ECON 211B
Final Paper

Maintaining Cooperation with Anonymous Individuals

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1. Introduction

It is widely observed that in many situations a non-cooperative Nash equilibrium yields an inefficient outcome. The very desire of mankind to find out a solution to achieve a better outcome can be thought of as a driving force that brought about various social devices such as social norms, laws, institutions, customs, etc. The basic element in those devices is punishment following socially undesirable behaviors and/or reward following socially desirable behaviors. As the society becomes larger in size and more individualized in nature, it is harder to identify people who we are dealing with. In this case, the punishment and reward scheme may not work and cooperation will be harder to maintain.

This paper considers the ways to achieve efficient outcomes with very limited information. Two main papers to be reviewed are Kandori (1992) and Ellison (1994). They give two different solutions to achieve efficiency. In section 2, I will overview and classify various situations that can arise in a repeated game. I will introduce Kandori's work in section 3 and Ellison's in section 4. Section 5 compares these two solutions and section 6 discusses potential applications and extensions of their works.

2. Overview

Suppose that people interact on a community basis. For convenience I will consider three classes of communities although there is no clear-cut division of these categories.

2.1 Small Community

In this class of communities, community members form personal relationships with each other. They meet on a daily basis or interact frequently. The examples of this class include family members and co-workers in a small business. In this situation, we can use personal enforcement by the victim without much problem. If person A cheats person B, then B can retaliate on A in a short time and frequently many times since A cannot avoid meeting B. Therefore, the usual Folk Theorem (for example, Fudenberg and Maskin (1986)), which assumes that a game is repeated infinitely by a stable set of players, can be applied to achieve efficient outcomes.

2.2 Identifiable Community

There is a class of communities that is characterized by infrequent interactions but known identities. Typical examples will be colleges and companies. In this class of communities, we can use community enforcement by community members. Suppose that person A cheats person B. Since every member in the community will observe that A has defected, each person who interacts with A later on can punish him. In this case, A's incentive to cooperate is the same as that in a small community. This observation is stated as Proposition 1 of Kandori. Therefore, observability and identifiability in a community can replace a long-term frequent relationship with fixed players.

2.3 Anonymous Community

This class of communities is characterized by infrequent interactions, unknown identities and no communications. This class becomes more ubiquitous in modern metropolitan areas. In this situation, it is difficult to implement the punishment mechanism by victims or community members compared to in small and identifiable communities. Suppose that person A cheats person B. Nonetheless, B cannot identify who A is and cannot tell others that he is cheated. Therefore, the incentive to cooperate seems to be a lot less in this case with very limited amount of information.

One way to achieve punishment in this situation is that the victim B starts a contagion process and defects any partner he gets to see in the future. Then everyone in the community will eventually behave non-cooperatively, which creates an incentive to cooperate to prevent contagion from starting in the community. Kandori's Theorem 3 shows that this contagious strategy constitutes a sequential equilibrium strategy for any given g and M (size of the population) if δ and l are sufficiently large in the prisoner's dilemma game given below:

	C	D
C	1, 1	$-l, 1+g$
D	$1+g, -l$	0,0

Table 1. Prisoner's Dilemma Game

Kandori makes comments on the limitations of the contagious strategy. First, the punishment is weaker than that in an identifiable community since the cheater is not punished immediately – it takes time to meet an infected individual – in the contagion equilibrium whereas the cheater gets to be punished right after the cheating in an identifiable community. Second, if the size of population is large enough, then it is impossible to maintain cooperation with the contagion effect (Proposition 3 of Kandori). Finally, when there is a small amount of noise in the community – either from trembles or from experimentations, cooperation breaks down in the end. Hence there is a problem of "robustness."

To overcome these limitations, Kandori and Ellison go into different directions – Kandori suggests the use of an information system and Ellison modifies the contagion process given above.

3. Information System

Kandori proposes five desirable properties that he wishes to have:

(i) Informational decentralization

(ii) Straightforward equilibrium (given in Definition 2 of Kandori)

(iii) Independence of the matching rule and the size of population

(iv) Global stability (given in Definition 3 of Kandori)

(v) Simplicity: the number of actions on the path of play and the number of information states should be minimal

He shows that under the assumption (A1) any individually rational and socially feasible payoff can be supported as an equilibrium payoff if players are sufficiently patient, with properties (i) through (v). This can be called the Folk Theorem with an information system. (A1) is basically saying that there exist action profiles that punish one player and reward the other player at the same time. The equilibrium strategy is the following: Start with the cooperative phase. If there is no deviation, keep cooperation. If both deviate, play the mutual minmaxing profile for T periods. If one player deviates, play the action profile that punishes the cheater and rewards the punisher. The information system keeps track of the state of a player – whether he is innocent or guilty, and if he is guilty, how many periods he has been punished. Finally, he shows that under a stronger assumption (A2) the number of the states can be reduced to two (innocent, guilty) with a randomizing device.

4. Contagious Strategy with Public Randomizing Device

Ellison considers the prisoner's dilemma game in table 1 with random matching and suggests the following contagious strategy:

> Start with cooperative phase where each player plays C. If there is any deviation, then go to punishment phase with a probability that depend on the discount factor. In the punishment phase, play D and remain there with the same probability.

The public randomizing device enables to choose the "right" severity of punishment – strong enough to deter the first deviation, but not too strong to avoid carrying out the punishment.

He shows that this contagious strategy can support cooperation as a sequential equilibrium for any M, g and l if δ is sufficiently close to 1 and further establishes global stability and limiting efficiency with noise. He also shows that the probability of staying in the punishment phase can be made independent of the discount factor and that the main results hold without public randomization by decomposing the game into some "component" games as well as with heterogeneity in discount factors.

5. Discussions

Information transmission is achieved using an information system in Kandori’s strategy while Ellison’s strategy utilizes a contagious effect to transmit information to members in the community. Ellison’s strategy requires less information structure in a sense that it does not ask additional information on opponent’s label. However, since anonymity is usually associated with a large population, it is doubtful whether the concern about contagion by itself can work well to deter any deviation in practice. In addition, agreeing to use a particular public randomizing device may be difficult especially with a large population. He shows the dispensability of the public randomizing device, but in that case players have to play potentially many component games, which may increase the probability of mistakes if players are only boundedly rational. Another unattractive feature of the contagion process is that it may involve punishing innocent players. The problem will be more complicated when players have altruistic and spiteful component in their payoffs and when they have to guess whether the opponent will defect them or not.

An information system, on the other hand, is systematic in a sense that it gives a specific rule to update information, and given straightforwardness and local processing it will be easy to follow once the rule is established. Moreover, it offers a plausible explanation for institutions and mechanisms in practice such as membership, license and credit card. Some questions regarding Kandori’s strategy include whether we can relax the assumption (A1), what the cost of implementing an information system is and who bears the cost, and how the incentive for truthful reports can be maintained.

For me, it seems that the contagious strategy is appropriate in a community that is not too large and cares about overall social sentiment or trust. An example may be a military unit. Information systems seem appropriate in a larger community where people naturally like to seek a piece of information on their partners rather than behaving as they were treated before since that may cause punishment on their side.

6. Potential Applications and Extensions

One of the possible applications of information systems is the credit market. If a society does not have an information system, then it will be harder to punish those who renege on a loan contract in the future. Therefore, the incentive to defect is higher in such a society, which is likely to lead to credit rationing or a high interest rate. If this is the case, establishing an information system with a reasonable cost will increase the welfare of the society.

There can be a model in which a contagious strategy and an information system are substitutes and selected by agents endogenously. With a general model, it may be found that a certain restriction on parameters implies a contagious strategy is more effective or an information system is more effective.

Another issue regarding an information system is its quality. Kandori assumed that information is updated and transmitted honestly. But there can be some occasions in which players can forge their label for a certain cost or there can be errors in information updates or transmission with a certain probability. Then the analysis should be modified and it will be interesting to see how the set of equilibrium payoffs changes as the quality of the information system changes.

Finally, as the use of the Internet becomes a commonplace, communications in a large community become easy and effective. If people can report defections to a large mass of others using, for example, an online message board, then it can make enforcement by community members more powerful and can play some roles of the information system. Therefore, by utilizing the ease of communications, it may be possible to come up with a third strategy that is better than the contagious strategy and the information system in some respects.

REFERENCES

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