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Analysis on stability of strategic alliance: A game theory perspective*

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Abstract: Strategic alliance has suffered much instabilities since its first implementation. Scholars have carried out many embedded, precise and comprehensive researches from both theory and empiricism. Here we try to find certain stable solutions by employing game theory, in an attempt to construct theoretical bases for strategic alliance, which people called "one of the most important organizational innovation in the end of the 20th century" (Shi, 2001), to exploit its advantages in the process of globalization. Finally, this article puts forward some advices for its success.

Key words: Strategic alliance, Stability, Game theory, Stable solution
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INTRODUCTION

Strategic alliances have become an increasing incidence and important practice of firms pursuing various kinds of economic objectives in the last two decades of the 20th century, as globalization becomes the most important feature of the global economy. From statistical data, there exist 60 strategic alliances on average over the time frame of the Fortune top 500 companies. As a newly emerging organization pattern, strategic alliances have been accepted as one of the most efficient ways for implementing global strategy, with the honor of being "one of the most important organization innovation in the end of the 20th century" (Shi, 2001).

Regardless of their popularity, strategic alliances tend to have relatively high instability rate. Das and Teng (2000) summarized the theoretical and empirical researches on the topic, and noted that "most studies indicate that the instability rate is somewhere between 30% and 50%". Mckinsey & Company surveyed more than 800 US corporate participants in strategic technology alliances since the 1980s and indicated that 40% of the alliances survived four years or longer, only 14% survived ten years or longer (Chen, 2000). In general, strategic alliances are plagued with high failure rate problem, though the percentage and the story may be different (Jiang, 2001). However, there are many successful alliance cases in the real world, of which Intel-Microsoft alliance is the most cited one. Using game theory, this paper focuses on finding certain stable solutions.

EXPLANATIONS OF ALLIANCE INSTABILITIES

Alliance instabilities refer to major changes or dissolutions of alliances that are unplanned from the perspective of one or more partners (Inkpen and Beamish, 1997). Researchers have attempted to explain alliance instabilities mainly from the following four approaches.

The first approach is from the perspective of relational contracting theory (Macneil, 1974) and transaction cost economics (Williamson, 1985). Relational contracting theory suggests that a sense of trust between partners is essential for a smooth cooperative relationship. On the other hand, transaction cost economics emphasizes the negative effect of

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opportunistic behavior on inter-organizational relationship.

The second approach employs game theory. Some scholars argue that the situation concerning strategic alliances is somewhat similar to that of “prisoner’s dilemma” in game theory. Participants have an intention to cheat or exploit their partner(s) when payoff from non-cooperation is higher than that from cooperation.

The third one is established on resource dependence and bargaining power perspective. Firms, as an aggregate of resources, may rely on certain resources owned by others. So the value of resources possessed by each firm determines its bargaining power in negotiation as well as bargaining results (Yan and Gray, 1994). Inkpen and Beamish (1997) argue that shifts in the balance of partner bargaining power are responsible for unplanned terminations of joint ventures. It claims that after firms get what they want from alliances, the need for further cooperation will diminish.

The fourth one is based on strategic behavior theory. Firms can obtain advantageous strategic competitive positions against their competitors through alliances (Porter, 1980; 1985). But imperfect or unrealistic goal planning and implementation and partner goal dissimilarity may lead to alliance instabilities. Therefore, Porter (1990) argued that alliances are transitional devices rather than stable arrangements.

There are some other ways, such as agency theory. In summary, despite of extensive research on the subject of alliance instability, no satisfactory explanation is provided (Das and Teng, 2000). Each approach mentioned above has its own limitation. For example, in the transaction cost economic approach, we should note that “the invisible hand of the market mechanism can have for the risk of opportunism” in the long run (Hill, 1990) as well as mechanisms, such as punishment (Evans and Thomas, 2001), do in the short run. And firms may enter into an alliance for other reasons rather than acquiring resources. Moreover, if firms intend to acquire knowledge, a special kind of resource, learning actually contributes to alliance success, whereas non-learning leads to alliance failure (Doz, 1996). So, here we will introduce a simple game theory model to solve the “prisoner’s dilemma”.

EXPLAINING INSTABILITIES FROM THE PERSPECTIVE OF GAME THEORY

Initial model

Suppose there are two players in the game of alliance, firm A and firm B. They have two choices of action in alliance, cooperation or non-cooperation. Cooperation means a player is willing to share resources or special advantages in manufacturing or other fields with partner; and non-cooperation means a player behaves opportunistically, pursues his own interest at the expense of the other. Payoffs are defined as the net revenue that is the total revenue minus all the costs, including visible or invisible costs arising from the alliance formation and management, such as negotiation cost, coordinate cost, organizational cost, opportunity cost, and cost regarding punishment when defection happens. And players can gain advantages from the economics of scale, economics of scope, economics of speed, economics of symbiosis as well as technology innovation (Shi, 2001).

Table 1 shows the action profile of alliance in either condition of players’ move, cooperation or not.

Table 1 The payoff matrix in alliance

		Firm B	
		Non-cooperation	Cooperation
Firm A	Non-cooperation	$s\Pi_1$, $(1-s)\Pi_1$	Π_2, Π_3
	Cooperation	Π_3, Π_2	$s\Pi$, $(1-s)\Pi$

Here we have:

$$\Pi>\Pi_2>s\Pi>s\Pi_1>\Pi_3;$$
$$\Pi>\Pi_2>(1-s)\Pi>(1-s)\Pi_1>\Pi_3,$$

where s and $(1-s)$ refer to shares players A and B get from alliance according to their contributions to alliance or bargaining power in alliance (Khanna *et al.*, 1998).

We make such an order because, first, when one player cooperates but the other does not, the latter not only will get more than the former, but also can take advantage of the other partner’s cooperative action to make additional revenue. So we get $\Pi_2>s\Pi>s\Pi_1>\Pi_3$. This is shown well in technology alliance. Because of previous investments, technology or know-how has been revealed more or less, which results in losses, even substantial damages to the cooperator. In contrast, non-cooperator will make huge sudden profits, exceeding that from cooperation.

Considering some other effects such as enforcement of impelling punishment mechanism, gains from non-cooperation could seldom exceed that from cooperation generally. That is to say $\Pi_2<\Pi$.

For players can protect well their know-how in the situation of non-cooperation, their interests may not be damaged although they cannot get more than that if they cooperate. Namely, $s\Pi_1>\Pi_3$ and $(1-s)\Pi_1>\Pi_3$.

Therefore, we come to the Nash Equilibrium $[s\Pi_1, (1-s)\Pi_1]$, which is a situation akin to that of "prisoner's dilemma". This somewhat explains the source of alliance instabilities. Well then, can we move to the Pareto Improvement Equilibrium $[s\Pi, (1-s)\Pi]$? And how can the equilibrium be achieved? We will discuss this later under the situations of both complete and incomplete information.

Alliance instability in infinitely repeated games

Suppose having complete information in the initial model, namely players not only know self-payoffs under various actions, they also know their partners' payoffs and their contingent action plan. Then if we extend the model to finitely repeated games with complete information, the only result we can get is "Chain Store Paradox". In other words, if only repetition is finite, the repetition itself cannot change the result (Zhang, 2001) when there is only one Nash Equilibrium. But if we extend it to infinitely repeated game, we will get the Pareto Improvement Equilibrium according to the Folk Theorem.

Suppose that two firms have the same discount ratio ϕ $(0<\phi<1)$ about the future revenue. So we have that the total revenue equals the sum of the stage revenue. As ϕ approaches to 1, the players behave more patiently, for they have a high evaluation on the future revenue; and vice versa.

Suppose both players choose "trigger strategy": (1) cooperate at the beginning; (2) cooperate until a player (include itself) chooses non-cooperation, and holds non-cooperation strategy from then on.

Consider firm A. Firm A can get $s\Pi/(1-\phi)$ in the long run if both firm A and firm B choose cooperation strategy; but $[\Pi_2+s\Pi_1\phi/(1-\phi)]$ if A takes non-cooperation strategy. So the condition where firm A takes cooperation strategy, rather than non-cooperation strategy, is:

$$s\Pi/(1-\phi)>\Pi_2+s\Pi_1\phi/(1-\phi), \quad (1)$$

then we have:

$$\phi>(\Pi_2-s\Pi)/(\Pi_2-s\Pi_1). \quad (2)$$

The result indicates that cooperation is a possible equilibrium outcome if ϕ is big enough. In other words, the future is important enough as to firm A, or if the "shadow of the future" (Axelrod, 1984) is long enough. The shadow of the future is "the bond between the future benefits a firm anticipates and its present action" (Parkhe, 1993). Through the expectations of reciprocity, and player's anticipated gains from mutual cooperation, "the future casts a shadow back upon the present" (Parkhe, 1993). It calls for firm A to set out with a view to building a long-standing, sustainable strategic cooperation relationship. Analyzing the result further, we can also minimize the right part of the formula in order to meet the condition, and have:

On one hand, to make $s\Pi$ as close to Π_2 as possible, namely, firm A cannot get more from non-cooperation than from cooperation in the situation firm B takes cooperation strategy. This is surely possible when there are few partners in the market, or it is difficult to make profits operating single-handedly, or punishment is severe enough to stop firm A from betraying firm B. As Evans and Thomas (2001) noted, "even if partner is pessimistic about the benefits of cooperating, he can be persuaded, through punishment, that non-cooperative behavior is even less appealing". Besides, a loss of reputation is another kind of indirect punishment. Any player coveting a short-term gain by defecting will suffer a decline of reputation for future games and alliances (Dollinger *et al.*, 1997), which make it hard to find any other partners in the future. This is the essential of "self-enforcing agreement" and "shadow of the future".

On the other hand, we ensure that Π_2 is bigger than $s\Pi_1$ and that the difference between Π_2 and $s\Pi_1$ is as big as possible. This is possible when partners are reciprocal complementarities in technology and knowledge, and it is hard to accumulate self-owned knowledge singly, or the risk or investment is so high that no profit is available if they do not cooperate.

In summary, the magnitude of the differences among the payoffs may be an important determinant of cooperation. In fact, any shift of the preferences and therefore the payoffs "either through deliberate strategies or exogenous events can transform a situation from one class of game into another" and "fundamentally alter the character of a relationship" (Parkhe, 1993). It is obvious that even if one condition mentioned above is satisfied, the possibility of cooperation increases.

In the same way, we can get the condition firm B chooses cooperation strategy:

$$\phi>[\Pi_2-(1-s)\Pi]/[\Pi_2-(1-s)\Pi_1]. \quad (3)$$

Alliance instability in finitely repeated games

In the above analysis we mentioned the "chain store paradox". Here we examine the problem by introducing incomplete information condition into the model. Here come down to the issue of "credible commitment" in game theory. If player A is certain of player B's willingness to cooperate, then the Pareto Improvement Equilibrium is achievable. Based on players' history of cooperation and reputation, we suppose the probability of firm A to cooperate is p, then the probability of not to cooperate is $(1-p)$; as to firm B, the probability to cooperate and not is q and $(1-q)$ respectively. Suppose there are t stages totally. Players adopt "trigger strategy" too.

In the situation where firm A cooperates:

(1) Suppose firm B cooperates too. Then firm B's payoff is

$$V_1=pq(1-s)\Pi(1-\phi^t)/(1-\phi). \quad (4)$$

(2) Suppose firm B does not cooperate. Then firm B's payoff is

$$V_2=p(1-q)\Pi_2. \quad (5)$$

In the situation where firm A takes a non-cooperation strategy:

(1) Suppose firm B cooperates. Then firm B's payoff is

$$V_3=(1-p)q\Pi_3. \quad (6)$$

(2) Suppose firm B does not cooperate either. Then firm B's payoff is

$$V_4=(1-p)(1-q)(1-s)\Pi_1. \quad (7)$$

That a firm chooses to cooperate or not depends on the comparison between its expected payoffs gained from cooperation and non-cooperation. When the expected payoff from a cooperation strategy is greater than that from a non-cooperation strategy, the firm will choose cooperation. Therefore, firm B will choose a cooperation strategy under the condition

$$\sum_{i=1}^{4} V_i(q=1) \geq \sum_{i=1}^{4} V_i(q=0). \quad (8)$$

Solving Eq.(8), we have:

$$p(1-s)\Pi(1-\phi^t)/(1-\phi)+(1-p)\Pi_3\geq p\Pi_2+(1-p)(1-s)\Pi_1. \quad (9)$$

It follows:

$$(1-s)\geq[p(\Pi_2+\Pi_3)-\Pi_3]/[p\Pi(1-\phi^t)/(1-\phi)-(1-p)\Pi_1]. \quad (10)$$

The formula expresses the condition for firm B to cooperate when it can get a sufficiently larger share from the alliance. Otherwise, firm B may be powerless, which may lead to a failure of the alliance.

With the same logic, we have the condition for firm A to cooperate:

$$s\geq[q(\Pi_2+\Pi_3)-\Pi_3]/[q\Pi(1-\phi^t)/(1-\phi)-(1-q)\Pi_1]. \quad (11)$$

For $s+(1-s)=1$, so the equilibrium can be only achieved on condition that the values of s and $(1-s)$ are close enough. The extreme situation is $s=(1-s)$, or $s=1/2$, meaning that partners contribute equally to a joint venture, or their bargaining powers are equivalent.

Here we denote $\Phi=(1-\phi^t)/(1-\phi)$. For $0<\phi<1$, Φ decreases as t increases, holding ϕ constant. So the values of the right parts of Eqs.(10) and (11) decrease as t increases, too, holding ϕ constant. This means that cooperation should increase with the length of their relationships, including the length of prior relationship and players' anticipation of the future of their relationship, which Heide and Miner (1992) defined as "extendedness of a relationship". Interaction over time may lead to commitment and to alliance-specific assets investment, which in turn encourage further commitment. And the more strongly a player expects that a relationship will continue in the future, the higher is the extendedness of their relationship therefore the higher cooperation level there is (Heide and Miner, 1992).

From Eq.(9) we also have:

$$p\geq[(1-s)\Pi_1-\Pi_3]/[(1-s)\Pi(1-\phi^t)/(1-\phi)-\Pi_2+(1-s)\Pi_1-\Pi_3]. \quad (12)$$

This means if p is big enough, a cooperation move is a probable choice, too. That is to say that an alliance may be sustainable if firm A sends out some impelling signals, such as a commitment promise and shows its willingness to cooperate through persuasive actions.

Of course, we can try to minimize the value of the right part of the formula, too. According to KMRW (reputation) model if only t and ϕ are big enough, the equilibrium result may change even if there is a little uncertainly about players, namely $p>0$.

With the same logic, we have the effect of firm A on the alliance instability when it is willing to cooperate:

$$q\geq(s\Pi_1-\Pi_3)/[s\Pi(1-\phi^t)/(1-\phi)-\Pi_2+s\Pi_1-\Pi_3]. \quad (13)$$

Finally, we examine the effect of total revenue on alliance instabilities.

From Eq.(9), we denote

$$\Omega=p(1-s)\Pi(1-\phi^t)/(1-\phi)+(1-p)\Pi_3-[p\Pi_2+(1-p)(1-s)\Pi_1]. \quad (14)$$

Differentiating Ω with respect to Π, we get:

$$\mathrm{d}\Omega/\mathrm{d}\Pi=p(1-s)\Pi(1-\phi^t)/(1-\phi)>0. \quad (15)$$

It means that players' willingness to cooperate is positively correlated with the total revenue.

Results

From the analyses above, we argue that no matter information is complete or incomplete, and the game is infinitely repeated or finitely repeated, an alliance can achieve a stable state with any/some of the following conditions:

(1) The discount ratio ϕ is big enough, players have a strong wish to cooperate;

(2) The alliance has designed an impelling mechanism to punish opportunistic behavior, or the potential indirect punishment of defection, such as loss of reputation or alliance-specific investments are large enough;

(3) Gains from cooperation greatly exceed those from operating single-handedly, even exceed those from opportunistic behavior, or in other words, "pattern of payoff" changes resulting from internal or external conditions;

(4) A good interaction history between players or a higher anticipated extendedness of their relationship;

(5) The contributions to alliance made by both partners or their bargaining powers are contiguous;

(6) The expected total revenue is considerable after an alliance formed.

In conclusion, alliance instabilities will fall if all these conditions or even part of them come true. In fact, "trigger strategy" employed above is not the most robust strategy in Axelrod's roundrobin computer tournament. The winner in this computer program is called "Tit for Tat", which consists of "starting with cooperation, and thereafter doing what the other player did on the previous move" (Axelrod, 1984). This means in the real world, we do have certain solutions to "prisoner's dilemma" in alliance.

A small numerical example

In this section, we use a numerical example to better illustrate our model. Suppose $\Pi=10$, $\Pi_2=8$, $\Pi_1=6$, $\Pi_3=2$, and $s=(1-s)=1/2$. Table 2 shows the payoff matrix with specified numbers.

Table 2 The payoff matrix with specified numbers

		Firm B	
		Non-cooperation	Cooperation
Firm A	Non-cooperation	3, 3	8, 2
	Cooperation	2, 8	5, 5

Applied to the results above, we have:

(1) While firms cannot anticipate the exact time of relation-termination, the condition where both

firms A and B take cooperation strategy is:

$$\phi>3/5. \tag{16}$$

(2) While firms cannot know well their partners' payoffs and contingent action plan, then we have the cooperation conditions:

$$p=q\geq 1/[5(1-\phi^{t})/(1-\phi)-7]. \tag{17}$$

This condition will be easier to achieve as $t(\phi)$ increases, hold $\phi(t)$ constant.

PATH TO A SUSTAINABLE ALLIANCE

Based on our conclusions for a stable alliance, we argue that alliances can be sustainable by making efforts in the following aspects.

First, players should adjust their attitudes to their alliance and consider the alliance as a long-term strategy. In dynamic alliances, the discount ratio stands for achievements of stage objectives. Its value increases in a non-linear pattern. The most important factor influencing the discount ratio is institution conditions, including formal and informal institutions, especially the latter one. Therefore, it is important for managers of alliances to take corresponding measures in different stages, according to the alliance objectives and modes. For example, firms should attach importance to partner-choosing as well as mode-choosing, and adjust in time. At the same time, firms should set up relevant rules and supervising mechanisms, especially a punishment mechanism and a gain distribution mechanism. After an alliance is set up, partners can make full use of their commitments, such as making investments, expressing their own willingness to cooperate, and strengthening know-how protection to reduce a sudden huge revenue loss.

As the alliance develops, partners can set out to build conflicts settlement mechanism and communication mechanism to ensure a smooth transfer of information. Many experimental studies revealed that preplay communication leads to higher levels of cooperation in prisoner's dilemma contexts (e.g., Heide and Miner, 1992). If the alliance can achieve a condition close to complete information, the needed conditions for alliance stability may weaken. Besides, by good communication, partners' interests in the alliance may arise, and this will facilitate mutual knowledge accumulation, as well as "create a convergence of the knowledge representations of strategies and in this way, altering expectations of others' behavior, promoting coordination, and creating norms" (Richards, 2001). Managers play an important role in the process. In fact, the Folk Theorem indicates that equilibrium is more than one, but the probability which one will come forth is equal. Richards (2001) proposed the role of a shared knowledge structure in addition to social constraints and institutional structures in achieving mutual cooperation, and argued that "it is not necessary to consider all possible strategies but only those have particular social meaning in a given context". However, in the real world, partners may take advantage of the information abstracted from the model, and come to a "focal point". Here, the information may be related to social norms or cultural practice or partners' cooperation history.

Moreover, an alliance should ensure the fairness of gain distribution, namely a "win-win" result should be ensured. Only if their expectation is realized, do partners have the incentive to continue their alliance. Furthermore, according to the above results, an equal contribution or bargaining power makes it easier to implement fair distribution, so firms should choose partners very cautiously. Besides, an alliance can set about to increase the total revenue by improving the success rate of innovation, promoting the market share of their new products, etc., to change the payoff matrix of "prisoner's dilemma".

All in all, the lack of competence of a single firm in such an internationalization surrounding determines the necessity to cooperate. However, the modern firms' essential need to survive and develop is decided on what stands for cooperation in continuous games of profit. But, where there is goodwill, there is a way. Market economy calls for "co-opetition", a newly emerging competing mode for those firms that want to survive and develop. With this in mind, a sustainable alliance is acceptable.

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