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Gonzalo Olcina Vauteren
Vicente Calabuig Alcántara

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Gonzalo Olcina Vauteren [1,2]
Vicente Calabuig Alcántara [1,2]

[1] UNIVERSITY OF VALENCIA
[2] LABORATORY FOR RESEARCH IN EXPERIMENTAL ECONOMICS (LINEEX)

Abstract

We present an overlapping generations model with cultural transmission of preferences, in which players face in each period a two-stage coordination game that consists of a production stage followed by a distribution phase. In the globally stable steady state of society, there will be a mixed distribution of preferences where both selfish and other-regarding preferences are present and, more importantly, players coordinate on the cooperative equilibrium of the coordination game. The presence of a significant fraction of individuals with other-regarding preferences acts as a stock of social capital in the society, reducing personal risk. If the proportion of selfish individuals in the initial condition of the dynamics is very high, there is still multiplicity of equilibria. We show that if there is heterogeneity in the behavior among groups and a positive rate of migration, then all groups will converge to the cooperative result.

Key words

Cooperation, coordination game, social capital, social preferences, cultural transmission.

Resumen

En este documento de trabajo trabajo presentamos un modelo de generaciones solapadas con transmisión cultural de preferencias en el que los jugadores juegan en cada periodo un juego de coordinación de dos etapas, que consta de una fase de producción y una etapa de distribución. Como resultado más destacable, obtenemos que en el estado estacionario globalmente estable de la sociedad existe una distribución mixta de preferencias donde tanto las preferencias egoístas como las preferencias de aversión a la desigualdad están presentes, y lo que es más importante, los jugadores se coordinan en el equilibrio cooperativo del juego de coordinación. La presencia de una fracción significativa de individuos con preferencias sociales actúa como un stock de capital social en la sociedad, reduciendo el riesgo personal. Si la proporción de individuos egoístas en la condición inicial de la dinámica es muy grande, se producirá también multiplicidad de equilibrios. Se demuestra que si hay heterogeneidad entre grupos y una tasa positiva de migración entre ellos, entonces todos los grupos convergerán al resultado cooperativo.

Palabras clave

Cooperación, juego de coordinación, capital social, preferencias sociales, transmisión cultural.

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C O N T E N T S

1. Introduction

THE OECD defines social capital as "the networks, together with shared norms, values and understandings that facilitate cooperation within or among groups". Most of the economic, social and biological research trying to explain the appearance, maintenance and evolution of cooperation in human societies has used the prisoner's dilemma as a simple game that exemplifies this central problem. But researchers have neglected the study of another old social dilemma that from our point of view deserves at least as much attention as the prisoner's dilemma: a simple coordination game, known as the stag hunt. This game formalizes a story told by Rousseau of two hunters who could cooperate by jointly hunting a stag or defect by individually hunting a hare. In contrast to a prisoner's dilemma, where defection is the best response regardless of the other's strategy, in stag-hunt games, defection is the best response to defection, but cooperation is the best response to cooperation. Thus, the stag hunt has two equilibria, one where players cooperate and one where they defect.

The viability of cooperation in society within and among groups depends on mutual beliefs and rests on trust. This crucial dimension of social capital is much better captured in the stag hunt game than in the prisoner's dilemma. In this latter game there is a conflict between individual rationality and mutual benefits (efficiency), while in the stag hunt there is a conflict between mutual benefits and personal risk. In other words, it is rational to cooperate but you need to trust mutually to do so.

Cooperative hunting of big animals is a very ancient game played by men and probably many of our prosocial traits and behaviors evolved and were transmitted in this context. But also in modern economies agents face this class of coordination games. Namely, in many economic situations players have to choose the kind of investment to be made, that is, its degree of relation-specificity. For instance, firms and workers often invest in job-specific assets and job-related training whose returns are shared through subsequent wage negotiations. If investments are not verifiable, so, non-contractible, then both parties have to make independent and simultaneous decisions between making a more specific (and costly) investment or a more general one, bearing the full costs of it in either case. This scenario generally results in a trade-off: highly specific investments yield a larger surplus to be divided between the partners but reduce the ex post bargaining position of the investor, provided his partner has chosen a less specific type of investment. There is a conflict between mutual benefit and the individual risk of getting locked in the relationship with a very weak bargaining position and being exploited by the other party in the negotiation stage.

In the language of game theory, there is a multiplicity of equilibria in this coordination game, one of them is Pareto dominant and the other is risk dominant (in the sense of Harsanyi and Selten, 1988).

This class of games has been analyzed in the literature from an evolutionary approach. Most of this work shows that it is difficult to escape of the risk dominant equilibrium in an evolutionary setting. See, for instance, Kandori, Mailath and Rob (1993), Young (1993) and Ellison (1993). The experimental evidence also shows that cooperative solutions to the coordination problem are not as easy to obtain as one might think (Cooper, 1999). Groups can get *stuck* at a non cooperative equilibrium (van Huyck, Battalio and Beil, 1990).

A common feature in the above works, is that they analyze an *isolated* coordination game. However, we believe that a more realistic approach entails to play this coordination game in two stages: a production stage followed by a sequence of actions like bargaining, punishment or sharing, that is, a distribution stage.

We think that this is an important and realistic feature of interactions in primitive societies where the expectations of what can happen after the hunt greatly condition their behavior in the hunt. As Alvard and Nolin (2002) note in his study of whale hunters in Lamalera (Indonesia):

> ... coordination may fail if participants are not assured a sufficient share of the surplus generated by collective action. Payoffs to hunting are described by distribution norms that produce a payoff schedule acceptable to participants and are presumably maintained by the threat of punishment. The distribution norms seem designed to facilitate a partitioning of resources in a way that is satisfactory to the hunt participants...

But it is also a more realistic feature in many modern economic situations provided there is incomplete contracting. Players renegotiate the division of the surplus and engage, in some situations, in punishing free-riding or opportunistic behaviors.

In this paper we want to know if it can be obtained the Pareto dominant (cooperative) equilibrium, (and if so, under which conditions), when players play the two-stage stag-hunt game. We think that a way to achieve cooperation would be to reduce personal risk through mechanisms that provide players the same expectations about the distribution of the surplus obtained in the production stage. It is easy to view the distribution norms as a solution to this sort of coordination problem. For example, members of a gang may engage in cooperative hunting if they have the assurance that each one uses the same distribution rules and therefore, trusts each other. The important point is that these coordination solutions require a cultural mechanism of information transfer to provide players the shared expectations crucial for coordinated behavior.

We will focus in this work on values or preferences and their role on building trust and achieving cooperation. For conventional economics, preferences are given exogenously. Moreover, they are assumed to be homogeneous in the population and selfish. But nowadays, there is overwhelming evidence to indicate that preferences in the real world populations are heterogeneous with the presence of a significant proportion of selfish but also of social or other-regarding preferences. However, to assume a particular heterogeneous distribution of preferences would be as *ad hoc* as the usual assumption of a completely homogeneous preferences distribution. Instead of that, we work with a dynamic model of cultural transmission, where the distribution of preferences in the population and the strategies in the two-stage coordination game in the long run are determined endogenously and simultaneously.

More precisely, we present an overlapping generations model, where agents live for two periods. In the first period she is a child who is educated in certain preferences or values. In the second period, she is an adult and is randomly matched with another member of the population to play the two-stage coordination game defined above.

Preferences in the population are heterogeneous. In each period there is a fraction of selfish players, and there is also a fraction of players motivated by reciprocal altruism. In particular, we use the concept of inequity averse preferences of Fehr and Schmidt (1999). We use this particular form of social preferences because reciprocity and inequity aversion often work in the same direction and we are just interested in the distributional aspect and not in the intentions of players.

The distribution of preferences in the population evolves according to a process of cultural transmission which combines direct transmission from the parents with oblique transmission from the society. Parents make a costly decision on education effort trying to transmit her own preferences. If they do not succeed, children acquire preferences from the social environment. So preferences evolve depending on the socialization effort of both types of parents, which is determined itself by the actual distribution of preferences (since oblique transmission is a substitute of vertical transmission), and by their expectations about the strategies to be played.

We characterize the long run behavior of this society, that is, the steady states of the dynamics. Our main result is that, for very general conditions, in the globally stable steady state of the society there will be a mixed distribution of preferences where both selfish and other-regarding preferences are present, and more importantly, players coordinate in the cooperative equilibrium of the stag hunt game. We also characterize the negotiation, sharing and punishing policies in the steady state.

The driving force of the result is that the presence of a significant fraction of inequity averse individuals in the population acts as a stock of social capital in the society. In other words, it works as a good substitute for complete contracting, reducing personal risk and this occurs because of their aversion to inequality. In a population that starts in an initial condition with a high proportion of inequity averse individuals, their effect is so strong that cooperation is the unique equilibrium. Inequity averse players are rather generous and fair when they have all the bargaining power, and this makes cooperation the best reply of selfish players even against defection. On the other hand, inequity averse players credibly threat to punish opportunistic and greedy behavior. This makes selfish players to behave also very generously when they have all bargaining power. Therefore, cooperation is also a dominant action for inequity averse players.

If the proportion of selfish players in the initial condition of the dynamics is high, then there is still multiplicity of equilibria in the population. We assume that there are several groups in the society, some of them play cooperatively and others do not. Socialization takes place inside the group, but there is a positive rate of migration among groups which parents anticipate. We show how all groups converge to the cooperative equilibrium. The non cooperative groups eventually end up playing cooperatively because the preferences distribution in the group evolves increasing the proportion of inequity averse individuals.

Our paper is related to a cultural transmission literature in dynamic models of preference evolution. Cavalli-Sforza and Feldman [1981] and Boyd and Richerson [1985], in their seminal work in evolutionary anthropology, were the first to propose models of cultural transmission with exogenous socialization efforts. However we follow the class of cultural transmission models first analyzed by Bisin and Verdier (1998) in which the socialization efforts are endogenous. Moreover, Bisin, Topa and Verdier

(2004) analyze the evolution of cooperation in a context where players play a prisoner's dilemma and in which there is also heterogeneity of preferences.

The paper is organized as follows. Section 2 describes the two-stage coordination game. Section 3 introduces the inequity aversion preferences and the behaviour of inequity averse players. Section 4 summarizes the mechanism of cultural transmission of preferences and analyzes the optimal education effort choice of the different types of parents. We study in section 5 the two-stage game with incomplete information. In section 6, we characterize the steady states of the economy for isolated groups which coordinate in one particular equilibrium. Section 7 presents our main result on migration among groups and cooperation. Finally, we conclude in section 8.

2. A Coordination Game with a Distribution Phase

WE consider overlapping generations of agents who only live two periods (as a young and as an adult). In the first period, the agent is a child and is educated in certain preferences, and in the second period (as an adult with well defined preferences), is randomly matched with another adult player, to play a two-stage game to be described later. In this second period, any adult player has one offspring and has to make a (costly) decision regarding his child education, trying to transmit his own preferences.

As it is usual in this sort of models we assume that fertility is exogenous, that is, an adult has only one child independently of his performance in the two-stage game, and thus the population size remains constant. It is also assumed that reproduction is asexual, with a parent per child.

2.1. The two-stage game: a stag-hunt game with a negotiation and punishment/sharing stage

All adult players, drawn from a large population, are randomly matched into pairs in each period to play a two-stage game. We denote these stages as the production and distribution stage, respectively. In the first stage the players interact to get a material payoff and in the second stage we allow for different mechanisms to implement the distribution of the previously obtained production. These mechanisms are dependent of the actions taken in the first stage. Let us explain this sequential two-stage game in a more detailed way.

In the production phase, each player has to decide, independently and simultaneously, whether to cooperate *(C)* or not to cooperate *(NC)* and their pair of actions determines the surplus obtained. If both players cooperate it is jointly obtained the highest total surplus, denoted by $2B$. If none of them cooperates, each one obtains a payoff of b. And, finally if only one cooperates, the co-operator obtains the lowest possible payoff, which we normalize to zero, whereas the defector obtains a material payoff of d.

We assume that $B > d > 2b > 0$, therefore the efficient outcome of this situation is the one in which both players choose the cooperative action. This specification of the stag-hunt game is also known as the assurance or mutualism game in other contexts.

In the distribution phase, players use several mechanisms of negotiation, punishment or sharing in order to divide between them the surplus obtained. The precise procedure used depends on the actions previously taken by the players.

Firstly, if both players have chosen the cooperative action, they have to decide how to distribute the joint surplus $2B$ between them. We assume that players use a negotiation procedure that provides the same bargaining power to both players. In particular, an ultimatum or take-or-leave-it procedure in which each player has the same probability of formulating the final offer (i.e. of being the proposer).

Secondly, in case they have chosen different actions, then the defector player has to decide which proportion ε of the material payoff d he has obtained, he is willing to share with his opponent. After observing this offer, the cooperator player has the option of punishing the defector at some unitary cost z for him. This implies that he can sacrifice z units of his own payoff to reduce the opponent's payoff in one unit.

Finally, when both players take the non-cooperative action, we assume for simplicity that no additional action is taken.

Assume, as conventional economics and game theory do, that all players have self-regarding preferences. Selfish players accept any division of the surplus when they are responders in the ultimatum negotiation game and offer nothing to the responder when they are the proposers and have all the bargaining power. Selfish players will never choose the action of punishing as it is costly and does not lead to an increase in his payoff. Given that he is not going to be punished a selfish defector player does not share with his cooperator opponent.

Therefore, if we solve the game by backward induction, we find that the players are facing the following simultaneous game in the production stage:

	C	NC
C	B, B	$0, d$
NC	$d, 0$	b, b

We have assumed that $B > d > 2b > 0$ and we will also assume that $b + d \geq B$.

So the coordination game has two (subgame perfect) Nash equilibria: the first one in which players will choose in the first stage *(C,C)* and, subsequently, in the negotiation stage, as proposers will offer zero and as responders will accept any offer and the second equilibrium, in which they choose *(NC, NC)*. Note that the first one, *(C,C)* Pareto dominates *(NC, NC)* but *(NC, NC)* risk dominates *(C,C)*. This is the standard stag-hunt game with multiple equilibria. There is a clear conflict between efficiency and risk-dominance. Nothing in the rational behavior of the players prevents choosing one of the two equilibria. It remains elusive a clear answer to this problem of equilibrium selection.

In this paper we will assume that there is heterogeneity of preferences, and that in addition to self-regarding people there is also a significant part of the population that has social preferences, that is, they are concerned by relative payoffs. In the next subsection we will introduce this type of preferences.

3. Social Preferences: Inequity Aversion

UNTIL recently standard game theory has assumed that all players are self-regarding, in the sense that they are only motivated by their own monetary payoff. This may be true of some people but, obviously it is not true of everybody. There are many pieces of experimental data that indicates that a significant fraction of the subjects does not care only about material payoff but rather relative payoffs. These experiments suggest that fairness and reciprocity motives affect the behavior of many people.

The distribution of preferences in each period is endogenously determined in our model by the decisions made by the adult players. In particular, there is a proportion p_t of self-interested agents in period t who are motivated exclusively by their own monetary payoff and a proportion $1 - p_t$ of agents motivated by inequity aversion in the sense of Fehr and Schmidt (1999). These agents are willing to give up some material payoff to move in the direction of more equitable outcomes.

Let $x = (x_1, x_2)$ denote the vector of monetary payoffs for both players. The utility function of player i is given by:

$$U_i\ (x) = x_i - \alpha \max \{x_j - x_i, 0\} - \beta \max \{x_i - x_j, 0\},\ j \neq i \qquad (3.1)$$

where $\beta \leq \alpha$ and $0 \leq \beta < 1$.

The second term in (3.1) measures the utility loss from disadvantageous inequity, while the third term measures the loss from advantageous inequity. The assumption $\beta \leq \alpha$ implies that a player suffers more from inequity that is to his disadvantage, that is, the inequity aversion is asymmetric.

In order to simplify the analysis we will assume that there are only two types of agents in the population.

On the one hand, there are selfish players, those with the above utility functions but with $\alpha = \beta = 0$, that is, $U_i\ (x) = x_i$ and on the other hand, there are strongly inequity averse players, those in which the utility function has the parameters $\alpha, \beta > 0.5$. We also assume that the following condition holds for the inequity averse players:

$$\alpha \leq (2\beta - 1)/(2[1 - \beta]) \quad (3.2)$$

This condition establishes an upper bound on parameter α, which is decreasing with parameter β. With this assumption we want to rule out non-realistic cases with extremely high values of α.

Players do not know the true type of the player with whom they are matched in period t. However, we will assume that they know the preferences distribution p_t in the population. Consequently, the optimal strategies of the players will depend on this distribution. Nevertheless, it is convenient to study the payoffs and strategies of both players when they are matched with probability one with a strongly inequity averse player, that is, in a complete information scenario.

The main change is that inequity averse players have very different negotiation, sharing and punishing strategies as compared to those of selfish players. They are very generous as proposers in the negotiation and do not accept greedy offers as responders; they are willing to share equally the surplus and, if a defector does not share equally, a cooperator inequity averse player punishes him, provided the unit cost of punishment is low enough. Let us prove these policies in turn.

3.1. Negotiation and sharing policy of strongly inequity averse players

If the inequity averse player gets to be the proposer in the ultimatum game it is easy to verify that it is a dominant strategy for him to always offer an equal split of the surplus which will be accepted by his opponent. Notice that starting in an unequal distribution advantageous for him, giving one euro more to his opponent, reduces in one unit his material payoff and consequently his utility, but it reduces also in two units the inequity and as $\beta > 0.5$, increases his utility in more than one unit. The net effect is an increase in utility. This argument also proves that the optimal sharing policy of this player when he has got a surplus d, is to share it equally. We relegate to the appendix a more formal proof.

On the other hand, when they are in the role of a responder they will only accept a certain proportion of the surplus $2B$ and will reject any offer below this threshold level, depending on their degree of (disadvantageous) inequity aversion (α). We denote this proportion as their acceptance threshold (t^{α}). This share of the surplus is the result of making the responder player indifferent between accepting and rejecting the offer. In order to compute it, we equalize to zero the utility function where, without loss of generality, we have normalized the surplus to one.

Thus $t^{\alpha} - \alpha\ (1 - 2t^{\alpha}) = 0$.

Therefore $t^{\alpha} = \alpha / (1 + 2\alpha)$. Note that this threshold is increasing in and strictly less than one-half for any finite α.

Summarizing, there is a dominant action for averse players, when they are proposers, which is to offer an equal split of the surplus (B) and they only accept offers greater or equal to $t^{\alpha}(2B)$.

3.2. Punishment policy of inequity averse players

If the players do not coordinate, and one chooses *NC* (defector) and the other chooses C (cooperator), the interim material payoffs would be d for the defector and zero for the cooperator. Recall that the defector can offer an amount ε of his obtained payoff (d) to the cooperator. This latter can, at a unitary cost $z < 1$, punish the opponent. If the cooperator uses this punishment reduces the material payoff of his opponent in x units at a cost zx.

Contrary to the behavior of the selfish players, the threat of punishing is credible in the case of the averse players. A cooperator averse player will punish the defector if this latter does not share equally the payoff obtained by defecting, provided the unit cost of punishing z is smaller than a critical value which is increasing on α, the parameter that measures disavantageous inequity aversion. The amount of punishment chosen by the cooperator player is inversely related to the share that the opponent offers him.

Lemma 1: Assume $z < \alpha / (1 + \alpha)$, if a cooperator averse player gets a share $\varepsilon \geq d/2$ from the defector, he will not punish his opponent. Otherwise, he will punish him and the amount of punishment will depend inversely of the offered share from the defector:

If the cooperator gets an offer ε, where $0 \leq \varepsilon \leq \varepsilon^* = dz/2$, he will punish with $x = d - \varepsilon$.

If the cooperator receives an offer ε, where $\varepsilon^* \leq \varepsilon < d/2$, he will punish with $x = (d - 2\varepsilon) / (1 - z)$.

Proof: see appendix.

The intuition behind this result is simple: by punishing, the inequity averse player reduces inequality against him and this effect more than compensates the reduction in material payoff.

Therefore, the payoff matrix of this sequential stage game with complete information, played between two inequity averse players is:

	C	NC
C	B, B	$d/2, d/2$
NC	$d/2, d/2$	b, b

Given the assumptions on the parameters, we have a unique Perfect Equilibrium because cooperation *(C)* is a dominant strategy for both players.

Much more interesting is the fact that the behavior of a selfish player changes when he is confronted with an inequity averse player. In particular, if he gets to be the proposer in the ultimatum negotiation game, he will anticipate that his opponent rejects any offer smaller than the threshold t^{α}. Therefore, he will offer exactly a proportion t^{α} of the surplus which will be accepted by the inequity averse player, although she gets a utility of zero. The selfish player will obtain a payoff of $2B\,(1 - t^{\alpha})$.

We already know that selfish players will not punish the opponent unless this produces an increase in their payoffs. Thus, in the hypothetical case the opponent did not share with him her payoff (a non-optimal action of the inequity averse player) he would not punish the other player either.

However his sharing policy depends on the player that he faces. If he plays against a selfish player he will not share anything, because he knows that the opponent will not punish him. Nevertheless, if he knows for sure that his opponent is an inequity averse player he will share equally, because he anticipates that she will punish him if he does not share. This result is stated in the next lemma.

Lemma 2: A selfish player that defects will offer half of the material payoff ($\varepsilon = d/2$) when faced with probability one with a cooperator inequity averse player.

Proof: See appendix.

Therefore, solving by backward induction, the payoff matrix that the players face in the production stage is the following:

	C	NC
C	$(1 - t^{\alpha} + 1/2)B, B/2$	$d/2, d/2$
NC	$d/2, d/2$	b, b

Where, we have assumed that the row player is selfish and the column player is inequity averse.

It is easy to verify that for both types of players cooperation is a dominant action. Thus, in this game with complete information, there is a unique perfect Nash equilibrium in which both types of players cooperate achieving the efficient outcome.

The intuition behind this result is the following. Cooperation is the best reply for a selfish player also against non-cooperation, confronted with probability one with an inequity averse player, because the latter does share equally even after defection.

On the other hand, cooperation is also the best reply of an inequity averse player against non-cooperation of a selfish player because, as inequity averse players credible threat to punish, the selfish player also shares equally the surplus d.

In other words, as strongly inequity averse players are very generous, selfish players do not fear being exploited by a defector. And, as inequity averse players are willing to punish defection and not sharing, selfish players behave also very generously.

But recall that players do not know the true type of the player with whom they are matched in period t. However, we will assume that they know the preferences distribution p_t in the population. We will begin the study of this distribution in the next section.

4. The Socialization Process and the Education Effort by Parents

PREFERENCES among players are influenced by a purposeful and costly socialization process. Children acquire preferences through observation, imitation and learning of cultural models prevailing in their social and cultural environment. We will draw from the model of cultural transmission of Cavalli-Sforza and Feldman (1981) and Bisin and Verdier (1998, 2000).

Let $\tau^i \in [0,1]$ be the educational effort made by a parent of type i where $i \in \{e, a\}$ and e denotes selfish and a denotes strongly inequity averse.

The socialization mechanism works as follows. Consider a parent with i preferences. His child is first directly exposed to the parent's preferences and is socialized to this preferences with probability τ^i chosen by the parent (vertical transmission); if this direct socialization is not successful, with probability $1 - \tau^i$, he is socialized to the preferences of a role model picked at random in the population (oblique transmission), that is to selfish preferences with probability p_t and to inequity averse preferences with probability $(1 - p_t)$.

Let P^{ij} denote the probability that a child of a parent with preferences i is socialized to preferences j. The socialization mechanism is then characterized by the following transition probabilities:

$$P_t^{ee} = \tau_t^e + (1 - \tau_t^e)\ p_t \tag{4.1}$$

$$P_t^{ea} = (1 - \tau_t^e)\ (1 - p_t) \tag{4.2}$$

$$P_t^{aa} = t_t^a + (1 - \tau_t^a)(1 - p_t) \tag{4.3}$$

$$P_t^{ae} = (1 - \tau_t^a)\ p_t \tag{4.4}$$

Given these transition probabilities it is easy to characterize the dynamic behavior of p_t:

$$p_{t+1} = [p_t\, P_t^{ee} + (1 - p_t)\ P_t^{ae}]$$

Substituting (4.1) to (4.4) we obtain:

$$p_{t+1} = p_t + p_t\,(1 - p_t)\ [\tau_t^e - \tau_t^a]$$

Note that this cultural transmission mechanism combines direct purposeful transmission with oblique transmission. Direct transmission is justified because parents are altruistic towards their children. But, an important feature is that they have some kind of imperfect altruism, their socialization decisions are not based on the purely material payoff expected for their children but on the payoff as perceived by their parents according to their own preferences. This particular form of myopia is called imperfect empathy. Direct transmission is also costly. Let $C\,(\tau^i)$ denote the cost of the education effort τ^i, $i \in \{e, a\}$. While it is possible to obtain similar results with any increasing and convex cost function we will assume, for simplicity, the following quadratic form $C\,(\tau^i) = (\tau^i)^2/2k$, with $k > 0$. Therefore, a parent of type i chooses the education effort $\tau^i \in [0.1]$ at time t, which maximizes:

$$P_t^{ii}\ (\tau^i, p_t)\ V^{ii}\ (p^E_{t+1}) + P_t^{ij}\ (\tau^i, p_t)\ V^{ij}\ (p^E_{t+1}) - (\tau^i)^2/2k$$

where P^{ij} are the transition probabilities and V^{ij} is the utility to a parent with preferences i if his child is of type j. Notice that the utility V^{ij} depends on p^E_{t+1}, which denotes the expectation about the proportion of selfish players in period $t + 1$. In this work we will assume that parents have adaptive or backward looking expectations, believing that this proportion of selfish players will be the same in the next period as today, that is, $p^E_{t+1} = p_t$.

According to the imperfect empathy notion, a parent of type i uses his own utility function in order to assess V^{ij}. Thus, parents obtain a higher utility if their children share their preferences. As a consequence, $V^{ee} \geq V^{ea}$ and $V^{aa} \geq V^{ae}$.

Maximizing the above expression with respect to τ^i, $i \in \{e, a\}$, we get the following optimal education effort levels:

$$\tau^{e*}(p_t) = k \cdot \Delta V^e\ (p_t)\ \cdot\ (1 - p_t)$$

$$\tau^{a*}(p_t) = k \cdot \Delta V^a\ (p_t)\ \cdot p_t$$

Here $\Delta V^e = V^{ee} - V^{ea}$ and $\Delta V^a = V^{aa} - V^{ae}$. That is, ΔV^i is the net gain from socializing your child to your own preferences. It also reflects the cultural intolerance of parents with respect to cultural deviation from their own preferences. In order to have interior solutions the parameter k must be chosen small enough so that in equilibrium $\tau^i < 1$.

Differentiation of the first order conditions with respect to p_t yields:

$$d\tau^e\,(p_t)\,/\,dp_t = -\,k\Delta V^e < 0$$

$$d\tau^a\,(p_t)\,/\,dp_t = k\Delta V^a > 0$$

Note that the education effort $\tau^e\,(p_t)$ of a selfish parent decreases with the proportion of selfish individuals in the population. The reason is very intuitive: the larger p_t is, the better children are socialized to the selfish preferences in the social environment. On the contrary, the educational effort chosen by the inequity averse players $\tau^a\,(p_t)$ increases with p_t, that is, the greater the proportion of selfish players in the population, the bigger the socialization effort of former parents in order to offset the pressure of the environment if they want their children to share their own preferences. In other words, oblique transmission acts as a substitute for vertical transmission. Bisin and Verdier (2000) refer this feature of educational effort as the cultural substitution property.

The other determinant of the optimal education effort is the relative profit ΔV^i to a parent of type i from transmitting her own cultural traits. This will depend on the equilibrium that they expect to be played in the incomplete information game that their children will face in the next period. The following section analyses this game.

5. Cooperation, Heterogeneous Preferences and Incomplete Information

IN this section, we characterize the Perfect Bayesian Equilibria of the incomplete information two-stage game played in each period. That is, neither player knows the true type of player that he is randomly matched with but they know the distribution of preferences in the population. This distribution of preferences will be endogenously determined in our model by the education decisions made by adult players.

Notice, first, that the negotiation, punishment and sharing policy of an inequity averse player does not change when there is incomplete information. Neither does the negotiation policy as a responder and the punishing policy of a selfish player.

However, both the negotiation as a proposer and the sharing policy of selfish players are affected by the existence of a fraction of inequity averse players.

To compute the optimal negotiation policy of selfish players, note that a player only knows the proportion of each type in the population, (recall that p_t is the proportion of selfish players and $1 - p_t$ the proportion of inequity averse players in period t). Nevertheless, in some cases, the particular realized surplus can also change his beliefs about his opponent's type. We will denote by μ_t the updated probability which the player assigns to his opponent being a selfish player after observing the result of the production stage. Then, if a selfish player is the proposer, has two options: first, to offer zero and he knows that only selfish players would accept this offer and second, to offer the threshold level, $t^{\alpha}2B$ and in this case both types of players will accept it. Therefore his expected payoff in the first case would be $\mu_t 2B$, whereas in the second case his payoff would be $2B\,(1 - t^{\alpha})$. Therefore, offering zero is better than offering $t^{\alpha}2B$ when $\mu_t > (1 - t^{\alpha})$.

The following lemma summarizes this result.

Lemma 3: If both players cooperate in the first stage and the selfish player gets to be the proposer, he will offer zero to his opponent if $\mu_t \geq (1 - t^\alpha)$, and the acceptance threshold $t^\alpha 2B$ if $\mu_t < (1 - t^\alpha)$.

Let us analyze next the sharing policy of this type of players with incomplete information.

On the one hand, if a selfish player does not share anything of his payoff d when he defects, he anticipates that the inequity averse player will punish him with the maximal punishment and with this type of players he will get a payoff of zero. Only selfish types will not punish. Therefore, his expected payoff would be $\mu_t d$. On the other hand, if he shares equally, his expected payoff will be $d/2$. Therefore, sharing equally will be better when $\mu_t \leq 1/2$, whereas if $\mu_t \geq 1/2$ is better not to share. We prove in the appendix that sharing a proportion smaller than $d/2$ is dominated by offering zero.

Let us again summarize this result in the following lemma.

Lemma 4: If the selfish player defects, he will share equally with his opponent if μ_t is less than 1/2 and he will not share anything if μ_t is greater or equal than 1/2.

Proof: see appendix.

Now we are in condition to obtain the Perfect Bayesian Equilibrium of this game. The following two lemmas characterize the two possible equilibria.

Lemma 5: The Cooperative Equilibrium. For every p_t, there exists a Perfect Bayesian Equilibrium in which both types of players will choose the cooperative action C in the production stage of the game.

In the distribution stage, if $p_t \geq (1 - t^\alpha)$, the equilibrium actions in the negotiation stage are:

1) for selfish players: as a proposer, to offer zero and as a responder, to accept every offer;
2) for inequity averse players: as a proposer, to offer half of the surplus (B) and as a responder, to accept only offers greater or equal than $t^\alpha 2B$.

The equilibrium payoff of the selfish player is $p_t B + (1 - p_t)\ B/2$ and the equilibrium payoff for the inequity averse player is $B - p_t B/2$.

On the other hand, if $p_t < (1 - t^\alpha)$, the equilibrium actions in the distribution stage are:

1) for selfish players: as a proposer, to offer $t^\alpha 2B$ and as a responder, to accept every offer;

2) for inequity averse players**:** as a proposer, to offer half of the surplus (B) and as a responder, to accept only offers greater or equal than $t^{\alpha}2B$.

The equilibrium payoff of the selfish players is $B - t^{\alpha}B + p_t t^{\alpha}B + B/2 - p_t B/2$ and the equilibrium payoff for the inequity averse player is $B/2 + (1 - p_t)B/2$.

The off-equilibrium beliefs that support this equilibrium are that, after observing a deviation, players believe with probability one that it comes from a selfish player.

Proof: See appendix.

Notice that as the cooperative equilibrium is a pooling equilibrium there is not updating of beliefs on the equilibrium path.

However, for some values of the distribution of preferences, there is also an equilibrium in which neither player plays the cooperative action in the first stage, that is, persists the multiplicity of equilibria of the static stag-hunt game. In the next lemma we characterize this non-cooperative equilibrium.

Lemma 6: The Non-cooperative Equilibrium. If $p \geq p' = (d - 2b)/d$, there exists also a Perfect Bayesian Equilibrium, in which the players choose not to cooperate (NC) in the first stage.

The equilibrium payoff both for the selfish and the inequity averse player is b.

The off-equilibrium beliefs that support this equilibrium are that, after observing a deviation, players believe with probability one that it comes from a selfish player.

Proof: See appendix.

We can summarize the previous results in a more compact form in the following proposition:

Proposition 1: For every p_t, there exists a Perfect Bayesian Equilibrium in which both types of players choose the cooperative action in the production stage of the coordination game. Furthermore, if $p_t \geq p' = (d - 2b)/d$, there exists another Perfect Bayesian Equilibrium in which both types of players choose the non-cooperative action in the production stage.

It is easy and intuitive to check that non-cooperation by the selfish players and cooperation by the inequity averse players does not form part of an equilibrium, because selfish players will deviate to cooperation. And, it is not either an equilibrium cooperation by the selfish players and non-cooperation by the inequity averse players because the latter will deviate to cooperation. A formal proof of this statement can be found in the appendix.

Given the results obtained in section 3 in a complete information scenario between a selfish and an inequity averse player, it is not surprising at all that for *low* preferences distributions, i.e. $p_t < p'$, the unique Perfect Bayesian Equilibrium of the game with incomplete information is the Cooperative equilibrium. The presence of a significant fraction of inequity averse individuals in the population acts as some kind of social capital. In the language of game theory, cooperation is a dominant strategy for selfish players, even if inequity averse players do not cooperate, because they are so generous that a selfish player prefers to reply cooperating than no cooperating. Moreover, for inequity averse players, cooperation is the dominant strategy given that they anticipate that selfish players will be generous also in sharing the surplus. In this case because the threat of punishment is very likely given the significant proportion of inequity averse players in the population.

But for *high* preferences distributions, that is, for $p > p'$, there exists also a Non-cooperative equilibrium. The intuition is that, if there is a majority of selfish individuals in the population, then this type will not deviate from non-cooperation since they correctly expect that selfish players do not share in this situation. Concerning inequity averse players, if they deviate to cooperation, they will have to punish the non-sharing behavior of selfish players. As this possibility has a high probability, punishing is very costly and it results on non-cooperation being the best reply to non-cooperation.

The existence of multiplicity of equilibria for the range of parameters $p_t \geq p'$, poses a question on which will be the expected equilibrium and the parents' expectation in a given period. It is clear that if $p_t < p'$, parents expect the cooperative equilibrium to be played in the next period for the whole population, but when $p_t \geq p'$, there are two equilibria and persists the indeterminacy. In a next section we will study the long-run distribution of preferences in the population and will show that, when we allow for a small rate of migration between groups that are characterized by playing different equilibria (in one group it is expected the cooperative equilibrium and in the other the non-cooperative), there is convergence to the cooperative equilibrium.

6. Preferences Distribution and Strategies in the Long Run

IN this section we will characterize the steady states of the economy for an isolated population, that is, in the absence of migration. A population of individuals coordinates in an equilibrium of the stag-hunt game and therefore given their adaptive expectations, expect this equilibrium to be played by the next generation. We need to know the optimal level of education that parents choose in each period that will depend on the net gain flows of educating. In order to do so we need, first, to compute the net gains for parents of transmitting their own preferences that are given by expression V^{ij}.

6.1. The long-run distribution of preferences in a cooperative population

We analyze firstly a population where parents play and expect to be played the cooperative equilibrium *(CE)*. This might happen for all initial p.

Firstly, we calculate the net gains for parents of transmitting their own preferences ΔV^i when $p_t \geq 1 - t^{\alpha}$. Recall that in this case, selfish players will offer zero as proposers in the negotiation and the inequity averse players will reject this offer.

— for selfish parents:

$$V^{ee} = p_t B + (1 - p_t)\ B/2$$

$$V^{ea} = B/2 + (1 - p_t)\ B/2$$

Therefore, $\Delta V^e = V^{ee} - V^{ea} = (p_t - 1/2)\ B \geq 0$

— for inequity averse parents:

$$V^{aa} = B/2 + (1 - p_t)\ B/2$$

$$V^{ae} = B/2\ (1 + p_t) - p_t \beta B - p_t \alpha B$$

Thus, $\Delta V^a = V^{aa} - V^{ae} = B\ (1/2 + p_t\ (\alpha + \beta - 1) \geq 0$.

Secondly, we compute the ΔV^i when $p_t < 1 - t^\alpha$. In this situation selfish players offer the threshold which is accepted by selfish and inequity averse players. Recall that the latter type by accepting obtains a positive material payoff but her utility is zero.

— for selfish parents:

$$V^{ee} = (1 - t^\alpha)\ B + p_t\, t^\alpha\, B + (1 - p_t)\ B/2$$

$$V^{ea} = B/2 + p_t\, t^\alpha\, B + (1 - p_t)\ B/2$$

Thus, $\Delta V^e = V^{ee} - V^{ea} = B\ (1/2 - t^\alpha) \geq 0$

— for inequity averse players:

$$V^{aa} = B/2 + (1 - p_t)\ B/2$$

$$V^{ae} = B - t^\alpha\, B - \beta\ (B(1 - 2\, t^\alpha)) + p_t\, [(t^\alpha\, B - \alpha\ \ (B(1 - 2\, t^\alpha))] + (1 - p_t)\ B/2$$

Therefore, $\Delta V^a = V^{aa} - V^{ae} = B\ (t^\alpha + \beta\ (1 - 2\, t^\alpha) - 1/2\ ) \geq 0$

Note that to compute V^{ij} we suppose that a parent of type i evaluates his child's well-being using her own utility function. For example, when $p_t \geq 1 - t^\alpha$, V^{ae} is the utility to an inequity averse parent if his child is selfish. This child will offer nothing to his opponent when he is a proposer and will accept any offer as a responder. This behavior produces inequality in the distribution of the payoffs for her child (advantageous in the first case and disadvantageous in the second), which reduces the utility in her parent's eyes. More precisely, $V^{ae} = B/2\ (1 + p_t) - p_t \beta B - p_t \alpha B$, is the utility to an inequity averse parent if her child is selfish.

From the previous expressions and from section 4 we can obtain the optimal educational effort function for both type of players:

If $p_t \geq 1 - t^\alpha$

$$\tau^{*e}_t = k\ (p_t - 1/2)\ B\ (1 - p_t)$$

$$\tau^{*a}_t = k\, B\ (1/2 + p_t\ (\alpha + \beta - 1))\ p_t$$

If $p_t < 1 - t^\alpha$

$$\tau*_t^e = k\,B\,(1/2 - t^\alpha)\;(1 - p_t)$$

$$\tau*_t^a = k\,B\,(t^\alpha + \beta\;(1 - 2\;t^\alpha) - 1/2)\;p_t$$

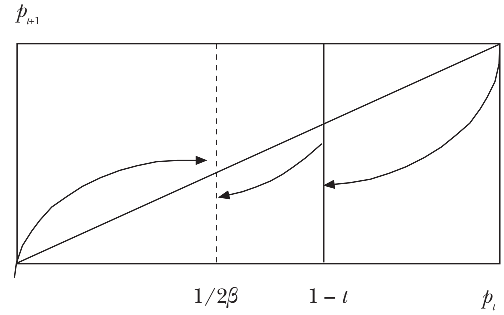
Substituting the previous optimal education effort levels in the equation in differences of section 4 we get the following two-branch dynamics under the assumption of backward looking expectations:

Dynamics A:
A) $p_{t+1} = p_t + p_t\,(1 - p_t)\,[- kB\,p_t^2 + kB\,(3/2)\;p_t - kB/2 - (k\,p_t\,B/2 + kB\,p_t^2\;(\alpha + \beta - 1))]$
if $p_t \geq 1 - t^\alpha$.

Dynamics B:
B) $p_{t+1} = p_t + p_t\,(1 - p_t)\;[Bk\,(1/2 - t^\alpha - p_t/2 + p_t\,t^\alpha) - (kB\,(t^\alpha + \beta\;(1 - 2\;t^\alpha) - 1/2)\;p_t)]$
if $p_t < 1 - t^\alpha$.

Notice that there is a discontinuity in $p_t = 1 - t^\alpha = (1 + \alpha)/(1 + 2\alpha)$. The phase diagram in graphic 6.1 shows this case.

GRAPHIC 6.1: Cooperative Equilibrium



The following proposition characterizes the globally stable steady-state of the economy.

Proposition 2: For any $p_t \in\;(0, 1)$, the preferences distribution of a cooperative population converges to $p^* = 1/(2\beta)$, where p^* is such that τ_t^a $(p^*) = \tau_t^e\;(p^*)$ in dynamics *B*.

Proof: See appendix.

The complete and formal analysis of this result is relegated to the appendix. But let us give some intuition.

Note that the dynamics has the following steady states: $p = 0$, $p = 1$ and the interior steady state $p^* = 1/2\beta$, where p^* is such that both educational effort levels get equalized under dynamics *B*.

The steady state $p = 0$ is unstable. This steady state is a completely homogeneous distribution of preferences, that is, all players being inequity averse. If the selfish players are in a minority (that is, p is very close to 0), their socialization effort will be very intensive in an attempt to offset the effect of oblique transmission. In this context, τ^{*e} exceeds τ^{*a} and the selfish preferences will spread over generations preserving their presence in the society. A similar argument explains why $p = 1$ is also unstable.

On the other hand, in the dynamics A, τ^{*a}_t is always greater than τ^{*e}_t, $\forall p_t \in (0, 1)$. This implies that the trajectory of A is always decreasing in the range $(1 - t^{\alpha}, 1)$.

The intuition of this result is that when the proportion of selfish players is high, i.e. for $p > (1 - t^{\alpha})$, selfish players follow a very greedy strategy when they have all the bargaining power (as proposers). This yields a very high ΔV^a. This reflects the degree of "cultural intolerance" of inequity averse parents with respect to cultural deviation from their own preferences and it is very big as compared with ΔV^e.

So eventually the dynamics will reach the region where $p < (1 - t^{\alpha})$. Then selfish players will offer the threshold when they are proposers because of the presence of a significant fraction of inequity averse players who will punish with rejection any greedy offer. In this branch B of the dynamics there is an interior rest point p^* which is the globally stable steady state.

6.2. The long-run distribution of preferences in a non-cooperative population

Suppose now an isolated population where parents play and expect to be played the non-cooperative equilibrium *(NCE)*. This can only happen if $p_t \geq p' = (d - 2b)/d$.

We start with the selfish parents. In this case:

$$V^{ee} = b \text{ and } V^{ea} = b. \text{ Therefore } \Delta V^e = V^{ee} - V^{ea} = 0$$

And for inequity averse parents:

$$V^{aa} = b \text{ and } V^{ae} = b. \text{ Thus, } \Delta V^a = V^{aa} - V^{ae} = 0$$

Previous results gives place to:

$$\tau^e_t = k \Delta V^e (1 - p_t) = 0$$

$$\tau_t^a = k\Delta V^a p_t = 0$$

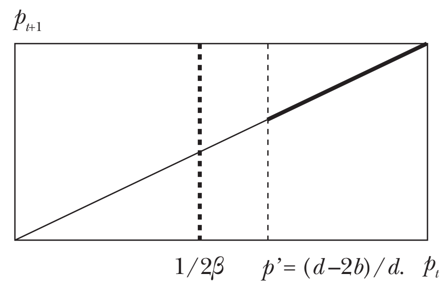
This means that in a non-cooperative group there are not incentives for socialization and therefore, the distribution of preferences will remain unchanged, that is, $p_{t+1} = p_t$.

Let us summarize these results in the next proposition:

Proposition 3: If $p_t \geq p' = (d - 2b)/d$, then in a non-cooperative population any initial distribution $p_t \geq p'$ is a stable stationary state.

Thus, if society coordinates in the non-cooperative equilibrium, it will remain locked in the same distribution of preferences. The phase diagram in graphic 6.2 shows this case.

GRAPHIC 6.2: Non-cooperative Equilibrium



7. Migration between Groups and Cooperation

IN the previous section we have shown that for initial preferences distributions greater than *p'*, there are two possible steady states of the society depending on whether the population coordinates in the cooperative equilibrium or in the non-cooperative equilibrium. Therefore, for this rank of parameters we still have a multiplicity problem.

Some authors have found this same difficulty and have just decided an equilibrium selection, that is, have assumed that all the population or groups coordinate in the same equilibrium. See, for instance, Bisin, Topa and Verdier (2004) and Mengel (2005). We think that this approach does not solve the problem. Instead of that, we will analyse the effects in the dynamics of the fact that typically populations are not isolated.

We will assume that there are several populations (groups) where each one expects and plays a particular equilibrium of the coordination game. Socialization takes place inside the group but there is a (probably small) rate of migration λ between groups. That is, a proportion λ of adult individuals migrate to other group to play the coordination game. They will play according to the expectations and customs of their new group. The parents in each group will socialize their children taking now into account that when they become adults they will have a positive probability of migrating and therefore ending playing a different equilibrium.

Denote as p_o^g the initial distribution of preferences in a group g. If $p_o^g < p'$, this group will coordinate in the unique Perfect Bayesian Equilibrium (*PBE*): the cooperative equilibrium.

But for the groups such that, $po^g > p'$, more possibilities arise. We will assume that, if there is only one group, it plays the non-cooperative equilibrium and if there are more than one group, at least one of them plays the cooperative equilibrium. This is what we denote as the Group Heterogeneity Assumption. We discard the extreme cases in which all groups play the same equilibrium when there is multiplicity.

Let us also assume that $p' > p^*$ (which is the case for payoff d being very large by comparison to payoff b). The next proposition states the main result of our work.

Proposition 4: Suppose, without loss of generality, that there are two groups with initial preferences distributions, p^1 and p^2 and assume that the assumption of group heterogeneity holds and $p' > p^*$, then for any p^1, $p^2 \in (0.\ 1)$ both groups converge to a preference distribution $p^* = 1/2\beta$, where the cooperative equilibrium is played.

Proof: See appendix.

Although the formal proof of this proposition is quite lengthy, the intuition is that now parents in the non-cooperative group have incentives to socialize in the presence of migration. Moreover, given the relatively high proportion of selfish individuals in this group, the educational effort due to migration motives of inequity averse parents is greater than the effort of selfish parents. The educational effort might also depend indirectly on the proportion of selfish individuals in the group their children migrate into. In particular, it depends on the levels of cultural intolerance ΔV^i in the cooperative group. If this group follows dynamics B, these levels are constant independent of the population distribution of selfish players in the cooperative group (p^c). However, if it follows dynamics A, the degree of cultural intolerance depends on p^c, so the dynamics of the preferences distribution of the non-cooperative group depends both on the proportions of selfish individuals in the home population and in the other population. But recall that the incentives for socialization under dynamics A are always greater for the inequity averse parents than for the selfish parents as we have explained in the previous section. Therefore, as a consequence of both the direct and the possible indirect effect, the distribution of preferences of the non-cooperative group decreases over time and eventually reaches a value smaller than p'. At this point non-cooperation is not an equilibrium and this population switches to the unique cooperative equilibrium.

Note that if $p' < p^*$, the previous result is not valid always, that is, for any initial conditions of the dynamics, since it can be the case that the proportion of selfish individuals in the non-cooperative group never gets smaller than the critical value p'. In other words, for some cases we will get convergence in both groups to p^*, but each group remains playing his particular equilibrium. So, migration is not a sufficient condition for the spread of cooperation between groups in this case.

8. Conclusions

CULTURAL transmission plays an important role in the formation of many preference traits and norms, like attitudes towards family, in the job market and cooperation. The importance of the social dilemma embodied in the stag hunt game is justified for the relevance of trust to achieve cooperation. In this coordination game, there is a conflict between mutual benefit and personal risk that can be alleviated if we resort to a sort of shared expectations or trust about the play of the opponent. Coordination solutions require a cultural mechanism of information transfer to provide players the shared expectations crucial for coordinated behavior. In this paper we obtain this *common* expectation by adding a second stage to the *isolated* stag-hunt game, that allows the use of different mechanisms as negotiation, punishment or sharing, together with a cultural transmission mechanism of preferences. In particular, we have worked with a dynamic model of cultural transmission, where the distribution of preferences in the population and the strategies in the two-stage coordination game in the long-run is determined endogenously and simultaneously.

Our main result is that, for very general conditions, in the globally stable steady state of the society there will be a mixed distribution of preferences where both selfish and other-regarding preferences are present, and more importantly, players coordinate in the cooperative equilibrium of the stag hunt game. The presence of a significant fraction of inequity averse individuals in the population acts as a stock of social capital in the society reducing personal risk.

If the proportion of selfish players in the initial condition of the dynamics is high, then there is still multiplicity of equilibria in the population. We have shown that if there is heterogeneity in the behavior among groups and a positive rate of migration, then all groups will converge to the cooperative result.

A natural future extension of our work is to explore the effects of different types of influences among groups (other than migration), as for instance, the existence of a degree of interaction in oblique transmission.

We will also consider the effects of other biased cultural mechanisms such as conformism or prestige-based imitation.

Appendix

The sharing policy of a strongly inequity averse player

Suppose that player 2 is an inequity averse player and chooses defecting whereas player 1 cooperates, the resulting material payoffs are $(0, d)$.

If the defector decides to share an amount ε, where $0 \leq \varepsilon \leq d/2$, her utility at most would be:

$$U_2\ (\varepsilon,\ d - \varepsilon) = (d - \varepsilon) - \beta\ (d - 2\varepsilon) = (1 - \beta)\ d - \varepsilon\ (1 - 2\beta)$$

Therefore, as $\beta > 0.5$, to maximize this expression player 2 has to set ε as big as possible, that is, to offer a share equal to $d/2$.

If player 2 offers a share of $\varepsilon > d/2$, her utility would be:

$$U_2\ (\varepsilon,\ d - \varepsilon) = (d - \varepsilon) - \alpha(2\varepsilon - d) = (1 + \alpha)\ d - \varepsilon\ (1 + 2\alpha)$$

that is less than $d/2$.

Thus, the optimal policy of averse players is to offer $d/2$.

Proof of lemma 1. Optimal punishing policy of inequity averse players

Suppose that the defector offers an amount ε of the payoff obtained d.

If the inequity averse player receives an offer $\varepsilon \geq d/2$, he will not punish.

The utility of punishing would be:

$$\begin{aligned} U_p\,(d - \varepsilon - x, \varepsilon - zx) &= \varepsilon - zx - \beta\ (\varepsilon - zx - d + \varepsilon - + x) = \\ &= \varepsilon - 2\beta\varepsilon + \beta d - x\ (\beta + (\beta - 1)z) \end{aligned}$$

This is maximized with $x = 0$

Next, we assume that $0 \leq \varepsilon < d/2$

We call x^* the amount of punishment that equals the payoff of both players after the punishment, that is, $d - \varepsilon - x = \varepsilon - zx$. The value of x^* is $(d - 2\varepsilon)/(1 - z)$.

If $x > x^*$, the payoff of the defector is smaller than the payoff of the cooperator, that is, $d - \varepsilon - x < \varepsilon - zx$. To maximize his utility (the same expression as above) the averse player has to set x as small as possible because this punishment generates advantageous inequality and this option is dominated by punishing until both players get the same payoff, that is, setting $x = x^*$.

If $x < x^*$, the payoff of the defector is still greater than the cooperator, that is, $d - \varepsilon - x > \varepsilon - zx$ and the utility of the inequity averse player is:

$$U_p\,(d - \varepsilon - x, \varepsilon - zx) = \varepsilon - zx - \alpha\ (d - \varepsilon - x - (\varepsilon - zx)) =$$
$$= -\alpha d + (1 + 2\alpha)\ \varepsilon + (\alpha - (1 + \alpha)z)x.$$

Then, in this case, when $\alpha x - (1 + \alpha)\ zx > 0$, the utility is maximized punishing as much as possible.

Note that if $\varepsilon = 0$ (the defector does not offer anything) the optimal amount of punishment is $x = d/(1 - z)$, but this is greater than d. We assume here that the punishment can not be bigger than the payoff d, so the maximal amount of punishment will be $(d - \varepsilon)$. We equate $(d - 2\varepsilon)/(1 - z)$ to d, in order to obtain, the threshold offer that will trigger the maximal punishment $(x = d - \varepsilon)$. This level is $\varepsilon^* = dz/2$.

Summarizing, the optimal punishment policy of the averse player is:

For $0 \leq \varepsilon < \varepsilon^*$, then the optimal amount of punishment will be $x = d - \varepsilon$.

For $\varepsilon^* \leq \varepsilon < d/2$, then the optimal amount of punishment will be $x = (d - 2\varepsilon)/(1 - z)$.

If the averse player receives an offer $\varepsilon \geq d/2$, he will not punish.

Proof of lemma 2. Optimal sharing policy of selfish players when facing inequity averse players with probability one

If a selfish player offers half of the material payoff obtained, $d/2$, then his utility will be $d/2$ since the other player does not punish him.

If the selfish player decides not to share or to share a smaller quantity, namely, an amount $0 \leq \varepsilon < \varepsilon^* = dz/2$, he knows that an inequity averse players will punish him with the maximal intensity, $x = d - \varepsilon$, and his utility will be zero.

If he decides to share an amount $\varepsilon \geq \varepsilon^* = dz/2$, the inequity averse player will punish him with $x = (d - 2\varepsilon)/(1 - z)$ and his utility would be $U = d - \varepsilon - (d - 2\varepsilon)/(1 - z)$, that is smaller than $d/2$.

Proof of lemma 4

First, if a selfish player offers the egalitarian share $(d/2)$, both types of players will accept, and his payoff would be $d/2$.

On the other hand, if he offers $0 \leq \varepsilon < \varepsilon^* = dz/2$, then the expected payoff is $\mu_t (d - \varepsilon) + (1 - \mu_t)\, 0$, because an inequity averse players would punish with $x = d - \varepsilon$. We can verify that $d/2 > \mu_t (d - \varepsilon)$ holds if $d/2$ is greater than $\mu_t d$ and this latter inequality is true if $\mu_t < 1/2$.

Finally, if he offers an amount ε, where $d/2 > \varepsilon > \varepsilon^* = dz/2$, his expected payoff would be $\mu_t (d - \varepsilon) + (1 - \mu_t)\, (d - \varepsilon - (d - 2\varepsilon)/(1 - z))$, since an inequity averse player would punish with $x = (d - 2\varepsilon)/(1 - z)$. This expression is smaller than $d/2$ for that $\mu_t \leq 1/2$. Substitute $\mu_t = 1/2$, (this is the worst case) then $d/2 > (d - \varepsilon) - 1/2\, (d - 2\varepsilon)/(1 - z)$, and therefore $d/2 > \varepsilon$.

Summarizing, if $\mu_t < 1/2$, the optimal offer for selfish players is to set $\varepsilon = d/2$.

If we turn to the case in which $\mu_t > 1/2$, we can check that offering $\varepsilon = 0$ dominates on offering $\varepsilon = d/2$, because $\mu_t\, d > d/2$.

On the other hand, to offer $0 \leq \varepsilon < \varepsilon = dz/2$ is dominated by offering $\varepsilon = 0$, since $\mu_t (d - \varepsilon) < \mu_t\, d$.

And finally, if he offers a quantity ε, where $d/2 > \varepsilon > \varepsilon$, his expected payoff would be $\mu_t (d - \varepsilon) + (1 - \mu_t)\, (d - \varepsilon - (d - 2\varepsilon)/(1 - z))$ that is smaller than $\mu_t d$ for $\mu_t > 1/2$. Note that this unequality holds for $p = 1$ and $p = 1/2$ and that the function $(\mu_t d - (d - \varepsilon) + (1 - \mu_t)\, (d - 2\varepsilon)/(1 - z))$ is monotonically decreasing.

Proof of lemma 5

We will show that there is not unilateral profitable deviation for any type of player from the pair of strategies $[(C, C), (C, C)]$ in the first stage, i.e., every type of player chooses the cooperative action. In order to make the computations the reader should recall the subgame perfect continuation strategies described in the main text.

Suppose first that $p_t \geq (1 - t^{\alpha})$ (in this case $p_t > 1/2$). Selfish players, as proposers, will offer 0 to their opponents and will not share their payoff when they are defectors.

The expected payoff of choosing C for the selfish type will be $p_t B + (1 - p_t)\ B/2$.

If this type of player deviates to NC, he will obtain an expected payoff of $p_t d$. As it can be checked this type of player will not deviate.

On the other hand, the strong inequity averse type of player 1 when she is proposer will offer half of the surplus, that will be accepted by both types of players, obtaining an expected payoff of $(1/2)\ B$. But when she is responder will only accept the threshold level and as the selfish player will offer nothing, she will reject the offer and both will have a payoff of zero with probability p_t, but with probability $(1 - p_t)$ the inequity averse opponent will offer B to her. In summary, the expected payoff of inequity averse player of choosing C, will be $(1/2)\ B + (1/2)(1 - p_t)\ B = p_t B/2 + (1 - p_t)\ B$.

Her expected payoff of deviating to NC will be $d/2$. So to choose C is too a best response for this type of player.

Suppose now that $p_t < (1 - t^{\alpha})$ but $p_t > 1/2$.

This means that in this case the behavior of selfish players is to offer $t^{\alpha} 2B$ when they are proposers and they do not share when they are defectors.

The expected payoff of choosing C for a selfish will be $p_t\ B + (1 - p_t)\ (1 - t^{\alpha} + 1/2)\ B$.

If the selfish player deviates to NC, nothing changes with respect the previous case because his expected payoff will be again $p_t d$. It is clear that given the assumption on the parameters that this player will not deviate and will choose C.

The utility of inequity averse players of playing C in this case will be $B/2 + (1 - p_t)\ B/2$.

Again, as in the previous case, it can be checked that this type of player will not deviate to NC since the payoff obtained in this cased $(d/2)$ smaller than that from cooperating. Suppose, finally, that $p_t < (1 - t^{\alpha})$ and $p_t < 1/2$.

Under these parameters, the sharing policy of selfish players changes since in this case they share equally his payoff when they are defectors.

The expected payoff of choosing C by the selfish type of player, will be $p_t\ B + (1 - p_t)\ (1 - t^{\alpha} + 1/2)\ B$.

If the selfish player deviates to NC, his expected payoff will be $d/2$. It is easy to verify that these payoffs are smaller than those from cooperating.

The utility of a inequity averse player, if she chooses C, as in the previous case, will be $p_t\ B/2 + (1 - p_t)\ B$.

Nothing changes either with respect to the analysis of the deviation, that is, her expected payoff of this action is $d/2$, that is strictly smaller than the above payoff and therefore she does not deviate.

Proof of lemma 6

Let us check under which conditions there is an equilibrium where players choose the non cooperative action in the production stage of the stag hunt game. In this pool both types of players obtain a payoff of b.

If a selfish player 1 chooses C, he will obtain in the first stage a material payoff of zero and his opponent a material payoff of d. His expected payoff will depend on the beliefs of the opponents. In particular, we suppose that the different types of players 2 believe that the deviation comes from a selfish player. The selfish type of player 2 will not share and then the deviator payoff will be zero. On the other hand, the inequity averse type of player 2 will share equally and the deviator payoff would be $d/2$. Therefore the expected payoff of the deviation is $(1 - p_t)\ d/2$. Thus, the selfish players will not deviate of choosing NC if $b > (1 - p_t)\ d/2$, that is, if $p_t > (d - 2b)/d$.

Consider now a strongly inequity averse player 1 that also would obtain a payoff of b if she chooses NC.

To check the possibility of deviating to C, we also suppose that the different types of players 2 believe that the deviation comes from a selfish player. The selfish type of player 2 will not share but recall that the inequity averse player will always punish if the opponent does not share the payoff d. Thus, her expected payoff will be negative, in particular, $-zx\ (1 + \alpha)$. On the other hand, the inequity averse type of player 2 will share equally and the deviator payoff would be $d/2$. Thus her expected payoff will be $(1 - p_t)\ d/2 + p_t\ (-zx\ (1 + \alpha))$. This means that inequity averse players will play NC as long as $p_t > (d - 2b)/(2(zx\ (1 + \alpha)) + d)$.

In any case, (NC, NC), (NC, NC) is part of a Perfect Bayesian Equilibrium if $p_t \geq (d - 2b)/d$, since the binding restriction is $p_t \geq p' = \max\ \{(d - 2b)/d,\ (d - 2b)/(2\ (zx\ (1 + \alpha)) + d)\}$, that is, the one given by the critical value of the selfish players.

Proof that {(*NC, C*), (*NC, C*)} and {(*C, NC*), (*C, NC*)} are not part of any Perfect Bayesian Equilibrium (*PBE*)

Firstly, let us check that {(*C, NC*), (*C, NC*)} does not form part of any *PBE*. Recall that the first member of each pair is the action that chooses the selfish type of player.

We will analyze the behavior of an inequity averse player 1, that chooses not to cooperate. Note that the payoff for this player of choosing *NC* would be $p_t\ (d/2) + (1 - p_t)\ b$, as selfish player 2 cooperates and inequity averse player 2 does not cooperate. Given the sharing policy of inequity averse players, player 1 will share equally with player 2 when the latter cooperates.

On the other hand, if this type of player deviates and chooses *C*, both types of player 2 will believe that she is a selfish player ($\mu(e/C) = 1$), and then the resulting payoff is $p_t B/2 + (1 - p_t)\ (d/2)$. This payoff is greater than the payoff from *NC*, so the inequity averse player 1 deviates.

Secondly, consider now the combination {(*NC, C*), (*NC, C*)}. Let us analyze the behavior of a selfish player 1. If he plays *NC* his expected payoff would be $p_t b + (1 - p_t)\ (d/2)$ since the threat of punishment of the inequity averse player 2 induces him to share the payoff *d*. If the selfish player decides to deviate and to play *C*, his payoff would be $p_t\ (d/2) + (1 - p_t)\ (1 - t^{\alpha} + 1/2) B$. Both types of player 2 believe that he is an inequity averse player, then the selfish player 2 offers him half of the payoff *d* and the inequity averse player uses her negotiation policy that provides a generous payoff to selfish player 1. As the payoff of choosing *C* is strictly greater than the one of choosing *NC*, the selfish player 1 deviates.

Proof of proposition 2

According to dynamics *A*, τ_t^a is always greater than τ_t^e, $\forall\ p_t \in (0, 1)$. This can be seen because the equation: $(\alpha + \beta)\ p_t^2 - p_t + 1/2 = 0$, has no real roots.

This implies that the dynamic behavior of (*A*) is always decreasing in the range $(1 - t, 1)$ and eventually p_t will fall below $(1 - t^{\alpha})$.

Under assumption (2), $p^* = 1/(2\beta) \leq 1 - t^{\alpha}$, then dynamics (*B*) defined in the interval $[0, 1 - t^{\alpha})$ has an homogeneous steady state $p = 0$ which is unstable and an interior steady state $p = p^* = 1/(2\beta)$ which is globally stable, where p^* is such that $\tau^{*e} = \tau^{*a}$. (See, Bisin and Verdier, 2001, proposition 1).

Proof of proposition 4

As the complete proof is very lengthy, here we only show the more relevant cases. The complete proof can be obtained on request from the authors.

We will introduce some additional notation.

Denote for $\Delta \underline{V}_j^i$ the increment of utility of parents of type *i* when they are in the group *j* and their child has a probability λ of migrating to group k, where $i = e, a$ and $j, k = 1, 2$. For example $\Delta \underline{V}_1^e = (1-\lambda)\,\Delta V_1^e + \lambda\,\Delta V_2^e$. In order to compute the resulting dynamics, note that the educational effort of this type of parents would be $\tau_t^{e1} = k\Delta \underline{V}_1^e\,(1-p_t^1)$ and $\tau_t^{a1} = k\Delta \underline{V}_1^a p_t^1$.

In what follows, it will be useful to recall that the utility increments in non-cooperative groups are zero, that is, $\Delta V_j^i = 0$, $i = e, a$. We will denote by $\Delta V_j^i\,(B)$, $i = e, a$ the utility increment of parents in a cooperative group if it follows dynamics B and $\Delta V_j^i\,(A)$, $i = e, a$ if it follows dynamics A. Note that in the first case this increment is a constant and in the second one depends on the proportion p^j.

Let us consider, in turn, several cases in which the groups can be found:

Suppose that $p^1, p^2 > p'$.

We assume, without loss of generality, that group 1 coordinates in the cooperative equilibrium and group 2 coordinates in the non-cooperative equilibrium.

1) Case A.1: $p^1, p^2 > p'$ and $p^1, p^2 > (1 - t^\alpha)$

Let us see the dynamic evolution of cooperative group 1. Note that this group follows initially dynamics A. If we compute $\Delta \underline{V}_1^e = (1-\lambda)\,\Delta V_1^e + \lambda\,\Delta V_2^e$, we observe that the last term, $\lambda\,\Delta V_2^e$, is zero, since parents in non-cooperative groups have no incentives to socialize. A completely similar reasoning applies for $\Delta \underline{V}_1^a$. Therefore it can verified that:

$$\Delta p_1 = p_{t+1} - p_t = p_t^1\,(1-p_t^1)\,(\tau_t^{e1} - \tau_t^{a1}) = p_t^1\,(1-p_t^1)\,(k\Delta \underline{V}_1^e\,(1-p_t^1) - k\Delta \underline{V}_1^a p_t^1) =$$
$$= p_t^1\,(1-p_t^1)\,[(1-\lambda)k\Delta V_1^e(A)(1-p_t^1) - (1-\lambda)\,k\Delta V_1^a(A)p_t^1)] =$$
$$= p_t^1\,(1-p_t^1)\,k\,(1-\lambda)\,B\,[(1-p_t^1)\,(p_t^1 - 1/2) - p_t^1\,(1/2 + (\alpha+\beta-1)\,p_t^1)]$$

That is, dynamics A but multiplied by $(1-\lambda)$. As we already know, Δp_1 decreases under dynamics A, since $\tau_t^{e1} < \tau_t^{a1}$. Therefore p^1 will fall until it reaches $(1 - t^\alpha)$ and eventually will jump to dynamics B (multiplied by $(1-\lambda)$). Once in this dynamics B, p^1 will continue reducing until to converge to $p^* = 1/2\beta$ (as we will see below).

On the other hand, the non-cooperative group has the following utility increment : $\Delta \underline{V}_2^e = (1-\lambda)\,\Delta V_2^e + \lambda\Delta V_1^e$. Note that the first term, $(1-\lambda)\,\Delta V_2^e$, is zero and in the second term, group 1 follows dynamics A. A similar argument applies for $\Delta \underline{V}_2^a$. Therefore:

$$\Delta p^2 = p_t^2\,(1-p_t^2)\,[(\lambda)k\Delta V_1^e(\text{A})\,(1-p_t^2) - \lambda k\Delta V_1^a(\text{A})\,p_t^2)] =$$
$$= p_t^2\,(1-p_t^2)\,k\lambda\,B\,[(1-p_t^2)\,(p_t^1 - 1/2) - p_t^2\,(1/2 + (\alpha+\beta-1)\,p_t^1)].$$

As we can check Δp^2 depends on both (p^1, p^2) and the evolution of p^2 is unclear. But as we know that p^1 is decreasing, once p^1 reaches the point $(1 - t^a)$, the cooperative group changes to dynamics B and then, Δp^2 will change only to depend on p^2 as we can see:

$$\Delta p^2 = p_t^2\ (1 - p_t^2)\ [(\lambda) k \Delta V_1^e(B)\ (1 - p_t^2) - \lambda k \Delta V_1^a(B)\ p_t^2)] =$$
$$= \Delta p^2 = p_t^2\ (1 - p_t^2)\ [kB\lambda\ \ ((1/2 - t^\alpha)\ (1 - p_t^2) - (t^\alpha + \beta(1 - 2\ t^\alpha) - 1/2)\ p_t^2.$$

Therefore, once group 2 follows dynamics B (multiplied by λ), p_t^2 will fall, since $\tau_t^{e1} < \tau_t^{a1}$ because $p^2 > p^*$ and eventually p_t^2 will be less than p' and group 2 will switch to a cooperative group.

Once group 2 is below p' and group 1 follows dynamics B, group 2 could follow dynamics A or B. If group 2 follows dynamics A and group 1 is in B, it can be easily checked that p_t^2 will continue falling since with probabilty $(1 - \lambda)$ follows dynamics A and with probability λ follows dynamics B, but dynamics B does not depend on p_t^1, and therefore the evolution of p_t^2 will depend exclusively on dynamics A, that implies a reduction in p_t^2 (since $\tau_t^{e2} < \tau_t^{a2}$). This value continues decreasing until it reaches $(1 - t^a)$ and then jumps to dynamics B, and then both groups follows dynamics B. In this situation, each p^1, p^2 follows dynamics B, that only depends on the preference distribution of each group, eventually converging to $p^* = 1/2\beta$.

2) Case A.2: $p^1, p^2 > p'$ and $p^1 > (1 - t^\alpha)$ and $p^2 < (1 - t^\alpha)$

In the cooperative group, p^1 follows the same scheme that in the previous case. Firstly, p^1 is in dynamics A and falls until it reaches dynamics B and finally converges to point $p^* = 1/2\beta$.

On the other hand, p^2 in the group 2 does not have a clear direction, while group 1 maintains in dynamics A, but once p^1 reaches $(1 - t^\alpha)$ and changes to dynamics B, the evolution of p^2 starts to reduce until reaches p', switches to a cooperative group and follows dynamics B. Thus, both groups follows the same dynamics B and applies the reasoning of case A.1.

3) Case A.3: $p^1, p^2 > p'$ and $p^1 < (1 - t^\alpha)$ and $p^2 > (1 - t^\alpha)$

In this case, p^1 follows dynamics B and in the end converges to p^*. In the non cooperative group, p^2 decreases because due to migration to group 1, the educational effort $\tau_t^{e2} < \tau_t^{a2}$, until p^2 is smaller than p', and both groups follows dynamics B, playing cooperatively.

4) Case A.4: $p^1, p^2 > p'$ and $p^1 < (1 - t^\alpha)$ and $p^2 < (1 - t^\alpha)$

This case is very similar to the previous case, but the convergence is faster.

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ABOUT THE AUTHORS*

GONZALO OLCINA VAUTEREN holds a PhD in economics from the University of Valencia and an MSc in econometrics and mathematical economics from the London School of Economics, University of London. He is currently professor at the Department of Economic Analysis of the University of Valencia. His research fields are game theory, information economics and behavioral economics. He has published more than twenty articles in national and international specialized journals and has written and collaborated in several books.
E-mail: gonzalo.olcina@uv.es

VICENTE CALABUIG ALCÁNTARA graduated in economics from the University of Alicante and holds a PhD from the University of Valencia. He is currently professor at the Department of Economic Analysis of the University of Valencia. His research fields are behavioral game theory, bargaining and labor economics. He has published more than ten articles in national and international specialized journals and has written and collaborated in several books.
E-mail: vicente.calabuig@uv.es

Any comments on the contents of this paper can be addressed to Gonzalo Olcina at gonzalo.olcina@uv.es

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