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Multi-Agent Conflict Coordination Using Game Bargain

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Abstract: For many years, researchers in both economics and policymaking have used various practices to achieve Nash Equilibrium values in Game Theory applications. Our approach is innovative in that we have combined the Multi-Agent Method with these concepts and designed a cooperative strategy for the multi-agent model constructed on the lines of ordinal utility used in economics. It is not designed for finding specific values, but instead is intended to discover the best strategic choices that will be acceptable to all parties participating in the game. The participants can input their strategies into the system from their network to handle conflict coordination problems. We also designed a corresponding method of finding solutions when other agents of conflict resolution fail. The agent mechanism not only enhances effectiveness in finding equilibrium solutions, but it also resolves the dilemmas formed when the cycle cannot be solved by playing strategic games. The present system dramatically shortens the time required for finding solutions within the game, enhances the effectiveness of devising cooperative strategies and offers as output the maximum strategic combination of payoffs obtainable by both companies.

Key words: Multi-agent, game bargaining, conflict resolution

INTRODUCTION

We used the Participant Observation Method to collect information and materials and then we annotated and analyzed them. Through observing interactions between manufacturers and marketing channel providers in the strategies of negotiations, we may understand participants preferences and expectations and analyze objective environments and the strong and weak parts of manufacturers and channel providers positions. By establishing the analytical framework of the strategy of negotiation, we used the concept of game bargaining to establish payoff matrices. Based on both payoff matrices and with the introduction of the Multi-Agent Method, we then established a cooperative strategy for the multi-agent system model to calculate viable solutions to the conflicts faced by both parties in working out their own bargaining policy-making decisions. Taking into account every solution offered by the game, we designed a complete flow chart and means of providing feedback that can solve each problem in the bargaining game that came up. We devised a workable and efficient means of working with multiple rules in the bargaining game through our cooperative strategy for multi-agent systems.

When an enterprise develops marketing channels, it establishes a relationship with channels of distribution with whom to cooperate. However, in business dealings, conflicts may arise and with them distrust. The disparity between the expected prices of target objects force both parties to bargain and negotiate. Uncertainties abound in the process of negotiation and communications and it is difficult to make the best policy decision in such a complicated situation. If they want to reach a compromise, contact between the parties involved should be established. At least one of the parties must change their claims or demands, or the conflict cannot be resolved. One can only use publicly-available information when performing conflict resolution in business. However, game theory can be applied to any sort of enterprise when trying to achieve optimal awards. The purpose of this study is to use agent mechanisms based on game theory to achieve conflict resolution.

In earlier two-party games, the two parties were often obliged to come up with Nash Equilibrium Solutions using Mixed Games in Game Theory, but this method was not always successful in finding such a solution (Taylor *et al*., 1998). Therefore, it cannot be said that the game theory of bargaining (Kreps, 1992) has actually solved many economic problems. Enterprises that always seek higher profits often face a puzzling range of choices regarding cooperation and competition. Particularly, when they face a targeted company with whom they wish to cooperate, they have to determine how to choose the best strategy to benefit their own company and how they will interface with the other company. Though conflict resolution strategies and the conflict resolution model are able to solve the problem, this has often proved impractical: it takes too much time and does not necessarily produce results that are acceptable to both parties. Often, the weakness in the solution is that the first company is not privy to the other business's important private information and therefore cannot factor it into the equations. On the other hand, when one party is in a strong position and the other is in a weak one within the game, there is the problem of how to choose an equitable strategy: how to consider the two parties equal. Therefore, after considering these related problems, we used a multi-agent mechanism to reconcile the parties conflicting strategies and used a cooperative strategy for multi-agent system models to effectively mediate between the strategic conflicts.

THEORETICAL BACKGROUND

Game Theory not only handles problematic values, such as payoffs gained from adopting a strategy, but it also allows enterprises to use some simple mathematical computations to render less-private information available to the other party and to find an optimal combination of strategies, providing enterprises with other ways of thinking during their strategy talks. Additionally, through our combination of Game Theory and the Multi-Agent Method, agents can play the roles of enterprises and conduct negotiations towards conflict resolution. Also, through the task of strategy coordination implemented by agent mechanisms, the effectiveness of strategy negotiations is enhanced. The following is a survey of related game theories and methodologies and the agents adopted in this study.

Bargain game theory: The most significant difference between game theory and other popular general policy-decision theories is that Game Theory explores the problems faced by a group of decision makers who are in a certain situation that will solve many economic problems. Kreps (1992) emphasized that there are at least three strong points in the mathematical model of game theory:

- The hypothesis in the model provides researchers with the tools for analyzing economies under different conditions.
- The application of the mathematical model can test the consistency of cognition and logic.
- The model can trace back from conclusions to hypotheses to understand hypotheses that lead to specific results.

In Game Theory, bargaining theory is used to explore the process of negotiating the distribution of benefits when there are only two players in the game. In addition to traditional bargaining theories, there are two more methods that are able to solve such problems. One is Nash's Axiomatic Approach; the other is the Sequential Bargaining Game. The basic bargaining process in both cases has the following characteristics:

- It involves two or more players.
- It offers significant or potential benefits.
- It allows players to work independently.
- Its participants are willing to solve their differences together.

Conflict resolution: In the past decade, increasing numbers of conflict resolution have been devised. These include Random Sorting, Compromise, Forced Sorting, Revision, Merged Targets and Easing (Bond and Gasser, 1988; Corkill *et al.*, 1986). Each has its own special characteristics.

- **Random sorting:** When only a small amount of effort has been used in the process of developing plans, this strategy can be used to posit many possible solutions for existing problems, from among which the best answer may be chosen (Chang, 1980).

- **Compromise:** Compromise is a facilitating strategy that is used to resolve changeable conflicts. It defuses problems by identifying optimal values representing all conflicting viewpoints. The most common method of compromise is to adopt the assumption of average values, when these values are numerical (Durfee and Lesser, 1983). If the numerical values are not well distributed, a deviant solution is often produced. In such a situation, adopting a median may lead to a better result. When the values are very high, statistical methodology can be applied.

- **Forced sorting:** This is similar to the strategy of Compromise, but it is used when the agent is not allowed to change its strategies (Curwin and Slater, 2002).

- **Revise and merge targets:** When all other methods fail, or when one believes that the problem is constrained, this strategy should be employed (Adler *et al.*, 1990).

- **Facilitation:** This involves the changing of some variables to solve conflicts. This strategy is used when there is a low level of conflict among the intervention variances. The variance can be at any numerical value or non-value and it may be changed or revised. This strategy may yield two types of answers: variable conflicts and variable forced conflicts (Rothschild, 1988).

The multi-agent system: The Multi-Agent System, or MAS, is an effective method for solving complicated systems. It can use parallel distribution-style handling technology and the concept of modulized design to divide complicated systems into independent agent subsystems into which the competition and the cooperating agent can find solutions for their complicated problems. Furthermore, because the data and MAS are decentralized, every agent has incomplete information; therefore, each agent has a limited ability to handle pending tasks. In fact, any one agent has only a partial understanding of the whole problem and is not an overall control system.

THE ANALYSIS OF CURRENT MARKETING COORDINATION APPROACHES

In problems of strategy coordination between manufacturers and channels of distribution, the role of the manufacturer is usually the weaker position of the two, because manufacturers are unable to sell their products quickly without the use of such channels. However, if we use the above-mentioned theories to conduct the coordination of both parties strategies, it cannot only keep the two roles balanced evenly, but it also can use MAS to automatically implement the strategy coordination that can help both parties to implement strategy coordination more easily and drastically shorten the time required for coordination.

Regarding the background of the manufacturer, the M International Company, Ltd., is a local paper manufacturer. The group that the case company affiliates is established in 1969. Its main product was paperboard in the company's early days, but they expanded into paper markets in 1990.

Company C, Ltd. (hereafter called Company C), was established in 1963. Their main business includes manufacturing pesticide and Western medicine and they also started a chain of supermarkets. They were listed in the stock exchange in 1989. Company C has become one of the major pesticide manufacturers and sellers in Taiwan and at this time the manufacturing of pesticides is their core business.

RESEARCH PLANNING

In the past, during the strategy coordination, because both parties controlled different information, when one party (Party A) adopted a strategy, the other party (Party B) responded with a strategy of its own. At this point, responding to Party B's strategy, Party A either agreed with it, or felt it necessary to change his own strategy to secure more payoffs. In the latter case, a series of responses and repeated changes of modified strategies were presented and it was possible to produce a solution that would achieve equilibrium. Therefore, we introduced an agent mechanism into the research with a hope that through three agents (the two parties' agents plus a new conflict mediator agent), strategy coordination could be conducted automatically. Both parties need only to input their own strategies and after giving expected payoffs to each other's responding strategies, the optimal strategic combination could be automatically produced through the interaction of the three agents.

The participant observation method: The Participant Observation Method of qualitative research was adopted in this project. The Participant Observation Method is a field observation or direct observation that is used to understand a specific group: the researcher establishes and maintains a multi-aspect and long-term relationship with the members of the group in the process of research. There are three practices of participant observation:

- Full participation
- Research participation
- Observation

The subjects of this research are manufacturers and marketing channels in traditional industries in Taiwan. Considering their different business positions and practical benefit negotiations, we determined that it was not appropriate to apply full participation. So we integrated research participation and observation to conduct data collection and thereafter to annotate and analyze the data.

Establishing a strategy for negotiation: The most important factors of any successful negotiation or bargain are satisfaction and the mutual expectations of the manufacturer and marketing channel; only by understanding participants preferences and expectations can one conduct bargaining negotiations with surety and confidence. The analytical framework of negotiation strategies between manufacturer and channel is shown in Fig. 1.

The coordination agent model of this study can also find the best strategy portfolio for each enterprise when the game is played between three or more enterprises. Structure as shown in Fig. 2.

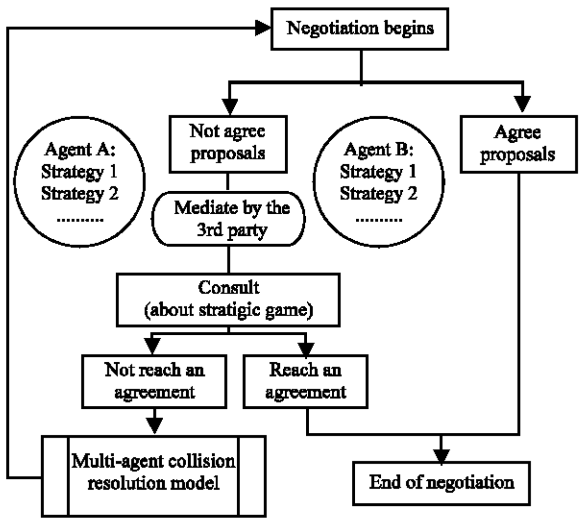

Fig. 1: The analytical framework of negotiation strategy

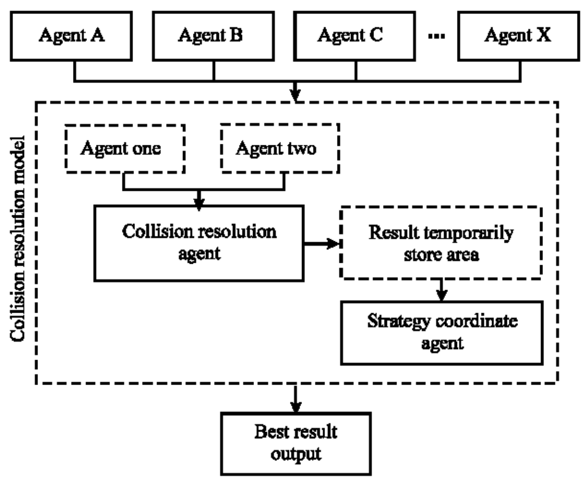

Fig. 2: The MAS actually works the overhead construction

Establishing a payoff matrix: Regarding the analyses of strategies exercises of both manufacturer and channel, this study took strategies of promise, threat and guarantee as the contents of this payoff matrix. For the channel provider, the strategy they present is the strategy that could lead to higher payoff values compared with the other strategies; so are the strategies the manufacturer presents. The manufacturer may also respond to the strategies presented by the channel provider with two strategic options. The option the manufacturer chooses should have a larger payoff value than the other option. In short, all the parties involved, being businesspeople, naturally seek the most advantageous and profitable strategy that can be accepted by the other parties.

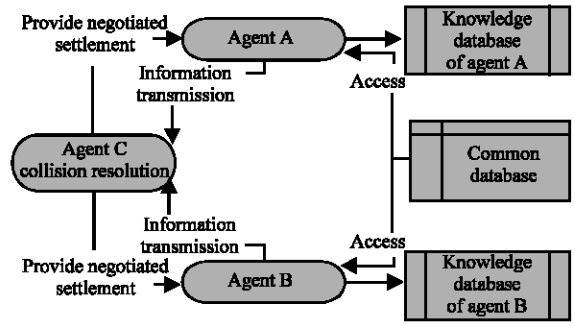

Fig. 3: A multi-agent framework

Multi-agent conflict resolution: In the framework of this research, we will assume that the game involved is a two-party, zero-sum game between the manufacturer and channel provider for the convenience of analysis. The channel, designated as Agent A, has two strategies – to cooperate, or not to cooperate; the manufacturer, or Agent B, has the same two strategies. It is necessary to have an agent to act as mediator (the third party), called the collision resolution agent, or Agent C, who is responsible for resolving conflicts. Based on the above assumptions, established policy-decision payoff matrix in which the numbers are the payoff because of the strategies.

When introducing multiple agents into a conflict resolution situation, the assumed conditions are as follows:

Agent A and Agent B share one common database, but they keep their own knowledge database separate from the common one, so as to keep their private information from each other.

Agents A and B are considered equally important. The reason is if Agent A is more important than Agent B, when they convey their opinions to Agent C, their positions will not be balanced. For example, under a designated issue, the value of Agent A is 0.4 and Agent B is 0.6, because 0.6 is greater than 0.5, if the policy-decision rule in the research adopts the higher value as the policy-decision variable, Agent C should accept Agent B's proposal. But in a organization, if Agent A is more important than Agent B, for example, if Agent A has more experience than Agent B, then Agent C should accept Agent A's proposal. In such a situation, it is difficult for Agent C to make an equitable decision. That is why the research makes such assumption (Fig. 3).

Agents A and B have to be independent of one another. If they are not independent, they will affect each other in making policy decisions. When Agent A decides its policy-decision variable, they must consider the value

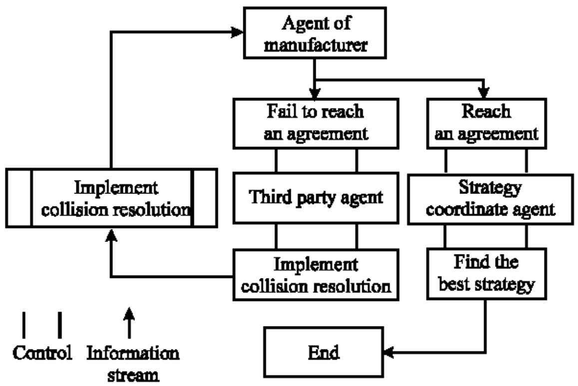

Fig. 4: Cooperative strategic game for MAS model

of Agent B and vice versa. In such a situation, the process of conflict resolution is more complex.

We constructed a cooperative strategy game for multi-agent system model to cover this sort of situation (Fig. 4).

DEVELOPMENT OF STRATEGY AND NUMERICAL SIMULATION

In this study, we tried to find a solution through agent mechanisms for conflict games. In order to allow the games to be more convenient, we describe the system's processes in detail in the following figure: the practical operation steps are shown as Fig. 5.

Step 1: All users only need to input their adopted strategy; the value of the strategies' remuneration does not need to be specified.

Step 2: The system will produce a m×n payoff matrix (hereafter called Matrix Z1) according to the quantity of strategies input by both parties. The research supposed that the two companies are Company A and Company B; m represents the numbers of strategy Company A wants to adopt and n represents the numbers of strategy Company B wants to adopt. At this point, the matrix will include any payoff value and the system will automatically generate all corresponding strategy combinations. The matrix shown as Table 1.

Step 3: The system will automatically send back all strategy combinations that have been produced to Company A and Company B. The two parties will arrange a sequence of all strategy combinations according to their own situations and give the strategies ranking values, from the highest to the lowest. Both parties will judge, from their own angle, which strategy combination will be

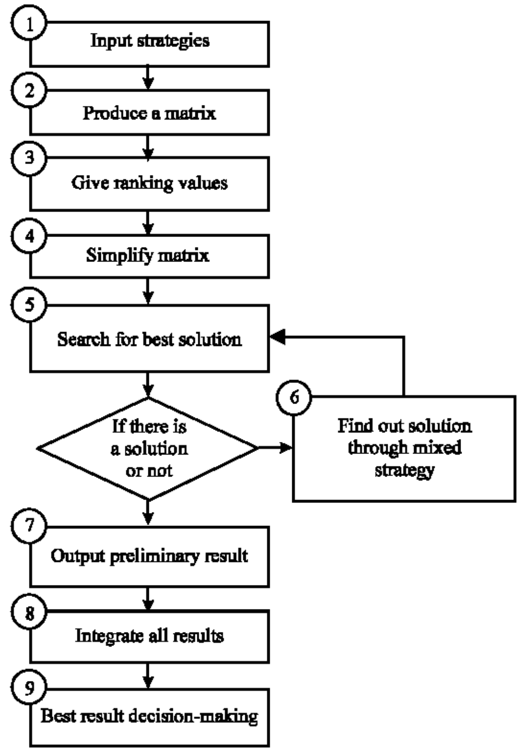

Fig. 5: Flow chart of conflict resolution

Table 1: The initial payoff matrix Z1 (without payoff values)

		B			
		B-1	B-2	...	B-n
A	A-1				
	A-2				
	...				
	A-m				

the most beneficial to their own company and give it the highest ranking value. Conversely, when the strategy combination is not beneficial, or is even detrimental to their own company, they will give it a low ranking value. Both companies conduct the judgment in hopes of securing their own maximum payoff as their goal. In other words, this step is the arrangement of order of benefit degrees by both companies for all strategy combinations.

Step 4: Fill out all corresponding columns in the Z1 Matrix with the values of row produced by step 3 and produce a two-person multi-strategy game payoff matrix (hereafter called Z2) with payoff values (please refer to Table 2). Then conduct a domination strategy judgment on the matrix Z2. In the payoff matrix of game theory, if there is any domination strategy (it is always better for a party to adopt one strategy over the others), you have to conduct a matrix simplification first. Only after simplifying the matrix (hereafter called Z3), can this process continue.

Table 2: Payoff matrix Z2 (P_{a1} ~ P_{amn}: Represent the given value of row of various strategy combinations for Company A, P_{b1} ~ P_{bmn}: Represent the given value of row of various strategy combinations for Company B)

		B			
		B-1	B-2	…	B-n
A	A-1	(P_{a1}, P_{b1})	(P_{a2}, P_{b2})	…	(P_{an}, P_{bn})
	A-2	($P_{a(n+1)}$, $P_{b(n+1)}$)	($P_{a(n+2)}$, $P_{b(n+2)}$)	…	(P_{a2n}, P_{b2n})
	…	…	…	…	…
	A-m	($P_{a((m-1)n+1)}$, $P_{b((m-1)n+1)}$)	($P_{a((m-1)n+2)}$, $P_{b((m-1)n+2)}$)	…	(P_{amn}, P_{bmn})

Step 5: At first, starting from the maximum payoff value, confirm if Company A chooses the strategy with the maximum payoff value and whether Company B can secure the maximum payoff value from adopting the responding strategy. If so, the strategy combination is one of equilibrium solutions; if not, Company B should respond by offering a strategy with a greater payoff value. Then in the same way, Company A should begin to determine if the strategy combination is a responding strategy that can secure the maximum payoff. If so, the strategy combination is an equilibrium solution; if not, Company A should respond a strategy with a greater payoff value. The action will continue in this fashion until an equilibrium solution has been found.

The situations of convergence in the search are as follows:

- Single equilibrium solutions (which converge to any intersection). A 1×1 matrix; in this situation, output the optimal equilibrium solution as the result of the bargaining game.
- Approximate equilibrium solutions (in which one party's strategy option converges to a single strategy). These use a 1×N or N×1 matrix; in this situation, we only need to consider the responding strategy option of greater payoff value that the undecided player may select. For the player who has already decided, adopting the strategy will definitely secure more payoffs.
- Double equilibrium solutions (evaluate solution by mixed strategies). These use a 2×2 matrix; this situation is the completely symmetrical equilibrium that can determine a feasible strategy combination through mixed strategies.
- No-equilibrium solutions (seek for solution by mixed strategy). These use a 2×2 matrix; under this situation, for forming a cycle, we may obtain an equilibrium strategy combination that can secure the maximum expected payoff through mixed strategies.

Step 6: If such a method of searching for an optimal solution cannot reach an equilibrium solution, the system will continue to repeat the cycle of proposing strategy combinations. At this point, the system will adopt mixed strategies in game theory to find a solution. Suppose that after simplifying the payoff matrix, two strategies remain for Company A and two remain for Company B; the resulting payoff matrix Z3 after simplification is shown in Table 3.

Table 3: Payoff matrix Z3

		B	
		B-1	B-2
A	A-1	(P_{a1}, P_{b1})	(P_{a2}, P_{b2})
	A-2	(P_{a3}, P_{b3})	(P_{a4}, P_{b4})

Table 4: The corresponding payoff matrix of payoff value (Hereafter called Matrix Za)

		B	
		B-1	B-2
A	A-1	P_{a1}	P_{a2}
	A-2	P_{a3}	P_{a4}

Table 5: The corresponding payoff matrix of payoff value (Hereafter called Matrix Zb)

		A	
		A-1	A-2
A	B-1	P_{b1}	P_{b2}
	B-2	P_{b3}	P_{b4}

Then divide Company A and Company B's corresponding payoff matrix into Za and Zb payoff matrices (Table 4, 5).

At first, for Matrix Za, the calculation of mixed strategy is as follows:

- Conduct a domination strategy judgment first. If the judgment can produce an equilibrium solution, send back the strategy used by the equilibrium solution directly. If the judgment cannot produce an equilibrium solution and is in an indefinite cycle, then continue to step 2.
- According to maximum and minimum theory, the attacking side (on the left side of the payoff matrix, referred to as A) can find out the maximum expected gains in the minimum payoff options (hereafter called Max-a) whereas the defensive side (on the upper side, referred to as B) can find out the minimum expected loss in the maximum loss options (hereafter called Min-b).
- According to the mixed strategy, the attacking (to obtain expected gains) is on the left side, while the upper side is the defensive side (to obtain expected losses).

A: Assume A chooses Strategy A-1→the probability of responding with Strategy B-1 is p1 and the probability of responding with B-2 is (1-p1).

$$EG\ (A) = P_{a1} \times p1 + P_{a2} \times (1-p1) \quad (1)$$

Assume A chooses Strategy A-2→the probability of responding with Strategy B-1 is p1 and the probability of responding with B-2 is (1-p1).

$$EG\ (A) = P_{a3} \times p1 + P_{a4} \times (1-p1) \quad (2)$$

Through Eq. 1 and 2, we can find the probability p. So the expected benefit of A is: B-1: EG (A) = (1), B-2: EG (A) = (2). If (1), (2) > Max-a, it means that if one adopts a mixed strategy, the expected benefit will be higher, that is why the attacking side adopts a mixed strategy to find a solution. The attacking side and the defensive sides now change places for the convenience of calculation.

B: Assume B chooses Strategy B-1→the probability of responding with Strategy A-1 is p2 and the probability of responding with A-2 is (1-p2).

$$EL\ (B) = P_{a1} \times p2 + P_{a3} \times (1-p2) \quad (3)$$

Assume B chooses Strategy B-2→the probability of responding with Strategy A-1 is p2 and the probability of responding with A-2 is (1-p2).

$$EL\ (B) = P_{a2} \times p2 + P_{a4} \times (1-p2) \quad (4)$$

Through Eq. 3 and 4, we can find the probability p. So the expected loss of B is: A-1: EL(B) = (3), A-2: EL(B) = (4). If (3), (4) < Max-a, it means that if one adopts a mixed strategy, the expected benefit will be lower; that is why the defensive side adopts a mixed strategy to find a solution.

Finally the system sends back the highest probability of strategy options (with the value of probability). If both strategies have the same probability, then both strategies are sent back. In the same way, for Matrix Zb, conduct the same calculation of mixed strategy and send back the strategy options (with the probability) of the maximum probability. If both strategies have the same probability, they are similarly both sent back.

Step 7: The system would simplify the results such as those shown in Table 3, retaining the strategy options which have the highest probability. The system yields the following three results:

- **The formation of an equilibrium solution:** After going through all the steps, the system produces a solution which is acceptable to all users, since it offers the greatest possible payoff to every user.
- **The formation of a compromise solution:** This means that one user agrees and the other does not. At this point one only needs to consider the user who does not agree. If the solution has the greatest payoff for this user, then this is the best solution, because all the solutions for the agreeing user offer the greatest payoff.
- **The formation of a collision solution:** This means both users have more than one solution. The solution which has the highest probability value gives the best result.

If the result is not an equilibrium solution, then this system proposes a solution which has the highest probability of being accepted by both parties. If the result from Step 7 is an equilibrium solution, then the solution has a probability value of 100%. Our Cooperative Strategy for Multi-agent System Model will present some information to all users and make sure the preliminary results satisfy all their conditions.

Step 8: This step calculates all the probability values from Step 7. If there are four users, then the step must be run six times, $c_2^4 = 6$. If the system finds an equilibrium solution, the optimum result to all users is thus achieved. When there is more than one result, proceed to Step 9.

Step 9: If the result is an equilibrium solution after Step 8, send this solution to every user. Note that this solution would be the best result which has the highest probability of being chosen. If there is more than one result, then send them to those users who have not decided yet. Those users should choose the best solution for them: the one that either has the better payoffs, or the minimum expectation of loss.

NUMERICAL SIMULATION AND ANALYSIS OF RESULTS

All users only need to input their adopted strategy, without requiring the numerical value of the strategy remuneration. In our example, we have three businesses to join in strategy coordination. The first step is choosing any two game rules of these businesses to start the bargaining game. The following passage will describe the system processes in detail, taking the manufacturer (M International Company, Ltd.) and channel provider (Company C, Ltd.) in the study as examples:

(1) First, input the strategy that both parties want to adopt. Here we choose an example in which there are two strategies for each of both parties to explore.

Table 6: The initial payoff matrix

		M		
		M-1	M-2	M-3
C	C-1	(,)	(,)	(,)
	C-2	(,)	(,)	(,)

Table 7: The initial payoff matrix

		M	
		M-1	M-2
M	C-1	(3,1)	(2,3)
	C-2	(1,4)	(4,2)

Manufacturer (M):
(M-1) Increases stock share amount by 30%
(M-2) Requests priority positions on shelves for their goods
(M-3) Increases advertisement of their goods

Channel provider (C):
(C-1) Share operation rights with the manufacturer
(C-2) Adjust stock share cycle

(2) Next, put two strategies of each party into the payoff matrix of the first stage. Here C represents the channel provider and M represents the manufacturer. The matrix shown as Table 6.
(3) Then give an estimated expected payoff value according to the strategies and responding strategies that have been adopted by both parties. These values are replaced in Table 7 by ranking values, in which the left side of the matrix is composed of payoff values of the channel provider, whereas the right side is composed of the payoff values of the manufacturer. The reason why we do this is to prevent too big a difference between a strong company and weak company that will lead to the neglect of the weak side. Then we observe if there is a domination strategy before simplifying the matrix. It is necessary to prevent a domination strategy; M-3 is the domination strategy in our example.
(4) Firstly, start with the maximum value of C and begin to find the optimal solution that is acceptable to both parties. Continue to do this until an equilibrium solution is produced that may be accepted by both parties, or produce a repeated cycle.

The maximum value C will emerge when Company C adopts strategy C-2 and M responds with strategy M-2. At this point, M will find out if they can secure the maximum benefit when they respond with strategy M-2 to Company C's C-2. But the matrix shows that they can secure a greater payoff value by responding with strategy M-1.

Repeating these steps, C chooses a strategy, M responds with a strategy of its own, M changes the strategy and replaces C's strategy with one that will enable C to secure a higher benefit, C responds to the new strategy and so on. A pattern of strategy choices will be produced as follows, in which side A adopts a strategy and expects the other side to respond with another strategy (Eric *et al*., 2003):

[C-2,M-2] → [M-1,C-2] → [C-1,M-1] → [M-2,C-1] → [C-2,M-2] → [M-1,C-2] → [C-1,M-1]....

Observing the route emerge in the above-mentioned process of finding the optimal solution, we can see that the game produces a fixed pattern as follows; therefore, we have to adopt a mixed strategy to find the best solution:

[C-2,M-2] → [M-1,C-2] → [C-1,M-1] → [M-2,C-1]

(5) Dissolve the payoff matrices of C and M. Both parties use their own estimated payoff values as the values in the payoff matrices (Table 8) to find a solution with mixed strategies. Here we use the part of Channel provider C as an example to explore.

Table 8: Expected payoff matrix of channel provider

		M	
		M-1	M-2
C	C-1	3	2
	C-2	1	4

- The left side of the mixed strategy is the attacking side (seeking for its own gains) and the upper side is the defense side (seeking for an expected losses): C:Assume C chooses Strategy C-1 - The probability of responding with Strategy M-1 is p and respond with Strategy M-2 is 1-p.

$$3p+2\,(1-p) = 2+p \qquad (5)$$

Assume C chooses Strategy C-2. The probability of responding with Strategy M-1 is p and the probability with M-2 strategy is 1-p.

$$1p+4\,(1-p) = 4-3p \qquad (6)$$

We can find $2+p = 4+3p \rightarrow 4p = 2 \rightarrow p = 50\% = 0.5$.
The expected benefit of C is:
C-1: EG (C) = $3\times0.5+2\times0.5 = 2.5$
C-2: EG (C) = $1\times0.5+4\times0.5 = 2.5$

- Then, exchanging the roles of both parties, we can figure out the expected loss of M and the probability of the responding strategy by M (Table 9):

Table 9: Expected payoff matrix of channel provider

		C	
		C-1	C-2
M	M-1	3	1
	M-2	2	4

M: Assume C chooses Strategy C-1 - The probability of responding with Strategy M-1 is p and the probability of Strategy M-2 is 1-p.

$$3p+1\ (1-p) = 1+2p \qquad (7)$$

Assume C chooses Strategy C-2 - The probability of responding with Strategy M-1 is p and the probability of Strategy M-2 is 1-p.

$$2p+4\ (1-p) = 4-2p \qquad (8)$$

We can find out $1+2p = 4+2p \rightarrow 4p = 3 \rightarrow p = 75\% = 0.75$.

The expected loss of M is:

M-1: EL (M) = $3\times0.75+1\times0.25 = 2.5$

M-2: EL (M) = $2\times0.75+4\times0.25 = 2.5$

- First, use the ordinary method to find out a solution to the matrix; adopt Max-Min Theory to look for expected losses and expected benefits and then compare these with the values of mixed strategy.

Channel provider C (the attacking side) adopts maximin principle in expecting to find maximum payoff among minimal benefits. They will find out payoff value 2, but if C adopts a mixed strategy to find out a solution, then the expected payoff value could be raised to 2.5. Therefore, Channel provider C wants to adopt a mixed strategy to find a solution.

Manufacturer M (the defense side) adopts minimax principle in expecting to find the minimum loss under the situation of maximal losses. They will find the loss value 3. If M adopts a mixed strategy to find out a solution, then the expected loss may be reduced to 2.5. Therefore, Manufacturer M, like Channel provider C, wants to adopt a mixed strategy to find a solution.

- Summing up the results of calculating these strategies proposed by both parties and reorganizing each probability of adopting various strategies by both parties, we have the following results. The probability for C of choosing C-1 is 75% and C-2 is 25%, the probability for M of choosing M-1 is 50% and M-2 is 50%. In our example, Business A is the manufacturer and Business B is the channel provider. The result of the game played by the Channel provider and the Manufacturer is shown as Fig. 6.

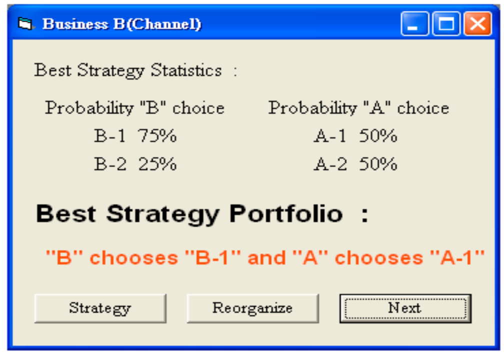

Fig. 6: Channel provider agent initial result

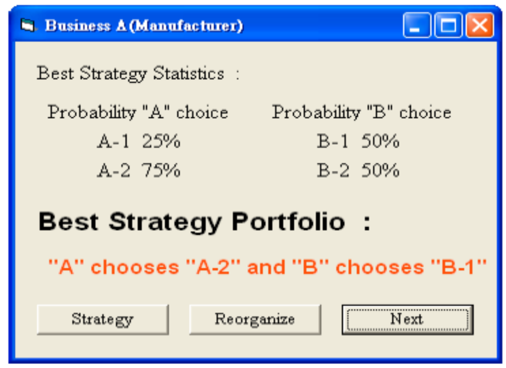

Fig. 7: Manufacturer agent initial result

The strategy combinations with the highest probability (the one which both parties think can secure higher benefits for them) are Strategy C-1 for C and Strategy M-1 for M.

Under the same conditions, we may use the payoff values set by M to devise a strategy combination and solution that is acceptable to both parties. The probability for M to M-1 is 25% and M-2 is 75% and the probability for C to choose C-1 is 50% and C-2 is 50% (Fig. 7).

Therefore, the strategy combinations with the highest probability (the one which both parties think can secure higher benefits for them) are Strategy M-2 for M and Strategy C-1 for C.

(6) Reorganize the above results and simplify the matrix (Table 10) in Step 3:

Finally, we can consider only the strategy suggested by M and not the strategy choice of C because for C, Strategy C-1 is a more important strategy choice and may be expected to secure a higher payoff. Therefore, the final strategy combination is that C adopts Strategy C-1 and M adopts Strategy M-2. The system offers strategy options

Table 10: The final payoff matrix

		M -------- M-2
M	C-1	(2,3)

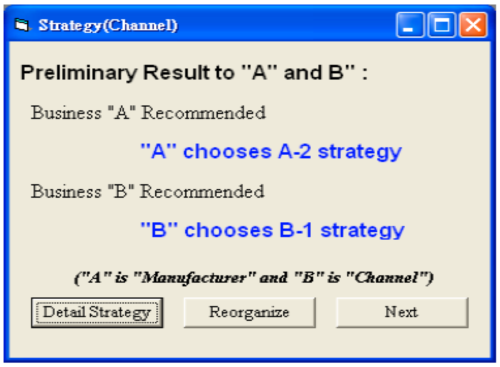

Fig. 8: The preliminary results

with the highest probability values and proceeds to calculate the results and integrate them.

(7) The system simplifies the results as shown in Table 2, retaining the strategy options which have the highest probability of acceptance. The system outputs the following three results (in our example, the preliminary result of channel provider and manufacturer is shown as Fig. 8. The manufacturer can see the same results as those of the channel provider):

- The formation of an equilibrium solution. After going through all the steps, the system produces a solution which may be accepted by all users. This solution should have the greatest payoff for every user.
- The formation of a compromise solution. This means that one user agrees and the other does not. At this point, one only needs to consider the user who does not agree. If the solution has the greatest payoff for this user, this is the best solution, because all the solutions for the agreed user would yield the greatest payoff.
- The formation of a collision solution. This means both users have more than one solution. The solution which has the highest probability value offers the best result.

If the result is not an equilibrium solution, then this system proposes a solution which has the highest probability of unilateral acceptance. If the result from Step 7 is an equilibrium solution, then the solution has the probability value of 100%.

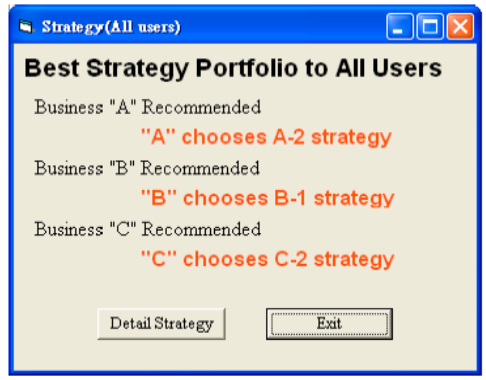

Fig. 9: The best strategy decision-making result

(8) This step calculates all the probability values from Step 7. If there are four users, then the step must be run six times,. If the system finds an equilibrium solution, the optimum result for all users is thus achieved and should be presented to all users. Our Cooperative Strategy for Multi-agent System Model will present some information to all users and make sure the preliminary result (Fig. 9) satisfies their conditions. When there is more than one result, proceed to Step 9.

(9) If the result is an equilibrium solution after Step 8, send this solution to every user. Note that this solution would be the best result which has the highest probability of being chosen. If there is more than one result, then send them to those users who have not decided yet. Those users should choose the best solution for them: the one that either has the better payoffs, or the minimum expectation of loss.

Game theory mostly aims to pursue a Nash Equilibrium solution and respond with different game models for different situations. The Cooperative Strategy for Multi-agent System Model introduced by the study can automatically and quickly find out the strategy combination by which both parties can secure the maximum payoff through multi-agents in different situations and under different conditions according to the information about the strategy that could be made public to the maximum extent. Because not every player in the game has the same conditions, from the angle of enterprises, there is a strong one and weak one that often leads to the collapse of the game: in other words, Game Theory finds itself unable to find a Nash Equilibrium in which both parties secure the same payoff. But for the mediation of conflicts between the strategies of both parties, our Cooperative Strategy for Multi-agent System Model can find out a strategy option that yields the maximum payoff available for both parties.

CONCLUSION

In present study, we observed the negotiations and mediations that took place between the manufacturers and the channel providers and noted the different strategies that they employed in their process of conflict mediation. Although the researchers wished to maintain the objective attitudes of observation, errors produced by personal, subjective explanations of participants' behavior during the game may have occurred.

This study combines a case-study examination with practice and theory and verifies the use of the theoretical model. So far, users of Game Theory have focused mostly on how to find a single equilibrium solution for both parties in which the same specific payoff value was awarded to both parties. In contrast, this study is trying to find a strategy combination acceptable for both parties on the conflict resolution of strategies, but it is unnecessarily to find a single, specific value.

The Cooperative Strategy for the Multi-Agent System Model can quickly and automatically find a solution acceptable to both parties that not only helps enterprises to protect more of their private information, but also maintains the equal role and position between two parties to achieve reconciliation in strategy consultations. This is an innovative way of thinking about conflict resolution and a fresh research topic in the application of game theory to policy-decision.

The use of strategy games is not limited to two parties; it may also be applied to competition and cooperation among multi-party. Accordingly, this study focused on the participation of multiple players within a single game. Combined with the multi-agent mechanism, it could enhance the efficiency of strategy mediation that facilitates enterprises with a more concise way. Thus, the problem in the game of multi-player can be solved by reducing complicated calculation in the application of game theory and advancing the steps toward the goal of solving the problems of multi-player and multi-strategy. In other applications, the competition and cooperation relationships between marketing channel providers and manufacturers are very delicate; besides strategy action games, there are other methods that can be applied mechanically, such as sequential bargaining games and average differences.

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REFERENCES

Adler, M.R., A.B. Davis, R. Weihmayer and R.W. Worrest, 1990. Conflict resolution strategies for nonhierarchical distributed agents. Morgan Kaufmann Series in Research Notes in Artificial Intelligence, DAI., 2 (3): 139-161.

Bond, A.H. and L. Gasser, 1988. Readings in Distributed Artificial Intelligence. Morgan Kaufmann, San Mateo, CA.

Chang, E., 1980. Participant Systems for Cooperative Work. Los Altos: Morgan Kaufmann, pp: 311-339.

Corkill, D.D., K.Q. Gallagher and K.E. Murray, 1986. GBB: A generic blackboard development system. Proceedings of the National Conference of AI, Philadelphia, PA., pp: 1008-1014.

Curwin, J. and R. Slater, 2002. Quantitative Methods for Business Decisions. Thomson Learning, London.

Durfee, E.H. and V.R. Lesser, 1983. Using partial global plans to coordinate distributed problem solvers. Proceedings of IJCAI-87, pp: 875-883.

Eric, R., J.Y. Young, J.Y. Chang and L.Z. Wu, 2003. The Game Theory and Information Economy. Wu-Nan Publishing Co., Ltd, Taipei.

Kreps, D.M., 1992. Game Theory and Economic Modeling. Clarendon Press, Oxford.

Rothschild, M.L., 1988. Advertising from Fundamentals Through Strategies. DC. Hearth and Co., Toronto.

Taylor, B.W., K.S. Wu and H.J. Chang, 1998. An Introduction to Management Science. Hua-Tai Book Store, Taipei.