Tags and Their Reputation in Demographic Donor-Recipient Game[1]

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***Abstract*—We consider the effect of tags and their reputation on the emergence of cooperation in demographic Donor-Recipient game. Players are initially randomly distributed in square lattice of cells. In each period, players move locally to random cell in neighbors or globally to random unoccupied cell in the whole lattice, and play multiple games against local neighbors or against randomly selected global players. We restrict patterns of move (play) to local or global; local (global) means with high probability the player moves (plays) locally (globally). If wealth (accumulated payoff) of player becomes negative or his age becomes greater than his lifetime, he dies. If his wealth becomes greater than some amount and there is unoccupied cell in neighbors, he has an offspring. In Donor-Recipient game, one player is selected at random as Donor and the other as Recipient. Donor has two moves Cooperate or Defect; Cooperate means Donor pays cost for Recipient to receive benefit. Defect means Donor does nothing. In this paper, we introduce tags and communication about tags. A player can be distinguished by his inheriting tag. Donor decides his move depending on Recipient's tag. Before Donor's move Recipient can communicate his experienced objective information such as this tag is cooperative and another tag is not cooperative to Donor. Donor holds this information from Recipients as hearsay reputation about tags and uses the reputation to adjust his strategy. We show, by Agent-Based Simulation, that introducing tags promotes the emergence of cooperation and reputation about tags also promotes the emergence of cooperation if the number of different tags is small.**

Keywords—emergence of cooperation; Donor-Recipient game; Demographic model; Agent-Based Simulation; tag; reputation

I. Introduction

This paper investigates the effect of tags and their reputation on the emergence of cooperation in demographic Donor-Recipient game (DR). We introduce tags and one option for Recipient into usual DR game. Recipient can communicate his experienced objective information about tags to Donor before Donor's move.

Epstein [1] introduces demographic model. He shows the emergence of cooperation where AllC and AllD are initially randomly distributed in square lattice of cells. Here AllC always Cooperate and AllD always Defect. In each period, players move locally (that is, to random cell within the neighboring 4 cells, that is, north, west, south, and east cells; von Neumann neighbors, if unoccupied) and play Prisoner's Dilemma (PD) game against local (neighboring) player(s). If wealth (accumulated payoff) of player becomes negative or his age becomes greater than his lifetime, he dies. If his wealth becomes greater than some amount and there is an unoccupied cell in von Neumann neighbors, he has an offspring and gives the offspring some amount from his wealth. Namekata and Namekata [2] extend Epstein's original model discussed above by introducing global move, global play, and Reluctant players, who delay replying to changes and use extended forms of TFT, into demographic PD game and consider the effect of Reluctant players on the emergence of cooperation, and show cases where the reluctance promotes the emergence of cooperation. Here TFT Cooperates at first encounter and at later encounters uses the same move as the opponent did in the previous encounter. Namekata and Namekata [3] examine the effect of move-play pattern on the emergence of cooperation and the distribution of strategies. They restrict patters of move and play of a player to simple structure; local or global, where local or global means that with high probability the player moves (plays) locally or globally, respectively. For example, a player with global move and local play (abbreviated as gl) moves globally with high probability and plays DR games against (possibly different) local opponents with high probability at each period. They show that cooperative strategies evolutionarily tend to move and play locally, defective do not, and AllC and AllD are abundant unless all strategies initially play locally. Namekata and Namekata [4] introduce a costless action for Recipient; Recipient can declare that he is cooperative before Donor's move, and examine the effect of declaration on the emergence of cooperation. They show cases where the declaration promotes the emergence of cooperation. Nowak and Sigmund [5] consider the emergence of cooperation in different non-demographic setting where two players are randomly matched, and play DR game at each period. Frequency of a strategy at the next period is proportional to the payoff of the strategy earned at the current period, which is also different from that in our demographic model. The chance that the same two players meet again over periods is very small. Every player has his own image score that takes on some range, is initially zero, and increases or decreases by one if he cooperates or defects, respectively. Donor decides his move (Cooperate or Defect) depending on the opponent's image score. Riolo et al. [6] deal with similar repeated DR game setting where, instead of image score, every player has his own tag and tolerance and Donor cooperates only if the difference between his tag and the opponent's is smaller than his tolerance.

In general, reciprocity explains the emergence of cooperation in several situations [7]: Direct reciprocity assumes that a player plays games with the same opponent repeatedly and he determines his move depending on moves of the same opponent. If a player plays games repeatedly and the opponents may not be the same one, indirect (downstream) reciprocity assumes that the player determines his move to the current opponent depending on the previous moves of this current opponent, or indirect upstream reciprocity (or generalized reciprocity) assumes that the player determines his move to the current opponent depending on the previous experience of his own. Since player in Namekata and Namekata [2, 3] determines his move depending on his own previous experience, they deal with generalized reciprocity. Nowak and Sigmund [5] deal with indirect (downstream) reciprocity because Donor determines his move to his opponent Recipient depending on the image score of the Recipient that relates to the previous moves of the Recipient. Namekata and Namekata [4] deal partly with indirect (downstream) reciprocity since Donor determines his move to his opponent Recipient depending on Donor's partial information about the opponent. There is no reciprocity, either direct or indirect in the model of Riolo et al. [6] because Donor's move does not depend on the opponent's previous moves as well as his own previous experience.

This paper examines the effect of tags and their reputation on the emergence of cooperation. In real life people distinguish others by some observable feature and act differently according to it. We call this observable feature as tag. They also communicate to others their experienced objective information such as tags 0 and 2 are cooperative and tag 1 is not, hold the information from others as hearsay reputation about tags, and use it to adjust their action. We show, by Agent-Based Simulation, that introducing tags promotes the emergence of cooperation and reputation about tags also promotes the emergence of cooperation if the number of different tags is small.

II. Model

We start with extending TFT as follows in order to introduce reluctant strategy: Let m=2; t=0,...,m+1; s=0,...,m. Strategy (m,t;s) has m+1 inner states. The inner states are numbered 0,1,...,m; thus m is the largest state number. State i is labeled D_i if $i<t$ or C_i if not. If current state is labeled C or D, then the strategy prescribes using C or D, respectively. In other words, the strategy prescribes using D if the current state $i<t$ and using C if not; thus the value t is the threshold which determines the move of player. Initial state in period 0 is state s; its label is D_s if $s<t$ or C_s if not. If current state is i, then the next state is $\min\{i+1,m\}$ or $\max\{i-1,0\}$ given that the opponent uses C or D, respectively, in this encounter. If $m>1$, then the strategy may delay replying to its opponent's change. Note that TFT is expressed as (1,1;1) in this notation. Thus strategy (m,t;s) is an extended form of TFT. To sum up, our strategies are expressed as (m,t;s); m is the largest state number, t is the threshold, and s is the initial state number. We omit the initial state like (m,t;*) if it is determined randomly. We also omit the initial state like (m,t) if we have no need to specify it. We call inner state as Cooperation Indicator (abbreviated as CI). Note that reluctant strategy (m,t;s) by itself decides its move to the current opponent depending on the previous experience of its own, meaning indirect upstream reciprocity, that is, generalized reciprocity. Also that AllC is denoted by (2,0) and AllD by (2,3).

We deal with Donor-Recipient (DR) game as a stage game. DR game is a two-person game where one player is randomly selected as Donor and the other as Recipient. Donor has two moves, Cooperate (C) and Defect (D). C means Donor pays cost c in order for Recipient to receive benefit b ($b>c>0$). Defect means Donor does nothing. Since it is common in demographic dilemma game that the sum of payoffs of player, in two successive games once as Donor and once as Recipient, to be positive if the opponent uses C and negative if D and the worst sum of player is equal to the best sum in absolute value, we transform the original payoffs to new ones by subtracting constant x. Constant x is given by $(b-c)/4$. We set b=4 and c=1 in this paper. We assume that each player plays 6 games against (possibly different) players at each period.

In this paper, we introduce tags and two costless moves for Recipient, Communicate or not, one of which is made before Donor's move. A player distinguishes others by their tags and act differently according to them in the following way: He has his strategy (m,t) and holds *numberOfTags* pieces of Cooperation Indicators (CI's), one for each tag. He changes CI for tag=i according to the moves of the previous encounters only with tag=i when he is Recipient and takes the action prescribed by CI for tag=i against opponent with tag=i as previously explained in the definition of (m,t) when he is Donor.

We explain in detail how Recipient communicates his experienced objective information about tags, Donor collects this information as hearsay reputation about tags, and adjust Donor's strategy (CI's): A player (as Recipient) keeps the number of experienced move C and the number of experienced move D from each tag as his *experienced objective information*. Before Donor's move Recipient communicates with probability *rCom* or not with probability 1−*rCom*. If he does communicate and he has some experienced objective information of some tag, he communicates these information in the form of "tag i is cooperative or not" for each i to Donor. If the cooperation rate of tag i in his experienced objective information, that is, (the number of experienced move C from tag i)/(the number of experienced move C from tag i + the number of experienced move D from tag i) is greater than or equal his expected Cooperation rate (*ecCr*), then the tag i is cooperative by experienced information. Here expected Cooperation rate (*ecCr*) is inheriting property of player. The *ecCr* is a subjective rate at which he expects the society is cooperative. Recipient tells his true experienced objective information about other tags than his own. He tells that the same tag as his own is cooperative irrespective of his true information with his probability *rPre* or tells his true information with probability 1−*rPre*. If Recipient does communicate, Donor (except AllC and AllD) holds them as *hearsay reputation* about tags and adjusts Cooperation Indicators (CI's). Hearsay reputation is summarized in the form of (Cooperation count of tag *i*, Defection count of tag *i*) for each tag *i*. If Recipient tells the information (Cooperative or Defective about tag *i* other than his own, then Donor increases the number of Cooperation or Defection count of tag *i* by one, respectively. If Recipient tells his own tag *i* is cooperative (he may not tell the truth), Donor checks his experienced objective information about tag *i* and his hearsay reputation about tag *i*. If at least one of them is cooperative, then Donor increases the number of Cooperation count of tag *i* by one. If none of them is cooperative, then Donor ignores Recipient's information about tag *i*. If Recipient tells his own tag *i* is not cooperative, then Donor increases the number of Defection count of tag *i* by one. We say tag *i* is cooperative by hearsay reputation if Cooperation count of tag *i* is greater than or equal to Defection count of tag *i*. After revising Cooperation or Defection count of all tags, Donor adjusts Cooperation Indicator (CI) for tag *i* of his strategy for all *i* as follows:

- Increase CI for tag *i* by one if tag *i* is cooperative by Donor's hearsay reputation and CI is less than threshold.
- Decrease CI for tag *i* by one if tag *i* is defective by Donor's hearsay reputation and CI is greater than or equal to threshold.
- Do nothing otherwise.

After adjusting CI for all tags, Donor uses his strategy to play DR game against current Recipient. Since Donor determines his move depending on his hearsay reputation about tags, we partly deal with indirect (downstream) reciprocity although the reputation is about a tag not a specific player and thus not complete information.

A player has the following properties that are inherited from parents to offspring; tag, expectedCr (*ecCr*), rateOfCommunication (*rCom*), rateOfPretend (*rPre*), strategy, rateOfGlobalMove (*rGM*), and rateOfGlobalPlay (*rGP*); whose initial distributions are summarized in Table I.

In period 0, *N* (=100) players (agents) are randomly located in 30-by-30 lattice of cells. The left and right borders of the lattice are connected. If a player moves outside, for example, from the right border, then he comes inside from the left border. So are the upper and lower borders. Players use strategies of (*m*,*t*;*s*) form. Initial wealth of every player is 6. Their initial (integer valued) age is randomly distributed between 0 and deathAge (=50).

In each period, each player (1^{st}) moves and (2^{nd}) plays DR games against other players. Positive payoff needs opponent's C. (The detailed description of (1^{st}) move and (2^{nd}) play is given in Table II.) The payoff of the game is added to his wealth. If the resultant wealth is greater than fissionWealth (=10) and there is an unoccupied cell in von Neumann neighbors, the player has an offspring and gives the offspring 6 units from his wealth. His age is increased by one. If the resultant wealth becomes negative or his age is greater than deathAge (=50), then he dies. Then next period starts.

In our simulation we use synchronous updating, that is, in each period, all players move, then all players play, then all players have an offspring if possible. We remark that the initial state for tag *i* of the offspring's strategy is set to the current state for tag *i* of the parent's strategy. There is a small mutationRate (=0.05) with which inheriting properties are not inherited. Initial distributions of inheriting properties given in Table I are also used when mutation occurs. We assume that with errorRate (=0.05) a player makes mistake when he makes

TABLE I. INITIAL DISTRIBUTION OF INHERITING PROPERTIES

property	initial distribution
tag	We deal with two distributions, RandomTag and NonRandom. RandomTag means tag takes one randomly from {0,…,*numberOfTags*−1}. *numberOfTags* takes 1, 2, 3, or 4. NonRandom means that more cooperative strategy (with smaller threshold *t*) tends to have smaller tag. Let *p*(*#tags*, *threshold*) be the distribution of tags of strategy (2,*threshold*) for *numberOfTags* = *#tags*. Then they are defined as follows: *p*(2,0)=*p*(2,1)=(2/3,1/3), *p*(2,2)=*p*(2,3)=(1/3,2/3), *p*(3,0)=(1/2,1/3,1/6), *p*(3,1)=p(3,2)=(1/4,1/2,1/4), *p*(3,3)=(1/6,1/3,1/2), *p*(4,0)=(2/5,3/10,1/5,1/10), *p*(4,1)=(1/4,2/5,1/4,1/10), *p*(4,2)=(1/10,1/4,2/5,1/4), *p*(4,3)=(1/10,1/5,3/10,2/5).
ecCr	Uniformly distributed in interval (0.2,0.5).
rCom *rPre*	We deal with two distributions LH and NO, where LH:={(1/2)L, (1/2)H}, which means *rCom* or *rPre* is uniformly distributed in interval L or H with equal probability 1/2. L:=(0.05,0.2) and H :=(0.8,0.95). In other words, a player communicates or pretends with low probability (L) or high probability (H) randomly. NO means *rCom*=0 or *rPre*=0.
strategy	We deal with distribution, 2ASYM:={(1/4)(2,0), (1/4)(2,1;*), (1/4)(2,2;*), (1/4)(2,3)}. The notation, for example, means that with probability 1/4 strategy (2,0) (AllC) is selected, with probability 1/4 strategy (2,1;*) is selected, and so on, where * indicates that initial state is selected randomly. Note that initially 50% of players use C on the average since both AllC and AllD are included with the same probability and so are both (*m*,*t*;*) and (*m*,*m*−*t*+1;*).
(*rGM*,*rGP*)	We deal with distribution, {(1/4)ll, (1/4)lg, (1/4)gl, (1/4)gg}. For example, gl means *rGM* is distributed in interval g and *rGP* in interval l, where l:=(0.05,0.2) and g:=(0.8,0.95), indicating to move globally and play locally. {(1/4)ll, (1/4)lg, (1/4)gl, (1/4)gg} means *rGM* and *rGP* are selected randomly among ll, lg, gl, and gg.

TABLE II. DETAILED DISCRIPTION

(1)[a]	With probability rateOfGlobalMove (abbreviated as *rGM*), a player moves to random unoccupied cell in the whole lattice. If there is no such cell, he stays at the current cell. Or with probability 1−*rGM*, a player moves to random cell in von Neumann neighbors if it is unoccupied. If there is no such cell, he stays at the current cell.
(2)[a]	With probability rateOfGlobalPlay (abbreviated as *rGP*), the opponent against whom a player plays dilemma game is selected at random from all players (except himself) in the whole lattice. Or with probability 1−*rGP*, the opponent is selected at random from von Neumann neighbors (no interaction if none in the neighbors). This process is repeated 6 times. (Opponents are possibly different.)

a. (1) describes move and (2) describes play in detail.

his move. Thus AllC may defect sometime.

Especially note that the initial distribution of strategy is 2ASYM (including AllC, (2,1), (2,2), and AllD). Also that the initial distribution of (*rGM*, *rGP*) has simple structures; with high probability a player moves and plays locally or globally, thus there are 4 move-play patters such as ll, lg, gl, and gg. And that average of expected Cr (*ecCr*) is 0.35, *rCom* and *rPre* (in LH distribution) take low or high value and their average is 0.5 from Table I.

III. Simulation and Result

Our purpose to simulate our model is to examine the effect of tags and their reputation on the emergence of cooperation and the distribution of strategies. We use Repast Simphony 2.1 (http://repast.sourceforge.net/) to simulate our model.

We execute 300 runs of simulations in each different setting. We judge that the cooperation emerges in a run if there are more than 100 players and the average C rate is greater than 0.2 at period 500, where the average C rate at a period is the average of the player's average C rate at the period over all players and the player's average C rate at the period is defined as the number of move C used by the player divided by the number of games played as Donor at the period. (We interpret 0/0 as 0.) This average C rate is the rate at which we see cooperative move C as an outside observer. Since negative wealth of a player means his death in our model and he has a lifetime, it is necessary for many players to use C in order that the population is not extinct. We are interested in the emergence rate of cooperation (Ce) that is the rate at which the cooperation emerges.

A. Emergence Rate of Cooperation, Ce

What is the effect of introducing tags and reputation about tags on the emergence of cooperation? We summarize the emergence rate of cooperation, Ce, in Table III. The first row indicates *numberOfTags*. R or N in the first column indicates that the corresponding row shows the results for RandomTag or NonRandom of distribution of tags, respectively. NoCom, LH, or NoPre in the second column indicates that the corresponding row shows the results for NO distribution of *rCom*, LH distribution of *rCom* and *rPre*, or LH distribution of *rCom* and NO distribution of *rPre* (and further Donor believes Recipient's information), respectively.

First we examine the effect of introducing tags on the emergence of cooperation. Ce is only 32.0% for 1 tag case. Ce increases, for example, from 48.3%, 52.0% to 54.7% as the *numberOfTags* increases for RandomTag and NoCom case. The same tendency holds for NonRandom tag and NoCom case. Thus introducing tags promotes the emergence of cooperation.

Althoug this monotonicity with respect to *numberOfTags* does not hold for (both RandomTag and NonRandom tag and) LH and NoPre cases, Ce's for 2 tags case, 64.7% (R and LH), 61.0% (R and NoPre), 66.0% (N and LH), and 69.7% (N and NoPre) are fairly large compared with or almost equal to those, for example, 59.0% 61.7%, 64.0%, 66.0%, for 3 or 4 tags cases. Thus reputation about tags promotes the emergence of cooperation if *numberOfTags* is 2. Ce's for NoPre are not so large compared with those of LH, meaning that in the effect of reputation about tags on the emergence of cooperation it is not so important for Recipient and Donor to tell the true information about his own tag and believe it, respectively.

TABLE III. Emergence rate of Cooperation, Ce, at period 500

	#tags	1	2	3	4
R	NoCom	0.320	0.483	0.520	0.547
	LH	-	0.647	0.607	0.590
	NoPre	-	0.610	0.633	0.617
N	NoCom	0.320	0.530	0.550	0.670
	LH	-	0.660	0.627	0.640
	NoPre	-	0.697	0.673	0.660

TABLE IV. (Average ecCr,Average rPre) at period 500

	#tags	2	3	4
R	LH	(0.345,0.595)	(0.339,0.565)	(0.342,0.588)
	NoPre	(0.323,0.0)	(0.327,0.0)	(0.332,0.0)
N	LH	(0.338,0.563)	(0.339,0.545)	(0.351,0.530)
	NoPre	(0.322,0.0)	(0.327,0.0)	(0.338,0.0)

Ce's in NonRandom tag cases are larger than the corresponding ones in RandomTag cases in Table III, for example, 69.7% is larger than 61.0% for NoPre and 2 tags case. Thus the tendency that more cooperative strategy has smaller tag promotes the emergence of cooperation. We conclude the following observation:

1. Introducing tags promotes the emergence of cooperation. Reputation about tags by introducing communication further promotes the emergenc of cooperation if the number of different tags is small, even if Recipient may not tell the true information about his own tag. The tendency that more cooperative strategy has smaller tag promotes the emergence of cooperation compaired with random tag.

B. Expected Cooperation rate, rate of Communication and Pretend

We examine the behavior of expected Cr (*ecCr*), rateOfCommunication (*rCom*), and rateOfPretend (*rPre*) of player that relate to communication. Table IV shows the average *ecCr* and *rPre* over all players at period 500. The average *ecCr* at period 500 is around 33.5% and is a bit smaller than the initial average *ecCr* 35.0% at period 0, meaning that players tend to be pessimistic about cooperative rate of Society evolutionarily. The average *rPre*'s (around 58.3%) at period 500 for RandomTag and LH case are larger than those (around 54.6%) for NonRandom tag and LH case, and both are larger than initial 50% at period 0. Finally most (86.1%) players communicate with High probability at period 500 although initially with 50% (not shown in table). We conclude the following observation:

2. Players tend to be a bit pessimistic about the cooperative rate of Society and to tell his own tag to be cooperative irrespective of true information evolutionarily. Most players communicate with High probability.

TABLE V. DISTRIBTUION OF STRATEGIES AT PERIOD 500

	AllD	(2,2)	(2,1)	AllC
1 tag	0.563	0.025	0.027	0.385
N, NoCom, 4 tags	0.388	0.051	0.295	0.266
R, LH, 2 tags	0.509	0.155	0.199	0.137

TABLE VI. COOPERATION INDICATOR, CI AT PERIOD 500

	(2,2)				(2,1)			
	tag0	*tag1*	*tag2*	*tag3*	*tag0*	*tag1*	*tag2*	*tag3*
1 tag	0.89	-	-	-	1.01	-	-	-
N, NoCom, 4 tags	1.33	0.87	0.73	0.61	1.36	1.01	0.75	0.47
R, LH, 2 tags	1.47	1.51	-	-	1.06	1.08	-	-

C. Average Distribution of Strategies and CI

We examine average distribution of strategies and Cooperation Indicator CI at period 500. Table V shows average distributions of strategies at period 500 for 1 tag case, 4 tags NoCom NonRandom tag case, and 2 tags LH (of *rCom* and *rPre*) RandomTag case. Table VI shows average of CI for those corresponding cases. Only AllC and AllD are abundant (>0.25) at period 500 in 1 tag case. (2,1) is also abundant (besides AllC and AllD in 4 tags NoCom NonRandom tag case. (2,2) has some proportion (>0.15) besides AllC, (2,1), and AllD. CI of (2,2) is less than 1 and that of (2,1) is around 1 in 1 tag case and they are not so different. CI of (2,2) and that of (2,1) are not so different in each tag for 4 tags NoCom NonRandom tag case. Differently with the previous cases CI of (2,2) and that of (2,1) are larger than 1 and the former is greater than the latter for 2 tags LH RandomTag case. We summarize them in the following observation:

3. Only AllC and AllD are abundant in 1 tag case. Introducing only tag makes (2,1) abundant besides AllC and AllD. Further introducing communication makes (2,2) have some proportion besides AllC, (2,1), and AllD. CI of (2,2) and that of (2,1) are not so different without communication but they are different with communication; especially the former is greater than the latter.

D. Two Typical Paths from period 0 to 500

We concentrate on two typical sample paths from period 0 to 500 and consider how strategy (2,1) or (2,2) grows. First typical sample path is one from 4 tags NoCom NonRandom tag case (see Fig. 1). The other is one from 2 tags LH RandomTag case (see Fig. 2, 3, and 4). We will explain partly how (2,1) or (2,2) grow because of tags without or with communication. In the upper graph in Fig. 1, (2,1) has two peaks around period 150 and around 270. We draw graph of SelfCooperation of (2,1) defined below in the lower graph in Fig. 1. SelfCooperation of (2,1) is the smoothed graph over 25 successive periods of the average rate with which (2,1) uses C against a tag over which (2,1) is the maximum frequency, and the average rate is defined by

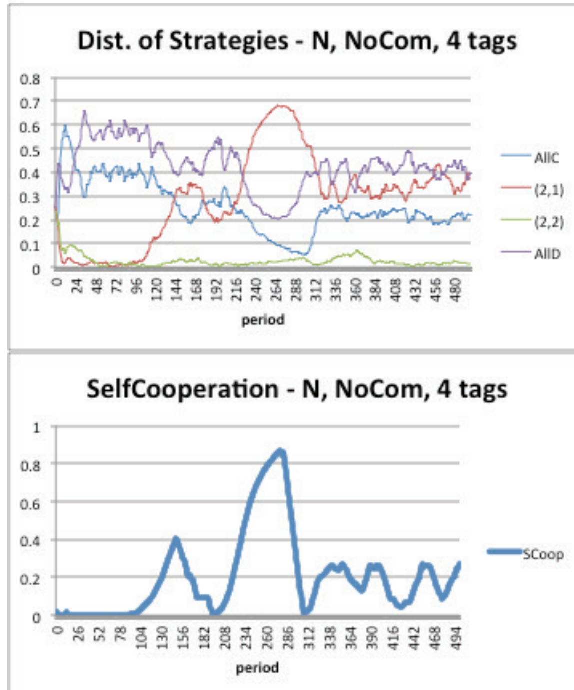

Fig. 1. Sample path in 4 tags NoCom NonRandom tag

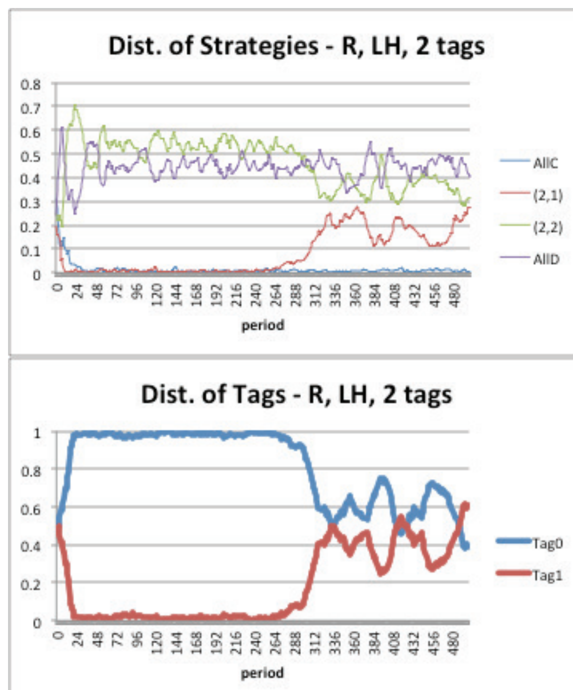

Fig. 2. Distributions of strategies and tags in sample path in 2 tags LH RandomTag

$$\sum_{t=0}^{3}\left[\begin{array}{l}\text{Rate}\{\text{tag}=t\}\\ \times\text{Rate}\{(2,1)\text{ is maximum frequency}|\text{tag}=t\}\\ \times\text{Rate}\{\text{Average CI for tag}=t\text{ of }(2,1)\geq 1\}\end{array}\right]$$

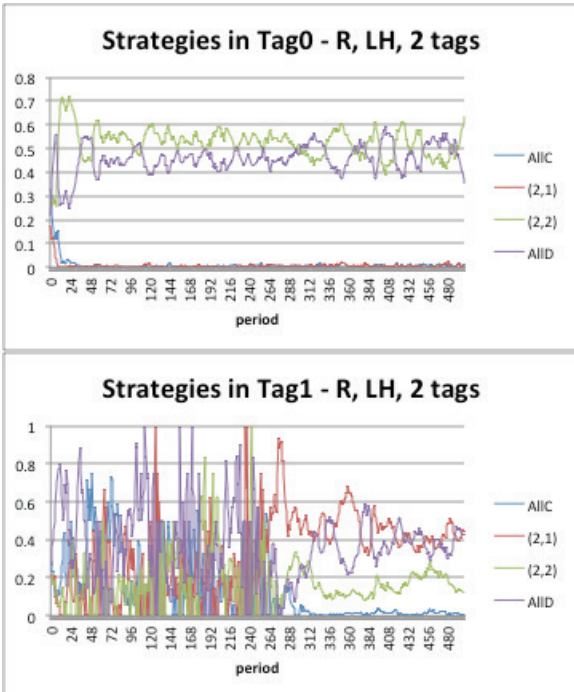

Fig. 3. Distributions of strategies in tag in sample path in 2 tags LH RandomTag

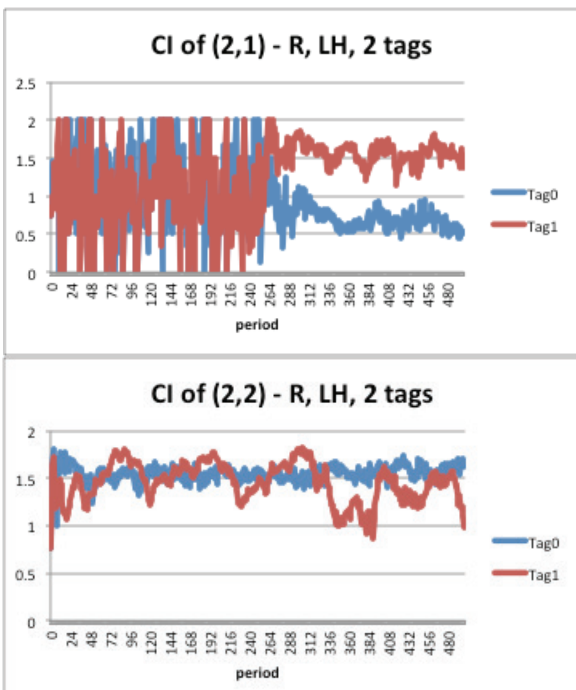

Fig. 4. Average of CI in sample path in 2 tags LH RandomTag

If (2,1) uses C against tag(s) over which (2,1) is the maximum frequency, then we expect that (2,1) grows rapidly. Note that changes of (2,1) in increase or decrease have almost the same pattern as those of SelfCooperation of (2,1) (see Fig. 1).

In Fig. 2, (2,2) has almost Tag0 and is abundant from the beginning because of initial large CI for Tag0 of (2,2) by communication (cf. Observation 3 and see the lower graph in Fig. 4). In Fig. 2, (2,2) diminishes a bit around period 290 because Tag0 diminishes a bit. There are many (2,2) in Tag0 (see the upper graph in Fig. 3). (2,2) keeps its population because of almost constant large CI (around 1.5) for Tag0 of (2,2) (see the lower graph in Fig. 4). In Fig. 2, (2,1) grows rapidly around period 290 since there are many (2,1) in Tag1 (see the lower graph in Fig. 3) and CI for Tag1 of (2,1) is around 1.5 and larger than CI for Tag0 of (2,1) around period 290 (see the upper graph in Fig. 4). Here it also holds that (2,*t*) uses or tends to use C against tag(s) over which (2,*t*) is almost the maximum or high frequency for *t*=1 and 2.

IV. CONCLUSION

We investigate the effect of tags and their reputation on the emergence of cooperation and the distribution of strategies in Demographic Donor-Recipient game. We show, by Agent-Based Simulation, that introducing only tags promotes the emergence of cooperation and reputation about tags also promotes the emergence of cooperation if the number of different tags is small. Introducing tags makes (2,1) abundant and further introducing reputation about tags makes (2,2) have some proportion. We also observe that it is key feature that (2,*t*) uses or tends to use C against tag(s) over which (2,*t*) is almost the maximum or high frequency.

Our results suggest that in order to promote cooperation it is effective for you to distinguish others by some observable feature (tag) and communicate your own objective information about tags to others (but tell your own tag to be cooperative irrespective of true information) if the number of tags is small.

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