mathrm{P(B)} = \begin{bmatrix} 1-P_{S1} & 0 & 1-P_{S1} & 0 \\ P_{S2} & 0 & P_{S3} & 0 \\ 0 & 1-P_{S2} & 0 & 1-P_{S4} \\ 0 & P_{S2} & 0 & P_{S4} \end{bmatrix} \quad (12)$$

According to the result of game B, there are eight groups of the result in total, which is demonstrated as Figure 2(b). The $\mathrm{P(B)}$ is the transition probability matrix of game(B). There are eight results such as $\{L,L,W\} = 0.9-\varepsilon$, $\{L,L,L\} = 0.9+\varepsilon$, $\{L,W,W\} = 0.25-\varepsilon$, $\{L,W,L\} = 0.25+\varepsilon$, $\{W,L,W\} = 0.25-\varepsilon$, $\{W,L,L\} = 0.25+\varepsilon$, $\{W,W,W\} = 0.7-\varepsilon$, $\{W,W,L\} = 0.7+\varepsilon$. The identical analytical method, which employed in capital-dependent Parrondo's paradox, can be employed here as well. By referring to discrete-time Markov chain, the obtained probability of each state can be expressed as $\frac{5}{22}$, $\frac{3}{22}$, and . Therefore, the associated probability for each state of game B can be described by using equation (13).

$$N_2 = \frac{1}{10}\cdot\frac{5}{22} + \frac{1}{4}\cdot\frac{3}{22} + \frac{1}{4}\cdot\frac{3}{22} + \frac{7}{10}\cdot\frac{5}{22} = \frac{1}{2} \quad (13)$$

According to equation (13), game B is a fair game. In addition to that, the boundary probability can be specified in equation (14):

$$N_3 = \frac{P_{S1}(1+P_{S2}-P_{S4})}{P_{S1}P_{S2} + (1-P_{S4})(1+2P_{S1}-P_{S3})} \quad (14)$$

According to equation (14), suppose $N_3 > \frac{1}{2}$, the corresponding game is a winning game. And if $N_3 < \frac{1}{2}$, the game is a losing game. In summary, the property of the compound game could be altered by modifying the

probability of each state as specified above. In addition to that, there are many correlated researches surrounded with the reversed Parrondo's paradox, which means two winning games can be combined in the formation of a losing expectation. Besides, it is possible to change predefined timing of using game A and game B in order to alter the result of combined strategy (Shu and Wang 2014). In this paper, major contribution is lying on further extending the concept of Parrondo's paradox into other potential business applications, which provides some insights for researchers from disciplines of business and public management.

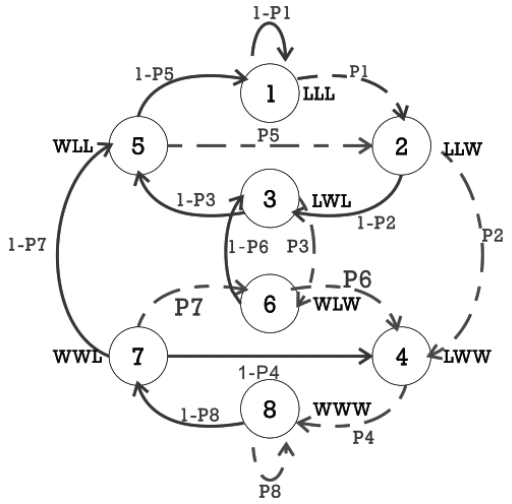

Figure 2(b). Path-dependent Markov chain of history-dependent Parrondo's Paradox (3 levels).

3 INITIAL APPLICATION OF PARRONDO'S PARADOX IN BUSINESS

In the discipline of business, the concept of Parrondo's paradox was firstly extended in refining and selecting appropriate investment strategy. Initially, when market participants use both strategies separately, it would lead to losing outcomes. However, once market participants choose to mix the initial two losing investment strategies, the winning expectation can be produced.

In order to handle the uncertainty and mitigate potential losses of investment portfolio, market participants seek to discover an effective way of retaining their wealth, and preferably, achieving desired level of return on investment. Meanwhile, it is known to all that the future trend of price movement of financial assets is almost unpredictable. Thereby, the risk management technique adopted in contemporary financial market is constructing the portfolio consists of multiple negatively-correlated financial assets, which aims to minimize the firm-specific risk. And with such believe, many scholars design a module to minimize the systematic risk. Market participants can create winning expectation via switching their investment strategies deterministically or completely randomly as advocated by Parrondo's paradox.

By referring to the investment strategy as specified above, it is possible to conclude that individually losing financial assets which analogous to the losing games in Parrondo's paradox, can be combined in the formation of a portfolio (alike to compound game of Parrondo's paradox) to minimize the potential firm-specific risk. For instance, the first selected investment strategy can represent game A, and the second one represents game B, market participants can choose the mixed investment strategy instead of one strategy alone. If the market participants know the amount of the instantaneous capital and the winning probability of each game, it is possible to choose appropriate investment strategy accordingly. Therefore, if information can be exchanged by communicating among market participants, it will boost the probability of profitability of selected portfolio. According to such phenomenon, the following conclusion can be concluded by determining an efficient way to realize the information exchange and correcting the cognition of the game, and then select the game by comparing the winning probability of both games.

In the prolonged evolution history of human beings, it's nature for a person to be risk-averse. For instance, if market participants notify that other market participants obtain positive return on investment, they will follow the same investment strategy. This phenomenon explains the reality that information can lead to the herd behavior of human beings. In reality, the entire financial market is one sophisticated system due to the partial available information and capacity. The information obtained by market participants through the internet only covers a very small portion of available information in the financial market. The entire market is a typical zero-sum game, while the winners win at the cost of the losers, so the best solution is to minimize the potential risk via constructing the portfolio consists of two correlated financial assets. As advocated by most recent research in the disciplines of investment, the flow of the message can influence and modify the initial behavior of market participants to promote their potential gains.

In conclusion, responsible government agency should pay close attention to information transparency of the financial market. Taking the advanced measures to promote the information transparency which maximizes the potential gains, and hence, stimulate the investment interest of market participants, and promote the overall health of the financial market.

4. POTENTIAL APPLICATION OF PARRONDO'S PARADOX

As mentioned above, the application of Parrondo's paradox is highly concentrated on non-business disciplines like species coexistence, evolutionary theory and species diversification. And the initial application of Parrondo's Paradox in the field of finance is primarily lying on selecting appropriate investment strategies. In this section, the framework of Parrondo's paradox is further extended into other sectors of business involving the study of cluster effect, tragedy of the commons, and the refinement of management strategy.

4.1 Parrondo's Paradox in Industrial Clusters

The majority of the competitive business can be classified as a zero-sum game as the resource are scarce. In the specified region, the small company decreases the price of production and sale of a single type of product leading to gain high profit in the long run, that's the losing game. Besides, the small company which produces single production will decrease the risk resistance capacity, that's another losing game. But in reality, many small companies accumulate in the industry park and run well, that's the phenomenon of Parrondo's Paradox.

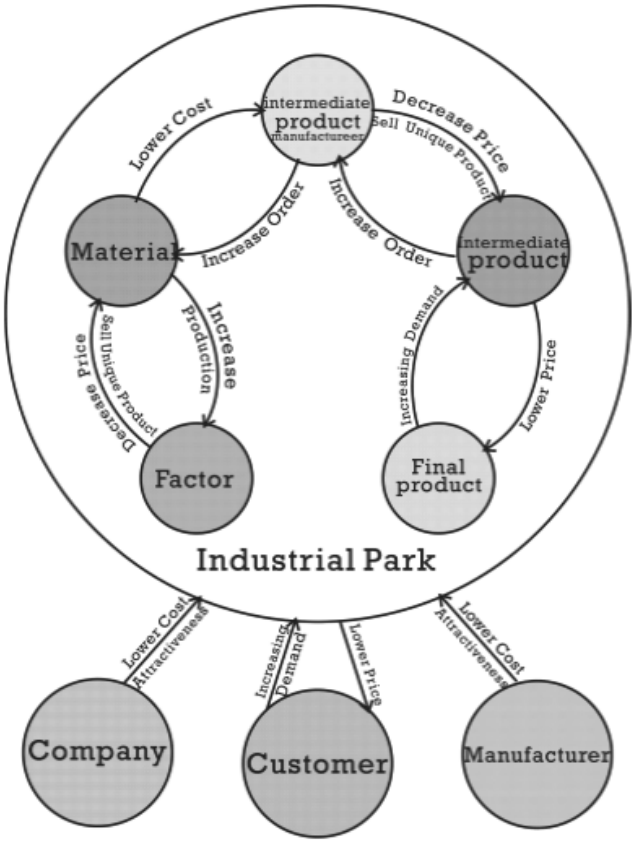

Figure 4 (a). The process of cluster effect.

As specified in figure 4(a), the phenomenon specified above is not conflicting if analyzing it with the knowledge about operation management. There are many small companies opened in that region, which prefer to produce and sell the heterogeneous product or complementary product rather than produce a homogeneous product. Once these small companies decrease the price of the material, which means the entire industry chain will decrease the cost and the final product will also lower prices. In that way, according to the supply-demand curve, the volume of demand will augment, which leads to an increase in the yield of the company, foaming the good business cycle such as figure 4(a). The reason why this phenomenon happened in industrial parks is that

many companies here sell complementary products such as material, intermediate products, and final products, then forming the industrial chain. If one of the companies decreases the price of the material or intermediate product, the price of the final product will decrease as well, then the customer places a high amount order to the final product company leading to an increasing order of intermediate product and material. Consequently, each company can gain profit from the final product and put partial profit into research and development, then reduce the cost of producing further. However, they still can benefit from the product because of the low cost and many companies also establish the branch here and decrease the cost of producing. That's why these companies tend to accumulate in one single region because it can decrease transportation costs and transaction costs.

The instance specified above is one kind of Parrondo's Paradox, the combination of two individual-losing games can lead to a winning outcome. This instance is a classical clustering effect, much more companies and manufacturers accumulate together because of forming the cost advantage as Figure 4(a) demonstrated above. This effect also happened in the megalopolis, more and more farmers pouring into the city leading to traffic jams and short of resource especially for the medical resource and real estate. Parrondo's Paradox can make an explanation of this phenomenon via the analysis of the forming mechanism of the megalopolis. Besides, game theory can also provide a good solution or inspiration to solve these problems.

4.2 Parrondo's Paradox In Business Strategy

Except for the cluster effect in running a business, Parrondo 's Paradox can also be used in business strategy. For instance, the small company cuts unnecessary production lines and increases the debt ratios, thereby surviving from the fierce competition and then occupying a specified market share. In the dynamics of internet technology, the small company, which produces homogeneous products that lacking technology, will be superseded once they lose the cost advantage. Moreover, many small company's devices are old, the production lines are also outdated and the efficiency of production is quite low, in order to keep a low price, they will not invest extra money in improving the quality of products. Conversely, the big company with advanced equipment and high efficiency can possess the cost advantage, which means selling the products at a lower price and eroding the market share of small companies, leading to the bankruptcy of small companies. Most of the small companies will be eliminated by the market, but parts of the small company are still alive. The Parrondo's Paradox can explain this phenomenon, the small company has a little resource and small market share, which leads to the less cash flow and fewer product types. Because of these disadvantages, the big company can erode the market share of the small company easily, that's the losing game. Moreover, the remaining small companies compete with each other to compete the remaining proportion of the market share, which leads to fierce competition. In order to keep the competition with other companies, small companies borrow from banks, that's the losing game too. Theoretically, because of fierce competition and high debt ratio, most of the small companies will fade away, but the truth tells a different story, the remaining small companies perform well in the competition, that's the winning expectation. These two factors can also be seen as weaknesses of the small companies, forcing the small company to adopt different strategies to survive from the fierce competition, which means reforms, like biological evolution.

Actually, the reason why the small company can run well is that their core competitiveness. Internet technology can make the information accessible easily and eliminate the inequality of information, which leads most of the wholesale and traditional companies to die out as the developing of information technology. Because of fierce competition with peer companies and the low technology product, forces the small company to improve its core competitiveness, only in that way, the small company can survive from the fierce competition. Initially, because of the high-cost and high sales prices of the product, the small company cannot compete with the big company. The reason why leading to the high cost in operation and production, that is, non-clear responsibility and small production scale. In order to decrease the cost and improve competitiveness, the small company begins to focus on refining the organizational structure, reduces the operation cost and improves production efficiency. After that, the small company can invest more capital to improve the product quality and product functionality, focus on the demand of customers and potential demand.

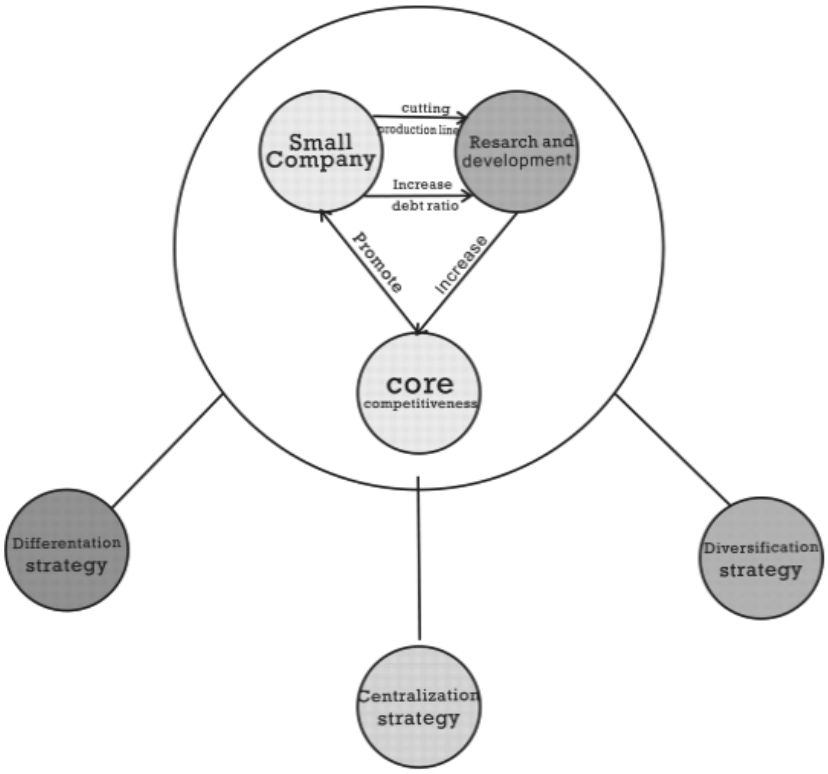

Figure 4 (b). The process of business Strategy.

As indicated in Figure4(b), in order to improve the competitiveness and technical content of the products, the small company may use the strategies of cutting its unnecessary production line, and increasing the debt ratios, focusing on R&D. While cutting the production line will lead to the loss of revenue, that's the key problem of the small company, in order to run the company continuously, the small companies loan capital from the bank. In that way, developing the core product of the company, and other companies cannot copy or imitate it. Core product enables the small company a unique competitive advantage, makes the company can compete with other companies. For example, a small company can make the product possess high technology, good operability, and convenience according to the research about the potential demand of customers. Besides, the small company can also meet the specified demand for customers to achieve a competitive advantage. For instance, the auto corporation produces the specified car for the army to obtain the big amount order of the military vehicle market, in that way, thereby getting huge profit and market share. Except for the profit and market share, the company also wins a good reputation, gets a fixed customer. In that way, because of the good reputation and high quality of the car, the country which needs to buy the vehicle for their army will choose the specified company above, which is called the differentiation strategy.

If the company achieves success through the differentiation strategy, it can expand its business in civilian cars to win the favors of the public, which is called correlated diversification strategy. The small company can also focus on the specified region or customer to form the competitiveness advantage in the specified product market or process field, which is called the centralization strategy. For instance, it can produce beautiful clothes or cosmetics for the young lady, produce the toy for the children. Although the small scale of production in small companies, the product possesses good competitiveness and even irreplaceable, which enables the product a high price and excess profit. Once the company begins to gain profit, it can pay the debt back to the bank and decrease the debt ratio. Besides, the small company can put the part of profit into research and development, perfect their product continuously. In this way, the company produces a high-quality product, which sells it at a high price to get high profit, then puts the profit into the refinement of the product and eventually forms a closed loop of continuous improvement. That's the instance of combining two individual-losing games

into winning expectation, the company can develop fast through the strategy, which expands its business field.

Maybe the big company pays attention to this small company, but the small company has gained the first-mover advantage and loyalty of customers, it's not economical for a big company to compete with the small company, that's called the barrier of competition. This barrier not only can mitigate the risk of competition and give some space to prepare for the competition but also can set a high barrier for the potential business, then decrease the risk of the small company. The small company focusing on specified customers and special products, forming a unique advantage, which helps the small company keep the core competitiveness and reach success in the long run. In a short, the strategy above is shrinking production line and loaning capital from the bank to develop the core product, that's one application of Parrondo's Paradox.

4.3 Parrondo's Paradox in Publicp Affairs

The Parrondo's Paradox can also be applied in the tragedy of the commons, it states such a story that herders graze sheep on public grassland, which leads the grassland to be destroyed and even degenerate to the barren land serval years later. But if the responsible government specifies the number of sheep in each allocated grassland, grassland can be preserved very well and be used continuously. As specified phenomenon above, because of grazing the initial number of the sheep in allocated grassland leading each sheep cannot be distributed with enough grass and lack of nutrition, the sheep cannot grow well, that's the losing game. Besides, each herder's sheep cannot exceed the maximum number of government-specified and only grazing in their specified grassland. In the absence of sufficient grass, herders must reduce the number of sheep. Because of grazing less sheep, the herders gain less profit, that's the losing game too. But if combining these two individual-losing games, the result breaks the tragedy of commons, that's the paradox.

The original intention of setting public grassland institutions is to offer convenience for herders, which cannot generate a good effect. The game theory can explain this phenomenon, let's make an assumption that there are two herders grazing in the grassland, Tom overgrazing in the grassland and Jim grazing moderately, Tom will get payoff 12 and Jim will get payoff 4. Both of them will get payoff 5 if Tom and Jim overgrazing in this grassland. Tom will get payoff 4 and Jim will get payoff 12 if Tom grazing moderately and Jim overgrazing. Both of them will get payoff 10 if Tom grazing moderately and Jim do the same. The detail of payoff listed in the following figure 4(c):

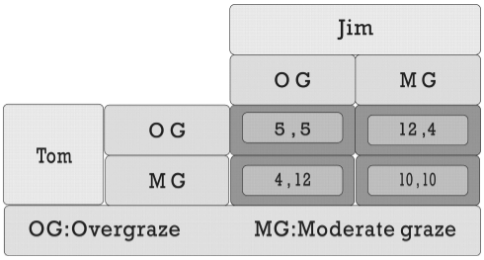

Figure 4(c). The process of game theory.

From the figure 4(c) above, the following conclusion can be determined, Tom chooses to overgraze first, Jim will also choose to overgraze as his best response because he will get payoff 5 if he chooses overgrazing, Jim will get payoff 4 if he chooses grazing moderately. If Tom chooses grazing moderately first, Jim will prefer to choose to overgraze rather than choose graze moderately, because he will get payoff 12 if he chooses to overgraze and get payoff 10 if he choose grazing moderately. So, Tom's best response is overgrazing and Jim's best response is also the same, that's called Nash equilibrium, and both of them will get payoff 5 rather than 10. That the explanation of the game theory.

Actually, the reason why the public territory has a losing result is that the general public pursues maximum profit in the supposition of rational mankind, the general public doesn't need to take responsibility for destroying the grassland. If a responsible government assigns grassland to each herder, then the herders will have their own grassland, so they cannot occupy the grassland of other herders. If herders carry out high-intensity shepherds, each sheep cannot feed enough grass. Once the grass was eaten up, these sheep will die of hunger. Besides, grassland degenerates to the barren land due to overgrazing, the herder will be punished. Because of none responsibility and abundant resources, herders pursue maximum profit and feed sheep as much as possible, regardless of the result of overgrazing, which leads to the grassland degeneration and environment destroyed. Maybe they consider that effect, but they underestimate the effect of overgrazing. With the

institution of specified grassland and limited sheep number, the whole grassland can be preserved very well. In addition, each sheep can grow well, which can sale at a high price, then herders also get identical or higher profit in contrast to the sheep in overgrazing. From the perspective of game theory, though both herders grazing moderately can get a more positive payoff than overgrazing, but overgrazing is the best response of herders, that's the same as the prisoner's dilemma. To overcome this dilemma, the Parrondo paradox was used as an analytical tool to assign grassland to each herder and limit the number of grazing sheep.

The tragedy of commons is not only happened in grassland but also in the public field, such as marine resources, water pollution, air pollution and deforestation, the general public abuses these resources due to the loss of supervision and effective regulations. The form of the tragedy of commons can be divided into intangible asset loses and tangible asset loses, the intangible asset includes the trademark, patent, and reputation, tangible assets include national assets. For instance, several companies possess a common corporate trademark, but these companies produce products with uneven quality and tied with the same trademark. Because of lacking supervision, once one of the companies produced a low-quality product, the entire trademark will be destroyed completely. In this way, no company is willing to build this trademark, because some companies dedicate to promote it while some others destroy it by producing the low-quality products or services. Moreover, in the fishing industry, each general public has the certification of fishing can catch fish in the sea, because of lacking supervision of the high seas, the fisher can catch fish randomly, which leads rapid reduction of fish resources, and some kinds of fish even becomes extinct because of overfishing. From the instances above, the following conclusion can be determined, the public resource is very special, which lacking clear responsibility bound and effective supervision, leading to the resource being abused and can't reach the ideal effect. Therefore, the government should clearly define the ownership of assets, delineate the boundaries of ownership, improve the system of public resources, and achieve the private supply of public goods. In addition, pay attention to the innovation of the motivation system and build the appropriate reward mechanism. Parrondo's Paradox can offer much inspiration for the measures of the reformation and help the company or responsible government to make the strategy to realize its goal.

CONCLUSION

From the content above, this paper explained Parrondo's Paradox, and gives a brief inference of Game A and Game B to demonstrate the details of Parrondo's game. This paper aims to display how to use Parrondo's Paradox to solve the problem happened in business and the public field. Besides, introducing initial application at first, analyzing the meaning of the initial application and influence of the information, then comes up with the correspondent measures. Furtherly, analyzing the cluster effect in the business field, explaining the reason why many small companies accumulate in one single region. The government also can use Parrondo's Paradox to analyze the problems in the megalopolis and take the appropriate measures to solve it. Because of the fierce competition and continuous improving internet technology, previous strategy of production diversification is not effective for small company anymore. Parrondo's Paradox can be used for business process reengineering. The company can reduce operating costs by cutting unnecessary production lines and increase debt ratios for R&D investment, focusing on core products to adapt to the changing economic environment and seize opportunities to develop itself. And thus survive. If this company adopts these two measures separately, it will lead to a failure result, because only borrowing funds from the bank, once the company cannot repay the loan in time, the company will go bankrupt or be acquired by another company. In addition, cutting multiply production lines will lead to a decrease in profit. Parrondo's Paradox can also be used to solve the problem of the public field. There are many problems in society management, which cannot be solved by one single general public or firm, leading to the wrong result if the government lets it go. Because of the assumption of rational human beings, each individual pursues the maximum profit and leads to the prisoner 's dilemma, but use Parrondo's Paradox can solve it from a third-party perspective. Inner attack is hard to break system equilibrium, but the vulnerability of the system can be found from the external view. So the Parrondo's Paradox can be used to solve the problems of the public field effectively.

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