

Full Length Research Paper

Study of Sino-US economic game and joint development

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Accepted 28 February, 2012

Nowadays, the economic relations between China and America have been one of the most important bilateral economic relations, which have a great impact on two countries' economy as well as the whole world. If the economic games between China and America are favorable, it will be beneficial to both countries. Otherwise, it will harm both of them. Under such circumstance, the paper focuses on economic games between China and America through incomplete information game model. It analyzes different decisions and benefits under anti-competitions and co-competitions. Through the exploration of economic action between China and America under co-games and anti-games, this research gains two conclusions and introduces a theory. In conclusion, it comes up with co-games between China and America's economy, and hopes to offer constructive suggestions to mutual development.

Key words: Sino-US economic game, competition and cooperation, joint development.

INTRODUCTION

Since the establishment of Sino-US relations, the total amount of bilateral trades has increased about 120 times during the past 31 years. Now, Sino-US economic relation has been one of the world's most important relations which deeply affected both US and China. With the warming of Sino-US economic relations, bilateral economic cooperation and development between them have raised much attention from international societies including domestic academia. Many domestic and overseas scholars have deepened the studies on cooperation and competition of Sino-US economies from current policy, economic policy and bilateral trades step by step. Meanwhile, many contribution and achievement have been made in this field, such as global liquidity cycle (Fels, 2009), security and the falling dollar (Shelton, 2008), the role of China in global external imbalances (Bagnai, 2009), United States—China bilateral trade

balance (Fung, 2006), the relationship between the Chinese interest rate and the US interest rate (Cheung, 2007).

At present, scholars who are interested in the study of Sino-US economic relations mainly focus on their own national interests. Therefore, it is inevitable that mutual gaming will emerge between the interactive processes. Considered high complementarity of these two countries, cooperation will bring more benefits compared with them of conflicts. Current studies about game theory, however, mathematical models and economic models are not well employed. Under such circumstance, this paper adopts game theory to deepen the China-US economic cooperation and development. Besides, it tries to explore how to carry out economic "cooperative game" in an attempt to provide constructive suggestions for further expansion of bilateral economic game.

METHODOLOGY

This paper adopts both the classical game model and the incomplete information game model to analyze Sino-US economic

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interaction. Game is the procedures that individuals, teams and other organizations take under certain rules. In each procedure, they can choose their own actions and strategies under permitted choices at the same time or in turns.

Game theory is a theory studying the strategies, interactions and balanced results of the rational decision-makers. It can be divided into cooperative game and non-cooperative game. The main difference between them is whether a binding agreement can be reached and carried out successfully. Each game involved in four main factors, participants, rules, strategies, and profits.

Participant: Main decision-makers in the game aim at selecting action and maximizing their profits. Those who do not make decisions can only act as passive parameters. Moreover, each participant must have optional strategies and definitely preferable function.

Rule: Three rules are contained in the game, opportunities and turns, action and gained information for participants in each procedure.

Strategy: Rules that participant should obey in selecting action, like the strategy of "tit for tat".

Profit: Utility or anticipated utility that participants gained under common strategies. All participants care about it especially, however, it is not necessary that each participant know their own profits clearly. Profit, which can be positive and negative, is the basis in analyzing game model. If the total profits of all participants are negative, it is called negative sum game. Otherwise, it is named positive sum game.

If the pay sum of all participants keeps zero all the time, it will be zero sum game. If the pay sum of all participants keeps a constant (not zero), it will be constant sum game. If the game fails to possess any mentioned characteristics, it will be variable sum game.

Because of the desire of self-profit seeking, there is no doubt that both China and US will adopt non-cooperative strategies to maximize their own profits in Sino-US economic cooperative and non-cooperative game. Even though one part is willing to cooperate with the other part, asymmetric information may result in non-cooperative result. Meanwhile, the aim of Sino-US cooperation will be dimmed and the total profits will be significantly affected. Therefore, it is crucial to change non-cooperative game into cooperative game.

ANALYSIS AND CONCLUSION OF SINO-US GAME MODEL

Analysis of the classical model

We will set up a basic model to analyze Sino-US economic competitive game.

Assumptions

(1) Economic information between China and US is close to be complete, so it is possible to get economic strategy spaces and a collection of payoff functions through various methods.

(2) Both Improvement of economic development rate and their own financial revenue are included in the goal of

Sino-US economic development. However, the main task of each country is to gain advantages in Sino-US economic competitions and enhance their own comprehensive economic strength.

Suppose China and US will compete in subsidies of domestic enterprises (China: A and United States: B). If they cooperate with each other, their profits will be A1. If only one part adopts cooperation, its profits will be A2 and the profits for the other part that does not cooperate will be A3. If China and US compete with each other, their profits will be A4, and the relationships among these are following: $A3 > A1 > A4 > A2$. The pay matrix in the game can be viewed in Table 1.

In Sino-US game, competition is a strictly dominant strategy for each participant and the result (A4, A4) is the Nash equilibrium. However, in the light of best interests of Sino-US whole economy, the result (A1, A1) of cooperation is the Pareto improvement. In this game, opportunistic behaviors of both sides will lead Sino-US game into "prisoner's dilemma".

Through the afore-mentioned analysis, it can be concluded that if both parts cooperate with each other, it will bring the most favorable result for the total amount of economic profits. Nonetheless, the result is unstable and cannot last for a long time, which can be justified by the fact that both parties desire to maximize their own profits. If one party has the desire to cooperate with the other party, the other part has other strong motivation for non-cooperation. Hence, if individual party just focuses on their own interests and external constraints are in the absent, then the non-cooperative economic competition will continue.

Model expansion analysis and conclusions of incomplete information game

Classical game theory employs complete rational assumptions, which fails to show the whole actual conditions of Sino-US relations. For one thing, it is common that learning will emerge between these two countries during their cooperative and non-cooperative action. For another thing, Sino-US competitive economic game is a long and repeated process. Therefore, it is quite necessary to further widen assumptions and expand classic economic model. Meanwhile, incomplete information bargaining model will be adopted to analyze and perfect Sino-US economic game. Finally, a conclusion will be drawn in this research.

1) Further added assumptions: First, Sino-US economic game is incomplete. Second, there are some differences in bargaining ability between China and US due to the economic strength and other factors.

Suppose the US stands for game party 1 and China stands for game party 2, they will compete in subsidies of

Table 1. Pay matrix in the stage game.

	US		
		Cooperate	Complete
China			
Cooperate		(A1, A1)	(A2, A3)
Complete		(A3, A2)	(A4, A4)

domestic enterprises which is named S. The result of S is V. At the beginning of the game, US proposes a program (X, 1-X), then the Chinese part decides whether accept or refuse the proposal. If he accepts, the game will be over. The corresponding profits will be VX and V (1-X). If Chinese part refuses the proposal, Chinese part will propose a new program (Y, 1-Y). US part can accept or reject. Then, the game continues and repeats like this till they reach an agreement. If they cannot reach an agreement, they will gain nothing. If the two sides agrees (X, 1-X) program at time t, the US part will gain $\delta_1 VX$, and Chinese part will gain $\delta_2 V(1-X)$. The discount factors δ_1 and δ_2 in the model represent the bargaining costs the extent of losses when the two sides fail to reach an agreement.

2) When only US part's information is incomplete, we assume that they have type H with high bargaining ability (P represent priori probability) and type L with low bargaining ability (1-P represents priori probability).

When at the state of type H, US part has a strong competitive advantage and corresponding discount factor for Chinese part is δ_{2L} . When at the state of type L, US part has lower competitive advantage and corresponding discount factor for Chinese part is δ_{2H} ($\delta_{2H} > \delta_{2L}$). The information for Chinese part is complete and corresponding bargaining factor for US part is δ_1 . US part proposes program (A,1-A) and program (B,1-B), which mean the only perfect equilibrium result of Sino-US complete information bargaining in type L and type H.

$$A = (1 - \delta_1) / (1 - \delta_1 \delta_{2L}) ; B = (1 - \delta_1) / (1 - \delta_1 \delta_{2H})$$

Apparently, (B, 1-B) is US part's first program.

When US parts proposes program (B, 1-B), if Chinese part accept it, they will gain V(B,1-B). If they refuse, they will gain

$$V\delta_{2L}(1-B)P + V\delta_{2H}(1-A)(1-P)$$

According to

$$P[\delta_{2L}(1-B) - \delta_{2H}(1-A)] < 1 - B - \delta_{2H}(1-A)$$

We can see that

$$V\delta_{2L}(1-B)P + \pi\delta_{2H}(1-A)(1-P) < V(1-B) \tag{1}$$

According to Equation 1, Chinese part gains more than expected profits if they accept program (B, 1-B). So, they will accept it. At this time, no conflicts will happen. Now, we can draw the first conclusion: if US unilateral information is incomplete, Chinese part will accept game program (B, 1-B) when they are at type H with high bargaining ability. Both parts will choose cooperative game to realize Joint development.

3) When Chinese part's unilateral information is incomplete, we suppose type H with high bargaining ability (Q represents priori probability) and type L with low bargaining ability (1-Q represents priori probability). When at the state of type H, Chinese part has strong competitive advantage and discount factor of US is δ_{1L} . When at the state of type L, Chinese part has weaker competitive advantage, and the discount factors of US are δ_{1H} ($\delta_{1H} > \delta_{1L}$). US part's information is complete and corresponding discount factor of Chinese part is δ_2 .

US part proposes program (C,1-C) and program (D,1-D), which mean the only perfect equilibrium result of Sino-US complete information bargaining in type L and type H.

$$C = (1 - \delta_2) / (1 - \delta_2 \delta_{1H}) ; D = (1 - \delta_2) / (1 - \delta_2 \delta_{1L})$$

Apparently, (C, 1-C) is US part's first program.

If US parts proposes program (C, 1-C), when at the state of type L, Chinese part will gain V(1-C) if they accept it. If they refuse, they will gain $V\delta_2(1-C)$ till they will accept it. When at the state of type H, Chinese part will gain (1-C) if they accept it. Otherwise, they will gain $V\delta_2(1-D)$

Supposing:

$$V\delta_2(1-D) = V(1-D_s)$$

$$D_s = 1 - \delta_2(1-D)$$

When $D \leq D_s$, US part proposes program (C, 1-C), Chinese part accept both type L and type H. When $D > D_s$, Chinese part only accepts type L for this program. US part expect to gain $V\delta_{1L}DQ + VC(1-Q)$. Because $Q(\delta_{1L}D - C) < D - C$, we learn that:

$$V\delta_{1L}DQ + VC(1-Q) < VD \tag{2}$$

According to Equation 2, US part's expected profit under

program (C, 1-C) is smaller than program (D, 1-D). So, US part will propose program (D, 1-D) and Chinese part will accept both at the state of type L and type H. Also, no conflicts will come into being.

Therefore, we can draw the 2nd conclusion: When Chinese part's unilateral information is incomplete, US part will propose program (D, 1-D) which stands for the only perfect equilibrium result of Sino-US complete information bargaining in type H. Now, Chinese part will accept program (D, 1-D) no matter whether they are under type H with strong bargaining ability or type L with low bargaining ability. Sino-US's economy will adopt cooperative game and realize Joint development.

DISCUSSION

In recent years, Sino-US economic relations continue to deepen and they are on the transforming from "weak China, strong US" to "strong China, strong US". Likewise, economic competitions have changed from "weak China, strong US" to "strong China, stronger US", in which economic cooperation and development is in a deeper and wider direction. At the same time, based on individual economic profits, economic competitions and frictions always follow.

Thus, more and more attention has been raised on Sino-US economic competitive game. And to date, it has become a rather important issue to be discussed in both two countries. In this paper, incomplete information game model is used to study Sino-US economic competitive game, discuss cooperative game and non-cooperative game. The two following conclusions are drawn from the afore-mentioned analysis.

According to the first conclusion, even if US' information is incomplete or both parts' information is complete, US part proposes game program (B, 1-B), and China will accept it appropriately when complete information is available. Then, Sino-US will develop cooperative game. If Chinese part is under incomplete information, it will be not sure whether Chinese part will accept US' proposal. Moreover, it is also not certain whether cooperative game can be developed.

The second conclusion indicates that even though Chinese part's information is incomplete or Sino-US' information is complete, US part proposes game program (D, 1-D), and China will accept this program no matter at the state of type H or type L under complete information. Sino-US relations will show cooperative game.

From the afore-mentioned two conclusions, we know that Sino-US can propose game and find an acceptable program when unilateral information is incomplete. Vicious competitive conflicts will not occur in the game. When US propose program (B, 1-B) and program (D, 1-D), China will accept them in some cases; On the other hand, Sino-US stress their own prosperity and improvement, which will not affect each other, but

oppositely advances each other's further development. Sino-US economic development will integrate in constant games gradually and realize joint development. Meanwhile, we put forward a lemma that cooperative game of Sino-US and Joint development can occur even if their information is incomplete. It means that Sino-US can develop cooperative game no matter whether their information is complete.

From the earlier discussion and analysis, it is realized that if both governments can develop scientific and reasonable rules and policies for the game running, Sino-US economic relations will surely run dynamically and mutually beneficial.

As long as both countries can take externalities into consideration when making policies for economic interactions, it will be possible to attain to dynamic equilibrium of long time cooperation. Meanwhile, we should take measures to strengthen cooperation from the following aspects, and do our best to avoid fragmented self-profit seeking and prisoner game.

Establishing a new, cooperative and mutually beneficial concept for Sino-US economy

We should have a clear understanding that Sino-US economic cooperation is a positive and mutually beneficial relation, and set up a new, cooperative and mutually beneficial concept for Sino-US economic development. Maximum of economic benefits and win-win development should be achieved in dynamic game.

Only with a cooperative and orderly competition can we maximize Sino-US overall economic profits. Only with the improvement of the overall economic profits can Sino-US gain more profits. Any action that destroys their cooperation will cause decreasing in profits. If both of them do not cooperate sincerely, it will be impossible for them to maximize their profits.

Establishing comprehensive mechanism for Sino-US economic cooperation

A comprehensive mechanism should be established in order to promote Sino-US economic cooperation and solve conflicts caused by individual and collective rationality. The way to solve conflicts between them is not denying their own economic profits. We should firstly achieve Sino-US individual rationality, and then reach collective rationality. If China and U.S reach common senses in economic measures and rules, a fundamental basis for bilateral cooperative game will possibly build up.

Therefore, it is effective to establish bilateral economic cooperation mechanisms, make rules and agreement for cooperation and improve proper competitions. On the basis of individual economic profits, firstly it is quite needed to improve Sino-US overall economic profits.

Establishing Sino-US consultative mechanism and enhancing the accessibility of information

Vicious competition ranges from conflicts in Sino-US economic interests, and also from unclear economic demands and poor communication between them (Deming, 2009). Hence, we should set up various bilateral dialogues and coordination mechanisms with Central Bank, Commercial Department, Financial Department and other relevant departments based on Sino-US trades, stability and improvement of world's economy, and macro control, so that interest demands can be fully expressed in Sino-US interaction. Only coordinate on the afore-mentioned principles can form continuous partnership (Xudong, 2010).

Strengthening bilateral dialogues and solving profits divergences between China and US reasonably

Sino-US should make good use of their economic strategy dialogues and business committees to improve their mutual trust, and widen their dialogues and cooperation. Meanwhile, they should establish higher and more stable administrative institutions to promote bilateral trades.

Conclusion

This paper adopts incomplete information game model to analyze Sino-US economic competitions. It explores cooperative game and non-cooperative game in their game and draws two conclusions. Besides, it proposes a lemma. No matter both parts' are at the state of complete information or not, they will develop cooperative game and realize Joint development. Mutual suspicions, non-cooperative game and prisoner's dilemmas will not happen because of unbalanced information.

However, this paper does not make a deep and definite study on how to set up assumptions and propose lemma with Mathematical formula. The author hopes the future studies can make further exploration on Sino-US economic competitions.

In short, with the rapid development of economic globalization and integration, divergences and contradictions are inevitable during the economic interactions among different countries. However, according to the afore-mentioned analysis and discussion, it is acknowledged that win-win Sino-US economic relationship will become the result of their long-

term interactive game. The expanding bilateral cooperation and maximizing mutual economic interests will set up a fundamental basis for Sino-US economic relations. Therefore, China and US should consider their economic interactions from the strategic perspective, use global forward-thinking, and keep pace with economic globalization integration. A long-term cooperation and win-win game should be established in order to solve contradiction and divergences, maintain and expand common interests, and vigorously promote the healthy and stable development of Sino-US economic relations.

ACKNOWLEDGMENTS

This study was supported in part by the National Natural Science Foundation General Project: (Number: 71173099) and National Natural Science Foundation Youth Project: (Number: 70903002). Also, it was supported in part by the Great Subject Research Project on Philosophy and Social Science of the Ministry of Education of the People's Republic of China "Common Benefit Type Society Welfare Theory and System Construction in China" (Number: 10JZD0033). In addition, it was supported by the Trans-Century Training programme Foundation for Talents of Humanities and Social Science by the Ministry of Education of the People's Republic of China (NCET-11-0228), 2011; and by the "Green-blue Project" in Jiangsu Province, 2010.

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