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Economic interactions and social tolerance: A dynamic perspective

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HIGHLIGHTS

- We investigate the relationship between economics and social tolerance.
- Our methodological framework is the replicator dynamics.
- Result 1: A fully tolerant society is associated with a higher social welfare.
- Result 2: Intolerance is much more persistent than tolerance.
- Result 3: Cultural integration should precede economic integration.

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ABSTRACT

We propose an evolutionary game to analyse the dynamics of tolerance among heterogeneous economic agents. We show that: (i) intolerance is much more persistent than tolerance; (ii) a fully tolerant society assures prosperity; (iii) cultural integration should precede economic integration.

1. Introduction

In this paper, we analyse how tolerance, which we define as a generic ability to accept diversity, is affected by wealth distribution between two economically interacting social groups. As pointed out by Tabellini (2010) and Florida (2004), intolerant behaviour affects economic growth and social development by reducing trust and cooperation among economic agents, obstructing the free movement of ideas and talents and favouring corruption and political patronage.

Furthermore, Bjornskov (2004) discusses the importance of individuals' tolerance for economic growth, showing that inequality reduces growth but mainly in societies where people perceive it as being relatively unfair. However we ascertain a substantial lack of theoretical economic models about the determinants and social dynamics of tolerance. To the best of our knowledge, one of the first theoretical papers on this topic is Corneo and Jeanne (2009). The authors propose a theory of tolerance using the approach of symbolic values in which benevolent parents select their children's values. They argue that society may be trapped in an intolerant equilibrium; moreover, moving from an intolerant to a tolerant society would increase aggregate income. Correani et al. (2010) propose an overlapping generations model, showing that the incentives that influence descendants' predisposition to tolerance depend on both institutional factors, where behaviour is imposed by rules and social (or cultural) factors. The authors confirm the absolute impossibility of affirming tolerance through formal rules. Intolerance is a persistent attitude and its control requires continuous interventions on the educational processes of new generations. Recently, Muldoon et al. (2011) have developed two models of rational motivation for toleration. Key to the first model is an application of David Ricardo's theory of trade and his related notion of comparative advantage. In their second model the authors assume one-on-one interactions between members of a

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Table 1
Payoffs of the interaction. The heading of the table points to tolerant (x_i) and intolerant ($\hat{x}_i$) agents of group i. The generic couple (a_i, a_j) describes the payoffs of the agents in the i-th row and j-th column.

	x_1	$\hat{x}_1$	x_2	$\hat{x}_2$
x_1	π_{11}, π_{11}	π_{11}, π_{11}	$\pi_{12} - (\alpha_1 + c_1), \pi_{21} - (\alpha_2 + c_2)$	0, 0
$\hat{x}_1$	π_{11}, π_{11}	π_{11}, π_{11}	0, 0	0, 0
x_2	$\pi_{21} - (\alpha_2 + c_2), \pi_{12} - (\alpha_1 + c_1)$	0, 0	π_{22}, π_{22}	π_{22}, π_{22}
$\hat{x}_2$	0, 0	0, 0	π_{22}, π_{22}	π_{22}, π_{22}

society, where the successful establishment of a link between two agents is constrained by their level of tolerance. The principal findings of Muldoon et al. (2011) are that individuals should be rationally motivated to become more tolerant, but only under specific conditions. First, heterogeneity in the population is necessary; second, individuals must have some material interests; third, agents must have a relatively small number of the skills available in the society.

The mathematical model developed in the present article relates to the literature on the evolution of social preferences (Bisin and Verdier, 1998, 2001; Pichler, 2010) and is a natural continuation of economic studies on fundamentalism (Iannaccone, 1997; Arce and Sandler, 2003, 2009; Epstein and Gang, 2007) and social tolerance (Corneo and Jeanne, 2009; Correani et al., 2010; Muldoon et al., 2011). To assess the evolution of tolerance in society, we use the replicator dynamics (Weibull, 1998), which implicitly assumes that tolerant and intolerant behaviour spreads on the grounds of a selection process: the behaviour (strategy) that gives a higher payoff tends to spread in the society. We introduce a random pairwise matching where two randomly selected agents are involved in an economic transaction (for example a working relationship or a business deal) which produces an amount of wealth that is assigned to the agents on the grounds of their initial economic contribution. Substantially, we assume that a group (group 1) is richer than the other and an agent of group 1 gives a greater contribution in producing wealth than the poorest agent of group 2.

Obviously, the economic transaction is strongly affected by the type of agents involved in it (Akerlof and Kranton, 2000) and, in particular, it is not carried out if the actors are agents of different groups and at least one of them is intolerant; as a matter of fact, a fully tolerant society is a Pareto dominant equilibrium, allowing the highest production of wealth.

The model produces a large number of different scenarios, but only in one case tolerance is a globally stable steady state, confirming the empirical evidence that intolerance is much more common and persistent than tolerance (Corneo and Jeanne, 2009). In particular, we will show that the selection process of dominant behaviour is strongly affected by wealth distribution and agents' perception of cultural differences among social groups. In other words, as stated in the empirical analysis of Becchetti et al. (2007) '*not only growth but also the distribution of growth dividends matters*' for the diffusion of tolerance. Notably, we find that, even assuming an identical initial capital endowment of the two groups (economic integration), the hypothesis of fairness in the allocation of wealth produced with the economic interaction implies the dissemination of intolerance. Thus, tolerance requires persisting differences in the distribution of produced wealth (group 1 should remain richer than group 2). This strange phenomenon is less prominent if an agent's perception of diversity is less marked, that is if cultural integration between the two groups is reinforced. These theoretical results suggest that cultural integration should precede economic integration.

The remaining sections of the paper are organized as follow. Section 2 describes the model and discusses the main results. Section 3 analyses the welfare implications of the evolutionary dynamics of social tolerance. Section 4 contains our conclusions and provides prospects for further research.

2. The model

We assume that a population of N economic agents is divided into two differentiated groups. Differences, such as ethnicity, religion, country of origin and social class are almost immediately recognizable. We indicate with N_i the number of members of group i, for $i = 1, 2$ and $N_1 + N_2 = N$. The cardinality of each group is supposed large enough, i.e. $N_i > 1$, for each $i = 1, 2$. For the sake of simplicity, N_i is assumed to be constant in time, i.e. populations do not grow or decrease. Each individual can be tolerant or intolerant towards the agents of the opposite group. We also assume that the percentage of tolerance varies in time. Let $0 \le x_i^t \le 1$ be the share of tolerant agents in group i at time t. In order to simplify our analysis, the explicit reference to time will be omitted whenever possible. Society is shared among tolerant and intolerant individuals:

$$\sum_{i=1}^{2} x_i N_i + \sum_{i=1}^{2} \hat{x}_i N_i = N, \tag{1}$$

where $\hat{x}_i = 1 - x_i$, for $i = 1, 2$.

Let us suppose that agents interact after being randomly matched, obtaining payoffs constant in time according to Table 1.

In general, $\pi_{ij} > 0$ is the gain obtained by an agent of group i when she interacts with an agent of group j. When interaction involves two agents of the same group, each of them obtains $\pi_{ii} > 0$ irrespective of their real attitude (tolerance or intolerance). The interaction between agents of different groups is more complex because their attitude to accept diversity can affect the outcome of the transaction. Indeed, by definition, intolerance rules out any interaction with the agents of different groups. The intolerant individual 'builds' around her an exclusive network of relations excluding all the individuals of the other groups; therefore, we conclude that interaction does not occur if the involved actors belong to two different groups, and if one of them is intolerant. In this case each agent gains 0.[1] Tolerance, here, is the willingness to engage with others, regardless of their ideological commitments. When interaction involves tolerant agents of two different groups i and j they respectively obtain, $\pi_{ij} - (\alpha_i + c_i)$ and $\pi_{ji} - (\alpha_j + c_j)$. More specifically, anyone who accepts interacting with an agent of the rival group sustains both a psychological cost α_i in terms of loss of identity (see Akerlof and Kranton, 2000) and a social cost c_i paid by the agents because their behaviour is disapproved of by intolerant individuals. The psychological cost α_i is assumed to depend on the payoff π_{ii}, i.e. $\alpha_i = \alpha_i(\pi_{ii})$ with $\partial \alpha_i / \partial \pi_{ii} > 0$. Social costs depend on the level of tolerance measured by the shares x_1 and x_2; we assume the function $c_i = \beta c_i(x_1, x_2)$, $i = 1, 2, \beta > 0$, with the following properties[2]:

[1] However, an agent who is highly intolerant of others may partner with an agent that she is intolerant of, but we assume that the relationship will be strained and less fruitful than a more amicable partnership: also in this case we assume that each agent gains 0 (see Muldoon et al., 2011).

[2] As in Muldoon et al. (2011) we propose individuals' rational self-interest and social diversity as the motivators for tolerant/intolerant behaviour, and social cost allows us to take into account the role played by inter-group differences such as religion or ethnicity, which cannot be captured by only considering pure economic incentives. In line with Alesina and La Ferrara (2005), 'contacts across different types of agents produce negative *utility*'.

(1) $\frac{\partial c_i}{\partial x_1} < 0$, $\frac{\partial c_i}{\partial x_2} < 0$;
(2) $\frac{\partial^2 c_1}{\partial x_1^2} \geq 0$, $\frac{\partial^2 c_2}{\partial x_2^2} \geq 0$;
(3) $\frac{\partial^2 c_1}{\partial x_1 \partial x_2} \leq 0$, $\frac{\partial^2 c_2}{\partial x_2 \partial x_1} \leq 0$;
(4) $c_i = 0$ if $x_1 = x_2 = 1$.

Condition (1) states that the individual cost increases when the share of intolerant people increases, while by condition (2) the higher the share of tolerant people in the agent's group, the lower the reduction in the cost generated by an increase in such a share. Condition (3) states that the social cost reduction produced by an increase in the share of tolerant individuals in the agent's group increases with an increase in the share of tolerant individuals of the other group. This means that the incentive to tolerance grows as the opposite group becomes more tolerant, i.e. tolerance is much more rewarding if it is reciprocal. Finally, condition (4) states that individual social costs are zero if there are no intolerant people in both groups.

The parameter $\beta \geq 0$ may be viewed as a measure of intolerants' 'fundamentalism'; when β is high, intolerant agents are strongly adverse to the members of the other group and the individual social costs deriving by mixed interaction are high.

Let $P_{x_i x_j}$ the probability that a tolerant agent of group i interacts with a tolerant agent of group j, $P_{x_i \hat{x}_j}$ the probability that a tolerant individual of group i meets an intolerant individual of group j, $P_{\hat{x}_i x_j}$ the probability that an intolerant member of group i meets with a tolerant member of group j and $P_{\hat{x}_i \hat{x}_j}$ the probability that an intolerant of group i meets an intolerant of group j. We obtain the following probabilities:

$$P_{x_1 x_1} = \frac{x_1 N_1 - 1}{N-1}, \qquad P_{x_1 \hat{x}_1} = \frac{\hat{x}_1 N_1}{N-1},$$
$$P_{x_1 x_2} = \frac{x_2 N_2}{N-1}, \qquad P_{x_1 \hat{x}_2} = \frac{\hat{x}_2 N_2}{N-1},$$
$$P_{\hat{x}_1 x_1} = \frac{x_1 N_1}{N-1}, \qquad P_{\hat{x}_1 \hat{x}_1} = \frac{\hat{x}_1 N_1 - 1}{N-1},$$
$$P_{\hat{x}_1 x_2} = \frac{x_2 N_2}{N-1}, \qquad P_{\hat{x}_1 \hat{x}_2} = \frac{\hat{x}_2 N_2}{N-1},$$
$$P_{x_2 x_2} = \frac{x_2 N_2 - 1}{N-1}, \qquad P_{x_2 \hat{x}_2} = \frac{\hat{x}_2 N_2}{N-1},$$
$$P_{x_2 x_1} = \frac{x_1 N_1}{N-1}, \qquad P_{x_2 \hat{x}_1} = \frac{\hat{x}_1 N_1}{N-1},$$
$$P_{\hat{x}_2 x_2} = \frac{x_2 N_2}{N-1}, \qquad P_{\hat{x}_2 \hat{x}_2} = \frac{\hat{x}_2 N_2 - 1}{N-1},$$
$$P_{\hat{x}_2 x_1} = \frac{x_1 N_1}{N-1}, \qquad P_{\hat{x}_2 \hat{x}_1} = \frac{\hat{x}_1 N_1}{N-1}.$$

Now, in order to provide more intuitive insights into the dynamics of tolerance, we will give an explicit shape of the cost function, supposing that:

$$c_i(x_1, x_2) = \beta(1 - x_1 x_2) \tag{2}$$
$$\alpha_i(\pi_{ii}) = \pi_{ii}. \tag{3}$$

Given the above probabilities the expected payoffs of tolerant and intolerant individuals in group i are, respectively:

$$E_{[x_i]} = \pi_{ii}\left(P_{x_i x_i} + P_{x_i \hat{x}_i}\right) + \left[\pi_{ij} - \pi_{ii} - \beta(1 - x_i x_j)\right] P_{x_i x_j}, \tag{4}$$

and

$$E_{[\hat{x}_i]} = \pi_{ii}\left(P_{\hat{x}_i x_i} + P_{\hat{x}_i \hat{x}_i}\right), \tag{5}$$

for $i, j \in \{1, 2\}$ with $i \neq j$.

To study the evolutionary dynamics of tolerance we will use the theory of replicators (Weibull, 1998). N being very large, we will consider the version of the replicator which is related to an infinite population. This is a simplifying assumption, which has the good feature to provide a more intuitive and meaningful economic analysis. The motion of tolerant population in group 1 with respect to time t will be then modelled by the following differential equation:

$$\dot{x}_1 = x_1 \hat{x}_1 \left(E_{[x_1]} - E_{[\hat{x}_1]}\right). \tag{6}$$

By repeating the same procedure for group 2, we can obtain a second differential equation that, along with Eq. (6), produces a system of two differential equations giving a complete description of tolerance dynamics:

$$\begin{cases} \dot{x}_1 = \dfrac{x_1 \hat{x}_1 x_2 N_2}{N-1}\left[\pi_{12} - \pi_{11} - \beta\left(1 - x_1 x_2\right)\right], \\ \dot{x}_2 = \dfrac{x_2 \hat{x}_2 x_1 N_1}{N-1}\left[\pi_{21} - \pi_{22} - \beta\left(1 - x_1 x_2\right)\right]. \end{cases} \tag{7}$$

The dynamics is assumed to start at an initial state $\left(x_1^0, x_2^0\right)$.

By applying Eq. (6), we have that the trajectories described in (7) are always into the phase plane:

$$F = \left\{\left(x_1^t, x_2^t\right) : 0 \leq x_1^t \leq 1, 0 \leq x_2^t \leq 1, \ \forall t > 0\right\},$$

for every starting point $\left(x_1^0, x_2^0\right) \in F$ and time $t \geq 0$.

By solving (7), we derive the steady states of the dynamical system set on the boundaries of the phase plane F:

$$\begin{cases} P_1 = (0, \psi); & \psi \in (0, 1]; \\ P_2 = (\xi, 0); & \xi \in (0, 1]; \\ P_3 = (1, 1); \\ P_4 = (0, 0); \\ P_5 = \left(1, \dfrac{\pi_{22} - \pi_{21} + \beta}{\beta}\right); \\ P_6 = \left(\dfrac{\pi_{11} - \pi_{12} + \beta}{\beta}, 1\right) \end{cases} \tag{8}$$

and all the steady states (x_1, x_2) within the phase plane F, derived by calculating the intersection of the isokine curves[3] $\hat{x}_2 = \frac{\pi_{11} - \pi_{12} + \beta}{\beta x_1} \equiv \Omega_1$ and $x_2 = \frac{\pi_{22} - \pi_{21} + \beta}{\beta x_1} \equiv \Omega_2$ with $x_i \neq \{0, 1\}$ $i = 1, 2$ that is: Q4

$$P_7 = \{(x_1, x_2) : x_1 \in (0, 1), x_2 \in (0, 1), \ \Omega_1 = \Omega_2\}. \tag{9}$$

The steady states have a precise economic and social meaning. Points P_1 and P_2 depict situations where one group (respectively group 1 and group 2) is wholly populated by intolerant agents. Point P_3 is the most preferable situation, given that all population agents are tolerant and social conflicts are absent; in contrast, point P_4 depicts a society characterized by totally intolerant agents. Finally, at points P_5 and P_6 the population of one group is completely tolerant while, at point P_7, tolerant and intolerant agents exist in both social groups. The point P_3 is of particular interest for our purpose being such a steady state related to the case of full tolerance. We will focus our attention on it.

[3] Isokine curves are obtained by imposing

$$\begin{cases} \pi_{12} - \pi_{11} - \beta\left(1 - x_1 x_2\right) = 0; \\ \pi_{21} - \pi_{22} - \beta\left(1 - x_1 x_2\right) = 0, \end{cases}$$

with $x_1 \in (0, 1)$ and $x_2 \in (0, 1)$.

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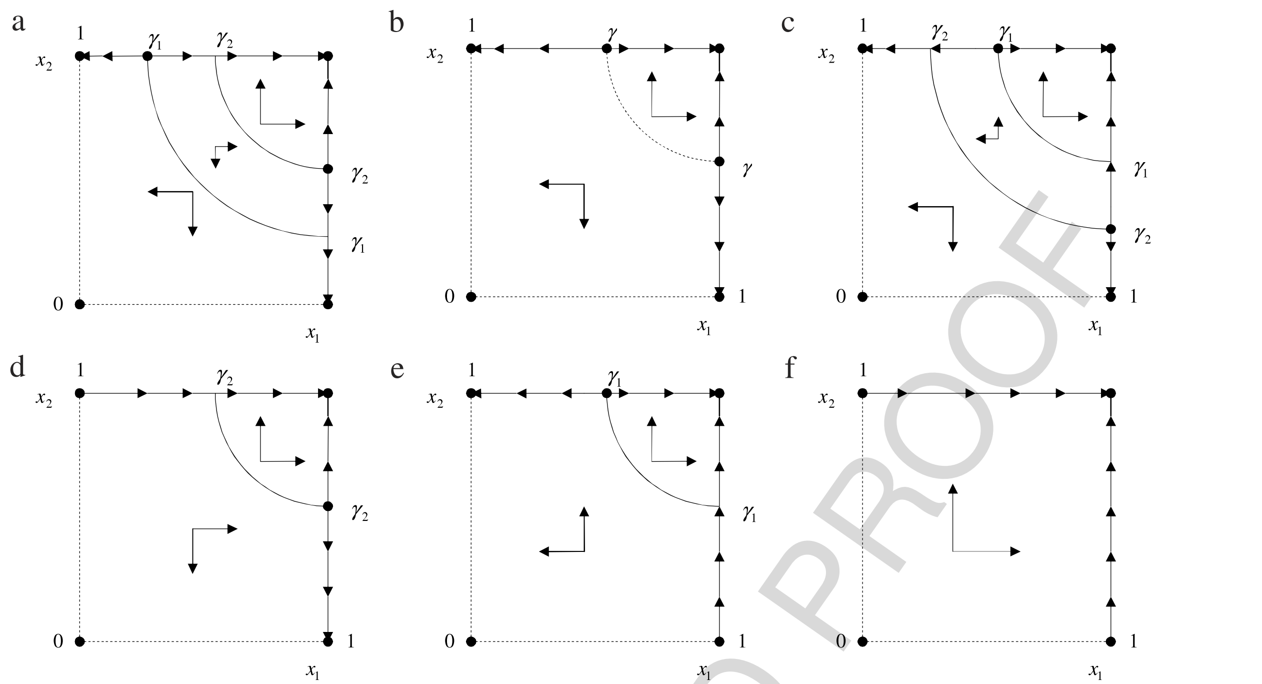

Fig. 1. Phase diagrams 1: (a) $\gamma_1, \gamma_2 \in (0, 1)$ and $\gamma_1 < \gamma_2$; (b) $\gamma_1 = \gamma_2 = \gamma \in (0, 1)$; (c) $\gamma_1, \gamma_2 \in (0, 1)$ and $\gamma_1 > \gamma_2$; (d) $\gamma_1 < 0, \gamma_2 \in (0, 1)$; (e) $\gamma_2 < 0, \gamma_1 \in (0, 1)$; (f) $\gamma_1 < 0, \gamma_2 < 0$.

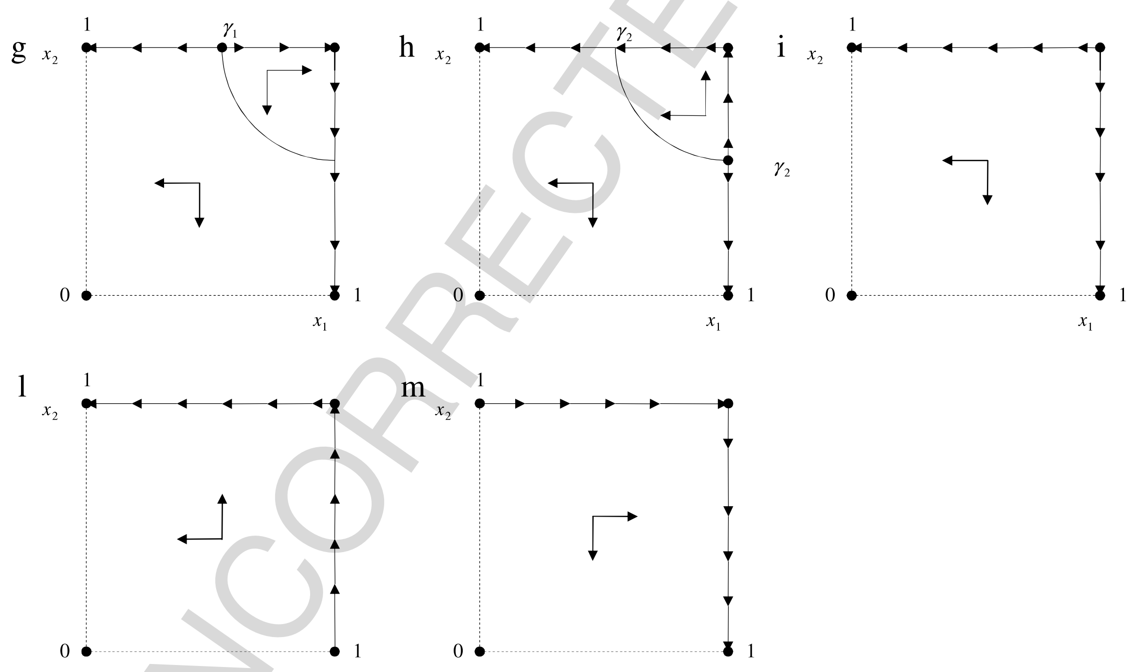

Fig. 2. Phase diagrams 2: (g) $\gamma_1 \in (0, 1), \gamma_2 \geq 1$; (h) $\gamma_2 \in (0, 1), \gamma_1 \geq 1$; (i) $\gamma_1 \geq 1, \gamma_2 \geq 1$; (l) $\gamma_1 > 1, \gamma_2 < 0$; (m) $\gamma_2 > 1, \gamma_1 < 0$.

The following facts will turn out to be useful:

1. if at a given time t we have $x_2^t > \Omega_i i = 1, 2$ then $\dot{x}_i > 0$;
2. if $x_2 = 1$ and $x_1 > \frac{\pi_{11}-\pi_{12}+\beta}{\beta} \equiv \gamma_1$ then $\dot{x}_1 > 0$;
3. if $x_1 = 1$ and $x_2 > \frac{\pi_{22}-\pi_{21}+\beta}{\beta} \equiv \gamma_2$ then $\dot{x}_2 > 0$.

Phase diagrams 1 and 2 show all possible scenarios for the dynamics of tolerance. More specifically, Phase Diagram 1 exhibits the entire range of opportunities in which trajectories can converge to the point $(1, 1)$ of full tolerance when P_3 is a stable equilibrium. Phase Diagram 2 shows all the opportunities when the point $(1, 1)$ is unstable. If we observe phase diagrams, we can notice that a necessary condition in order to say that tolerance spreads in both groups is $\gamma_i < 1, \ \forall i = 1, 2$. Such a condition is not sufficient because convergence towards the equilibrium point $(1, 1)$ is possible only for sufficiently high value of x_i^0, for $i = 1, 2$.[4]

[4] In line with Muldoon et al. (2011) we observe that a 'uniformly intolerant society will have a hard time becoming less intolerant, precisely because there are no examples of tolerance to learn from'.

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Phase Diagram 1 also shows that only in panel (1*f*) with $\gamma_i < 0$ convergence to the point (1, 1) is realized for any starting point different from the equilibria in the phase plane F.

Condition $\gamma_i < 1$ is verified if and only if $\pi_{ij} - \pi_{ii} > 0\ \forall i, j \in \{1, 2\}$ and $i \neq j$. Therefore, the spread of tolerance is wider when the payoffs obtained in mixed interactions are higher than the payoffs resulting from the interactions between two members of the same group.

This fact forces us to give a more comprehensive description of payoffs; to be more precise, we assume that every interaction between two agents of groups i and j produces aggregate wealth $R_{ij}\left(k_i, k_j\right)$ that is distributed between them and then consumed. The produced wealth depends on the (physical and human) capital contributed by both agents. If the two agents are members of the same group, they divide wealth equally. If they are members of two different social groups, produced wealth is not equally divided. In this case we call the shares of wealth of the group i member δ_i and the share of the other one $\delta_j = 1 - \delta_i$. More precisely, we suppose that δ_i depends on the relative contribution of capital k_i, namely $\delta_i \equiv \frac{k_i}{k_i+k_j}$. A different portion of wealth can be justified assuming differences in group productivity or different initial (human and Q5 physical) capital endowments.[5] We assume that members of group 1 are in general richer than members of group 2 so that $\frac{1}{2} < \delta_1 < 1$ and given that $R_{12} = R_{21} \equiv R_2$ payoffs become:

$$\begin{cases} \pi_{11} = \dfrac{1}{2}R_{11}; & \pi_{12} = \delta_1 R_2, \\ \pi_{22} = \dfrac{1}{2}R_{22}; & \pi_{21} = (1-\delta_1)R_2, \end{cases} \tag{10}$$

where $R_{11} > R_2 > R_{22} > 0$. The analysis of the phase diagrams and the payoff structure in (10) gives the following result:

Proposition 1. *The necessary condition in order that tolerance spreads in both groups is* $\delta_1 \in [\Psi_1, \Psi_2]$, *where* $\Psi_1 \equiv \frac{1}{2}\frac{R_{11}}{R_2}$ *and* $\Psi_2 \equiv 1 - \frac{1}{2}\frac{R_{22}}{R_2}$.

Proof. From system (7) we observe that $\dot{x}_1 > 0$ and $\dot{x}_2 > 0$ require respectively $\pi_{12} > \pi_{11}$ and $\pi_{21} > \pi_{22}$. Using payoffs in (10) we obtain $\delta_1 > \frac{1}{2}\frac{R_{11}}{R_2}$ from the first condition and $\delta_1 < 1 - \frac{1}{2}\frac{R_{22}}{R_2}$ from the second one. □

Remark 1. Note that $\Psi_i > \frac{1}{2} \forall i \in \{1, 2\}$ but it is not necessarily true that $\Psi_1 < \Psi_2$. More precisely $\frac{1}{2} < \Psi_2 < 1$ and $\Psi_1 > \frac{1}{2}$. Furthermore, from (10) it is easy to show that:

$$\Psi_1 < \Psi_2 \quad \text{iff} \quad R_{11} < 2R_2 - R_{22}, \tag{11}$$

from which we derive the following results:

Corollary to Proposition 1.

1. *Tolerance is impossible if* $\Psi_1 > \Psi_2$ *for any* $\delta_1 \in [0, 1]$. R_2 is not sufficiently high and, therefore, there is no economic incentive to mixed interaction.
2. *Imposing fairness in the allocation of wealth* R_2 *(i.e. if* $\delta_1 \to \frac{1}{2}$*), reduces the level of tolerance.*

   Since $\Psi_1 > \frac{1}{2}$, Proposition 1 gives that a necessary condition for the spread of tolerance is $\delta_1 > 1/2$. The borderline case of $\delta_1 = 1/2$ is associated with fair distribution of wealth R_2. Hence, $\gamma_1 > 1$ and $\gamma_2 < 1$, and the system is that reported in panels 2(h) and 2(l), where the equilibrium (1, 1) with full tolerance is clearly unstable. Given that $R_{11} > R_{22}$, when $\delta = 1/2$ the agents of group 1 have no economic incentive to cooperate with the agents of group 2.
3. *If there are no differences in productivity between the groups, then* $R_{11} = R_{22} = R_2$ *and intolerance spreads.*

   With $R_{11} = R_{22} = R_2$ we have $\Psi_1 = \Psi_2$ and at least one group (group 1 if $\delta_1 < \frac{1}{2}$, as in panel 2(h), and group 2 if $\delta_1 > \frac{1}{2}$, in panel 2(g)) experiences a reduction in the share of tolerant agents, $\dot{x}_i < 0$. Increasing intolerance in this group generates more costs for tolerant agents of both groups, producing a growing intolerance in the other group as well. If $\delta_1 = \frac{1}{2}$ the system is described by panel 2(i). In the long run, at least one group will be entirely composed of intolerant agents. We conclude that between two different social groups of agents with the same productivity, a conflict is inevitable.

A sufficient condition to have tolerance in both populations is summarized in the following proposition:

Proposition 2. *A sufficient condition for the spread of tolerance in both groups at any starting point* $\left(x_1^0, x_2^0\right) \in F$ *is* $\gamma_i < 0\ \forall i = 1, 2$, *that is* $1/2 < \Gamma_1 < \delta_1 < \Gamma_2 < 1$, *where* $\Gamma_1 = \Psi_1 + \frac{\beta}{R_2}$ *and* $\Gamma_2 = \Psi_2 - \frac{\beta}{R_2}$.

Proof. From panel 1(f) we observe that all trajectories converge to the point (1, 1) if $\gamma_1 < 0$ and $\gamma_2 < 0$. From $\gamma_1 < 0$ we obtain $\delta_1 > \frac{1/2R_{11}+\beta}{R_2} \equiv \Gamma_1$ and from $\gamma_2 < 0$ that $\delta_1 < 1 - \frac{1/2R_{22}+\beta}{R_2} \equiv \Gamma_2$. □

Note that $\Gamma_1 < \Gamma_2$ if and only if $R_2\left(\Psi_2 - \Psi_1\right) > 2\beta$, which means that the spread of tolerance requires economic incentives favouring inter-group interaction ($\Psi_1 < \Psi_2$, as stated in the necessary condition) and sufficiently low tolerance costs (small β). Therefore, we can conclude that the diffusion of tolerance is very difficult when social aversion to diversity becomes more marked.

3. Welfare and policy

We assume the amount W of expected payoffs of each agent as a suitable measure of total welfare in the steady state P_j:

$$W_{(x_1,x_2)} = \sum_{i=1}^{2}\left(E_{[x_i]}N_i x_i + E_{[\hat{x}_i]}N_i\hat{x}_i\right). \tag{12}$$

When $\gamma_1 \in (0, 1)$ and $\gamma_2 \in (0, 1)$, then steady states P_5 and P_6 are always unstable (see phase diagrams in Figs. 1 and 2) and are not Q6 taken into consideration in the welfare analysis. In contrast, equilibrium points P_1, P_2, P_3 and P_4 can be stable or unstable according to the values assumed by γ_1 and γ_2, and therefore, they constitute the core of the welfare analysis.[6]

By substituting (4) and (5) into the welfare equation (12), and assuming $\frac{N_i}{N_i-1} \approx 1$, we obtain the following levels of welfare:

$$W_{P_1} \approx \pi_{22}\left(\psi N_2 - 1\right) - \pi_{11}, \tag{13}$$

$$W_{P_2} \approx \pi_{11}\left(\xi N_1 - 1\right) - \pi_{22}, \tag{14}$$

$$W_{P_3} \approx \left(\pi_{11} + \pi_{21}\right)N_1 + \left(\pi_{22} + \pi_{12}\right)N_2 - \left(\pi_{11} + \pi_{22}\right); \tag{15}$$

$$W_{P_4} \approx -\left(\pi_{11} + \pi_{22}\right). \tag{16}$$

[5] These hypotheses are reasonable if, for example, we consider a group of natives owning most of the production factors and a group of migrants with low skills (Darity et al., 2006; Hazari and Sgro, 2003; Moy and Yip, 2006) or if we assume that "one racial group has racial privilege in exercising control over both public and private resources while members of the other groups do not have such power" (Darity et al., 2006).

[6] The assumption $R_{11} > R_2 > R_{22}$ rules out the equilibrium point P_7.

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From comparison we observe that

$$W_{P_3} > \max\{W_{P_1}, W_{P_2}, W_{P_4}\}. \tag{17}$$

Therefore, welfare maximization requires total tolerance between the groups. Government policies must promote tolerance to maximize welfare and favour a fair distribution of wealth; however, since our model predicts a trade-off between wealth distribution and diffusion of tolerance, this can be a very hard task. Let us assume, for example, that a population is formed by two conflicting groups with $\Psi_1 < \Psi_2$ and is characterized by a high level of intolerance. In this case, a policymaker's first objective should be that of satisfying condition (12) by favouring *cultural integration*, that is by reducing β, and maintaining inequality, so that the sufficient condition $\Gamma_1 < \delta_1 < \Gamma_2$ is satisfied. In this case, the dynamics are that of phase plane (f) in Fig. 1, where groups' attitudes converge to full tolerance. When the state of the population is sufficiently close to the steady state point (1, 1), then we can realize *economic integration*, reducing δ and the productivity gap between the groups (which is making $\Psi_1 \approx 1/2$ and $\Psi_2 = \Psi_1 + \epsilon$), but maintaining necessary condition $\Psi_1 < \delta_1 < \Psi_2$. At this point, dynamics will be described by one of the phase planes from (a) to (e) in Fig. 1; disparities will be significantly reduced and tolerance will spread in both groups. It is important to remark the fact that a different policy where *economic integration* precedes *cultural integration* does not produce social tolerance.

4. Conclusions

Usually we think that the tolerance between two different social groups is a natural consequence of *economic integration*, defined as fairer distribution of wealth among people. Our model contradicts this idea; in fact, even though it confirms that a large gap between wealth endowments of different groups produces intolerance, when we assume no differences ($R_{11} = R_{22} = R_2$) or impose fairness in the allocation of wealth produced by economic interaction ($\delta \rightarrow 1/2$), i.e. *economic integration*, we obtain the counterintuitive result that intolerance increases and aggregate wealth reduces. Thus, tolerance requires that a group must be richer than the other. However, such a phenomenon is reduced by sufficiently low tolerance costs; more precisely, when the perception of diversity existing between the agents of different groups becomes negligible, these groups can freely cooperate in economic interactions without incurring in economic and social retaliation. By defining a society with low tolerance costs ($\beta \rightarrow 0$) as culturally integrated, we conclude that *cultural integration* must precede *economic integration*; fairness and equity without a corresponding decrease in the perception of diversity will produce intolerance. The conclusions derived from this analysis are solely based on the assumption of the existence of static wealth. In the real world, we observe that physical and human capital and production are dynamic; therefore, future research will have to focus on the impact of inter-group tolerance on economic growth models, where the mathematical law of motion of capital is also affected by the level of social tension.

Uncited references

Berggren and Elinder, 2010, Das et al., 2008, Engel, 2003 and Solow, 1993.

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