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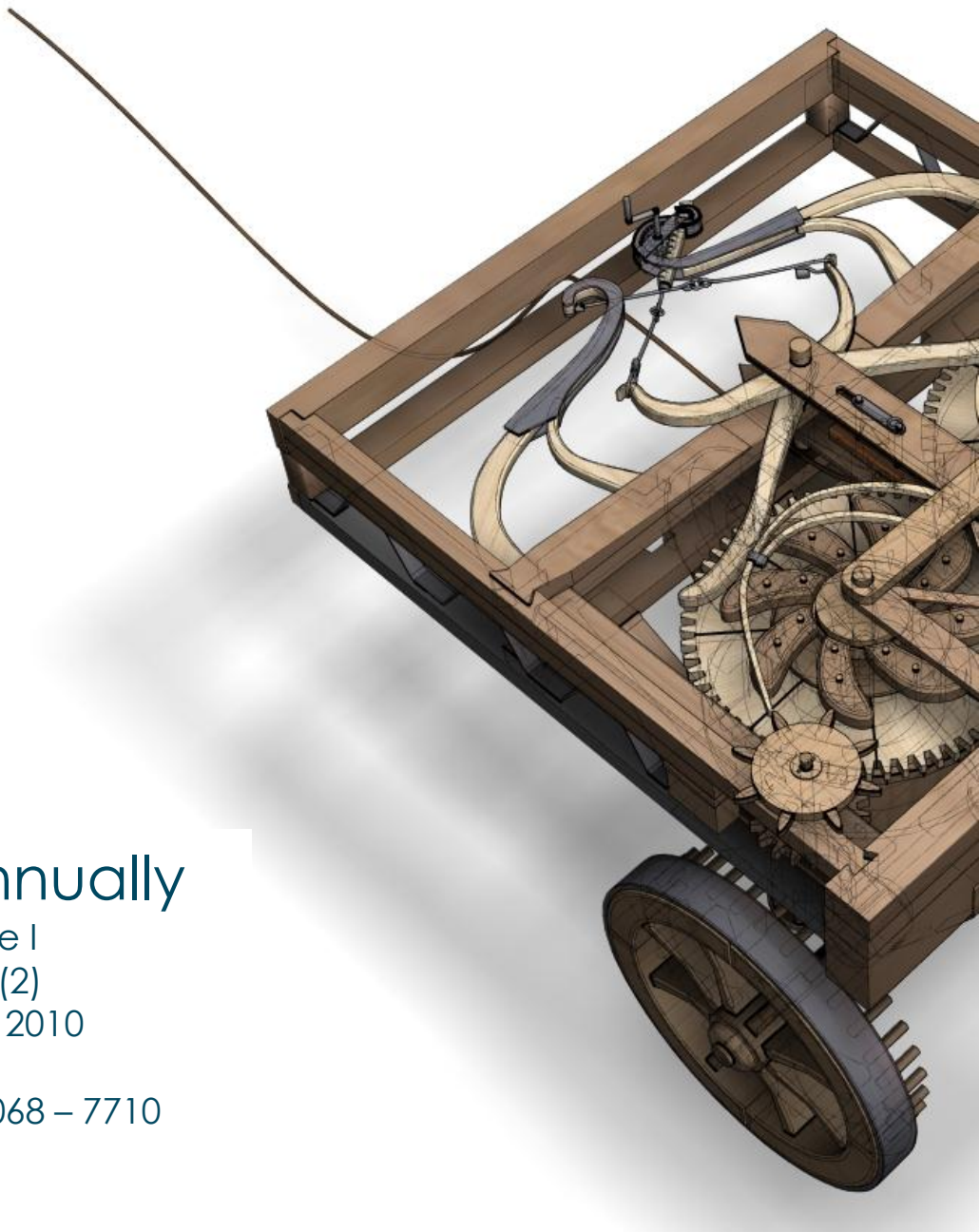

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THE EVOLUTIONARY DYNAMICS OF TOLERANCE*

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Abstract

This paper incorporates the phenomenon of tolerance into an economic analysis, showing how different attitudes to trust and cooperation can affect economic outcomes. In the economic system we propose, tolerance is associated with the different weight that agents attribute to their own nature and to the institutional parameters in their utility function. We thus construct an overlapping generations model (OLG), showing that the incentives that influence descendants' predisposition to tolerance depend on both institutional factors, where behaviour is imposed by rules, and on social (or cultural) factors, found in popular customs and established traditions. Our study highlights the absolute impossibility of affirming tolerance through formal rules. In fact, we show that intolerance emerges as persistent attitude (intolerance trap) and its control is only possible through constant and continuous interventions on the educational processes of new generations.

Keywords: tolerance, overlapping generation model

JEL Classification: D1, Z1

1. Introduction

This paper shows that the phenomenon of tolerance, defined as a generic ability to accept diversity, can easily be integrated into an economic model, providing a new explanation for a number of both economic and social phenomena. The economic literature on this subject is fairly recent; intolerant behaviour inevitably affects several important factors of economic growth and social development, such as trust between economic agents, cooperation, the free movement of ideas and talent and at the same time promoting corruption and rewarding group membership rather than merit (Tabellini 2010).

The theory developed in this article is the natural continuation of Iannaccone's (1997) economic study on fundamentalism that recently culminated in Arce-Sandler's (2003-2008) and Epstein-Gang's (2007) theoretical models and in Corneo-Jeanne's (2009) preliminary and pioneering study on the economic theory of tolerance.

In this paper, we adopt a model to analyse the evolution and persistence of social attitudes towards tolerance through the dynamic properties of a precise mechanism of cultural transmission and socialization.

More specifically, tolerance is incorporated in an OLG model, showing that this has a remarkable impact on the economic equilibrium of the system. In our model, the cultural values of tolerance are transmitted through the educational efforts exerted by parents on their children. However, the incentives that influence the descendants' predisposition to tolerance depend on both institutional factors, where behaviours are imposed by rules, and on social (or cultural) factors, found in popular customs and established traditions. The tolerant individual reaches a compromise between the different influences by minimizing the friction between her own and social choices. In this choice, economic-type evaluations will prevail.

Our model assumes that there are two social categories, 'tolerant' and 'intolerant', identified on the basis of their different behavioural characteristics, or rather, by a different representation of own preferences. Each

* We are grateful for constructive comments to seminar participants at various universities where a previous version of this work were presented. We have profited from helpful comments by Barbara Annicchiarico and Guido Cozzi on an earlier draft. The authors alone are responsible for the views expressed in the paper and for any errors which may remain.

member of the population has either the 'tolerant' or 'intolerant' characteristics deriving from the educational efforts of parents in the transmission of these characteristics. According to Bisin and Verdier's (1998, 2001) approach, parents choose the cultural transmission coefficient (educational effort), or rather, the probability with which their cultural traits (their true disposition to tolerance) are adopted by the child. If the child (i.e. the new generation) does not learn from the parent, then she will assume the character of an individual at random. Our analysis demonstrates that the model is able to replicate some important social and historical phenomena, such as the persistence of widespread intolerance in countries that have adopted strong legislation to protect freedom and respect for diversity (Inglehart 1997, Inglehart, and Baker 2000). As it is confirmed by empirical evidence (Corneo, and Jeanne 2009), in our model intolerance is much more common and persistent than tolerance.

Under specific conditions and institutional arrangements, society can converge on one of two possible stable equilibriums: a 'good equilibrium' where there is a balance between the share of tolerant and intolerant individuals and a 'bad equilibrium' characterized by widespread intolerance where tolerant individuals, representing a minority, are encouraged to hide their true character.

What is interesting is that equilibrium with widespread tolerance ('good equilibrium') is particularly fragile in the sense that, following a minimal change in the agent expectations, the system tends to move away from this, automatically converging towards the 'bad equilibrium'. In contrast, equilibrium with widespread intolerance is particularly robust, insensitive to any changes in agent expectations. The system, therefore, tends to naturally exist in a situation called the 'intolerance trap' where the only means to exit is through constant public interventions. Significant policy implications derive from these propositions. The maintenance of a social system inspired by the values of tolerance requires a steady and sustained commitment from the authorities, since the system is unable to ensure its own stability. This result provides a convincing explanation of the frequent outbursts of intolerance that occur in societies, which for some time now have been considered free from ideological constraints and a respectful of diversity, but also explains the profound differences in the levels of tolerance between different industrialized countries (*see* for example Florida 2004).

From an economic perspective, this study allows assessing the effectiveness of specific policy interventions in order to facilitate the dissemination and integration of values in society. The model demonstrates the ineffectiveness of policies aimed at spreading tolerance based exclusively on legislative and institutional reforms, suggesting instead the adoption of systems that leverage on 'profound' factors, through the appropriate education of young generations. Such interventions, however, must never stop: any disruption would in fact plunge society back into a state dominated by intolerance. The analysis proceeds as follows. Section 2 outlines the model or agents' preferences and associated educational choices; in Section 3 we determine the equilibrium steady state of the system by identifying its main characteristics and showing under which conditions the system enters into the *intolerance trap*; in Section 4 we analyse the economic policy implications arising from the propositions set forth in the previous sections; section 5 contains our conclusions.

2. The model

In this section, we propose an OLG model in which each individual lives for two periods, first as a child (*new agent*) and then as an adult (*older agent*). In the first period of life, the child has not yet assumed well-defined cultural traits and preferences, which are instead acquired through observation, imitation and the adoption of the cultural models that they will come into contact with.

Each child, in fact, is first subjected to the influences of the family (represented by an adult) and then to those of society. In the former case, this is about *vertical* transmission, in the latter the *oblique* transmission of cultural traits[36]. In this context, the socialization process can be interpreted as the result of an economic choice: each parent (adult) will invest resources in an effort to educate the child according to her aptitudes. The parent's educational effort is subject to a form of myopia known as 'imperfect empathy' and plays a key role in the analysis: the parent is altruistic but perceives the child's welfare through a filter of her own preferences.

The tolerant parent exercises an educational effort τ^i, which also indicates the probability with which this effort will succeed, in which case the child will assume the same preferences as the parent. Otherwise, she will remain *naive* (without well-defined preferences), and will begin to be subjected to the influences of society. That is she will become a tolerant adult with probability z_i (which indicates the portion of tolerant individuals in society) and she will become intolerant with a specular probability of $1 - z_i$.

[36] The transmission mechanism of cultural traits hypothesized in the paper is in accordance with Cavalli, and Sforza and Feldman's (1981) key studies on cultural anthropology.

The incentive for adults to influence their descendants' predisposition towards tolerance also depends on institutional factors, specifically on the expectations of how much the value of tolerance will be protected by regulations and social relations. To this end, the model hypothesizes a simple mechanism for the formation of institutions whereby norms and attitudes are affirmed, incorporating that which has been affirmed on a social level.

The social life of an individual can thus be ascribed to three environmental influences[37]:

- an *institutional environment,* in which behaviours and attitudes are governed by laws (formal rules);
- a *social environment*, which summarizes customs and traditions (informal norms), not necessarily in line with that established by law;
- an *individual environment*, represented by the individual's set of values and attitudes, the result of upbringing and social conditioning.

The three environments are closely interlinked: the generalized attitudes of individuals consolidate traditions and customs that, in turn, contribute to the formation of laws (North 1990). On the other hand, as will become clearer later on, the regulatory apparatus of a State can induce significant changes in the evolutionary dynamics of individual aptitudes, thus inverting the causality link. The tolerant individual makes a clear compromise between the different influential environments, endeavouring to create the least amount of friction between her choices and those imposed by norms and personal aptitudes. To the contrary, the intolerant individual, in making her own choices, takes into account only the values and standards pertaining to her individual sphere, not accepting any compromise with that established by the rules (formal and informal) that are inconsistent with her own principles. The ideological fundamentalism that characterizes the intolerant person leads her to assign the maximum loss of welfare to any deviation, even minimal, from her own principles and to attribute the highest satisfaction in all cases where these principles are fully respected, even if the institutional context openly condemns them[38].

As observed by Sen (2006), the fundamentalist has a strong sense of belonging to specific values and principles, which sooner or later will lead to conflict with people and institutions that do not share them, openly manifesting her intolerance.

2.1 The preferences

Economic agents are distinguished by their predisposition to tolerance. This model studies the simplest case where there are only two types of individuals: those with attitude a, the tolerant, and those with attitude b, the intolerant. Let us suppose that tolerance is measured by an index i so that $a = sup[i]$ and $b = inf[i]$ where $a = 1$ and $b = 0$.[39]

As will be made clearer later on, an individual type that has a measure of tolerance $i = a, b$ can actually manifest behaviour that is 'remote' from her own nature, i.e., declaring through her choices a tolerance level $b < j < a$ as a result of the conditions created by formal and informal rules. An individual of type $i = a, b$ can manifest her predisposition to tolerance in such a way as to maximize the following quadratic (utility) function:

$$U_i = -\left[a_{1i}\left(\theta^f - m_i\right)^2 + a_{2i}\left(\theta^{nf} - m_i\right)^2 + a_{3i}\left(i - m_i\right)^2\right] \qquad (1)$$

where $b \le m_i \le a$ indicates the declared predisposition to tolerance, $b \le \theta^f \le a$ the tolerance level of formal institutions, $b \le \theta^{nf} \le a$ the tolerance level of informal institutions and i the individual's actual predisposition to tolerance. The vector (a_{1i}, a_{2i}, a_{3i}) is indicative of the saliency that the individual assigns to the various environmental influences (institutional, social and individual), with $\sum_{j=1}^{3} a_{ji} = 1$ and $a_{ji} \ge 0$.

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[37] Many sociological studies use similar conceptualizations to those we have introduced. *See* in this regard the work of Persell, Green, and Gurevich (2001).

[38] Rather often, individuals openly demonstrate intolerance despite facing sanctions, in demonstration of how ideology prevails over evaluations of convenience.

[39] A possible objection could be that the model corresponds to a boundary (knife-edge) case in the set of possible specifications. However it is easily to show that even considering a non-degenerate case with $a<1$ and $b>0$ with $0<b<a<1$ for respectively tolerant and intolerant individuals, our main results do not change.

In distinguishing only two types of individuals, the objective function becomes:

$$U_a = -\left[a_{1a}\left(\theta^f - m_a\right)^2 + a_{2a}\left(\theta^{nf} - m_a\right)^2 + a_{3a}\left(1 - m_a\right)^2\right] \qquad (2)$$

for the tolerant individual and

$$U_b = -\left[a_{1b}\left(\theta^f - m_b\right)^2 + a_{2b}\left(\theta^{nf} - m_b\right)^2 + a_{3b}\left(0 - m_b\right)^2\right] \qquad (3)$$

for the intolerant individual[40].

The difference between a tolerant and an intolerant individual resides in the different weight they attribute to their own nature (a_{3i}) and to the institutional parameters (a_{1i}, a_{2i}).

The intolerant individual is by nature averse to the principles of sharing and socializing with people who do not have the same preferences. It is therefore reasonable to assume that she tends to indulge and manifest high levels of intolerance, even though condemned at the institutional and social level. In her decisional process, therefore, the intolerant individual attaches little weight to institutional parameters: without compromising the results of the model, it is assumed that $a_{3b} = 1$, for which the objective function is reduced to $U_b = -\left(m_b\right)^2$.

To the contrary, the tolerant individual tries to create minimal friction between her attitude and that determined by formal and informal rules. The distribution of weight will thus be less unbalanced than that of the intolerant individual, i.e. $\left(a_{1a}, a_{2a}, a_{3a}\right) >> 0$.

By maximizing the objective function, we obtain the tolerance attitude of the two types of agents:

$$\begin{aligned} m_a^* &= a_{1a}\theta^f + a_{2a}\theta^{nf} + a_{3a} \\ m_b^* &= 0 \end{aligned} \qquad (4)$$

where $0 < m_a^* \leq 1$ and $m_a^* = a = 1$ when $\theta^f = \theta^{nf} = 1$.

Now we expand the model by adding the temporal dimension and considering an overlapping generation mechanism by which parents and society transmit cultural traits to future generations.

Each agent lives two periods. In the first period, she is a child and has no specific preferences; in the second, she becomes an adult with a definitive attitude towards tolerance and chooses to manifest the attitude by maximizing her utility function.

Preferences are transmitted to the child by the parent's educational efforts (vertical transmission) and by the cultural influences of society (oblique transmission)[41]: if the child does not learn from the parent, she adopts the preferences of a randomly chosen adult. Parents want to maximize their child's future well-being, but they evaluate the welfare of their children through their own preference structure according to the hypothesis of imperfect empathy (*see* Bisin, and Verdier 2001)[42].

Empathy is the psychological process that consists in directly absorbing the emotional conditions of another person; the imperfection we attribute to this process consists in a kind of myopic behaviour of the parent who evaluates the future choices of her child without considering the child's effective preferences and exclusively referring to their own.

To formalize these concepts let us suppose at time t each adult of type i $(i = a, b)$ has a child and chooses the effort τ_t^i to educate her. This effort equates to the probability with which the child will adopt the

[40] In this first version of the model we suppose society as divided in totally tolerant and totally intolerant individuals. The dichotomy allow us an easily application of the cultural transmission mechanism introduced by Bisin-Verdier (2000) widely applied in important studies on cultural transmission of preferences (see Hauk-Marti, 2002). Further and more advanced reelaboration of the model could adopt a representation of the evolution of tolerance in the cultural formation of continuous preferences framework, which has recently been introduced by Pichler (2010).

[41] On the concepts of vertical and oblique transmission of cultural traits, see Cavalli-Sforza, (1996) and Cavalli-Sforza, Fieldman, (1981).

[42] Given that at the time of its education the child still has no precise preferences, the parent evaluates the child's future utilities through her own perspective. In other words, she will use her own utility function as if it were the child's.

parent's preferences $\left(0 \le \tau_t^i \le 1\right)$. Now, letting $P_t^{i,j}$ be the transition probability that a child of parent i is of type j and considering a tolerant adult, we can write

$$P_t^{a,a} = \tau_t^a + \left(1-\tau_t^a\right)z_t \qquad (5)$$

$$P_t^{a,b} = \left(1-\tau_t^a\right)\left(1-z_t\right) \qquad (6)$$

where z_t is the proportion of tolerant adults at time *t*. Similarly, for the intolerant adult we have

$$P_t^{b,b} = \tau_t^b + \left(1-\tau_t^b\right)\left(1-z_t\right) \qquad (7)$$

$$P_t^{b,a} = \left(1-\tau_t^b\right)z_t \qquad (8)$$

2.2 The education choice

We can now characterize the education choice following Bisin, and Verdier (1998, 2001).

A type *i* parent will choose the educational effort $\tau^i \in [0,1]$, which maximizes

$$\Gamma_i = \beta\left(P_t^{i,i}U_t^{i,i}\left(\theta^e\right) + P_t^{i,j}U_t^{i,j}\left(\theta^e\right)\right) - C\left(\tau^i\right) \qquad (9)$$

where β is the discount rate, $C\left(\tau_t^i\right)$ the cost of educational effort made by the type *i* parent which is assumed to be twice continuously differentiable, strictly convex with $C(0)=0$, $C'(0)=0$ and that for all τ $C'' > C' > 0$, and $U_t^{i,j}\left(\theta^e\right)$ the expected utility from the economic action of a type j child as perceived by a type i parent when she expects $\theta^e = [E\left(\theta^f\right), E\left(\theta^{nf}\right)]$. $U_t^{i,j}\left(\theta^e\right)$ is therefore dependent on the expectations on the future level of tolerance in formal and informal institutions.

Given the assumption of imperfect empathy, when estimating $U_t^{i,j}\left(\theta^e\right)$ the type *i* parent will apply its own utility function.

However we suppose a fundamental difference in the educational aptitude of intolerant adults. The intolerant adult will only accept the full sharing of her own values, assigning any deviation from them to a maximum loss of wellbeing. Despite the tolerance manifested by a tolerant child being $b < m_a^* \le a$, the intolerant parent will value this choice as if $m_a^* = a = 1$, thus assigning a maximum loss of wellbeing to tolerance: in fact, it can be demonstrated that $b = argmaxU_b$ and $a = argminU_b$. From these considerations we can see that, independently of expectations, for the intolerant parent it will always be $U^{bb} = 0$ and $U^{ba} = -1$.

We consider this behavior to be close to the 'fundamentalist' attitude typical of intolerant individuals.

Furthermore, given that $m_a^* > m_b^* = 0$ we get $U^{i,i}\left(\theta^e\right) > U^{i,j}\left(\theta^e\right)$ for each θ^e. That is, each parent prefers a child that adopts her own preferences.

By solving the maximization problem[43] and suppressing the time indicators, we obtain the following conditions[44]:

$$\beta\left(U^{a,a} - U^{a,b}\right)\left(1-z\right) = C'\left(\tau^a\right) \qquad (10)$$

$$\beta\left(U^{b,b} - U^{b,a}\right)z = C'\left(\tau^b\right) \qquad (11)$$

From these equations, it follows that the optimal effort level is $\tau^i = \tau^i\left(z, U^{ii} - U^{ij}\right)$, $i, j = a, b$ $i \ne j$.

[43] Note that $C(\tau)$ must be sufficiently convex so that the optimal solution is $0 < \tau < 1$.

[44] Expressions (9) - (15) are a recapitulation of results already shown in Bisin, and Verdier (2001).

Using the implicit function theorem, we get

$$\frac{\partial \tau^a}{\partial z} = -\frac{\beta\left(U^{a,a} - U^{a,b}\right)}{C''\left(\tau^a\right)} < 0 \qquad (12)$$

$$\frac{\partial \tau^b}{\partial z} = \frac{\beta\left(U^{b,b} - U^{b,a}\right)}{C''\left(\tau^b\right)} > 0 \qquad (13)$$

Given that $U^{i,i} - U^{i,j}$ depends on the expectations, the same will apply to the educational effort $\tau^i = \tau^i\left(z, U^{ii} - U^{ij}\right)$.

The educational effort of type a (tolerant agent) decreases as the proportion of tolerant agents increases. In fact, higher values of z indicate a higher probability that the child assumes the same preferences as the parent simply by socializing with a member of society; this induces the parent to reduce the educational effort. Similarly, if the proportion of tolerant agents increases, intolerant parents must intensify their educational efforts.

We can now characterize the dynamic behaviour of z_t with the following difference equation:

$$z_{t+1} = z_t P_t^{a,a} + (1 - z_t) P_t^{b,a} \qquad (14)$$

where substituting for $P_t^{a,a}$ and $P_t^{b,a}$ the dynamic equations becomes

$$z_{t+1} = z_t + z_t(1 - z_t)\left(\tau_t^a - \tau_t^b\right) \qquad (15)$$

The analysis of the dynamic equation will focus on the stable expectation hypothesis, with $U^{aa} - U^{ab}$ and $U^{bb} - U^{ba}$ constant for each *t*.

In this hypothesis this difference equation has two unstable fixed points $z = 0$ and $z = 1$, and a unique stable fixed point $z = z^*$

$$z^*\left(\theta^e\right) = \frac{U^{a,a}\left(\theta^e\right) - U^{a,b}\left(\theta^e\right)}{U^{a,a}\left(\theta^e\right) - U^{a,b}\left(\theta^e\right) + U^{b,b}\left(\theta^e\right) - U^{b,a}\left(\theta^e\right)} \qquad (16)$$

with $\tau^a = \tau^b$.

(**Proof**: *see* Appendix)

2.3 The choice of institutions

In this model we distinguish between formal and informal institutions, according to North's definition (North, 1990), and formalize the concept by using the vector $\theta = \left(\theta^f, \theta^{nf}\right)$. According to this definition, formal institutions are the political, social and economic regulations in force; they usually emerge to increase the effectiveness of habits, customs and religious traits (informal institutions) diffused in the population. We can thus suppose that informal institutions represent the level of tolerance of the prevailing type in each period. If the fraction z_t is larger than $\frac{1}{2}$, then tolerant agents are in the majority and their attitudes constitute informal institutions, and $\theta^{nf} = a = 1$. On the other hand when z_t is less than $\frac{1}{2}$, the level of θ^{nf} will be strongly affected by fundamentalist customs and $\theta^{nf} = b = 0$.

To summarize

$$\theta^{nf}(z_t)=\begin{cases} a & if \quad z_t > \frac{1}{2} \\ b & if \quad z_t \leq \frac{1}{2} \end{cases} \qquad (17)$$

The mechanism we have introduced allows us to formalize the idea that tolerant habits and beliefs spread when there is insufficient social aversion to oppose them.

On the other hand, institutions reduce the cost of individual convictions, and hence ideologies, religion and moral codes can produce very significant institutional alterations (North 1990). This consideration allows us to assume that when formal institutions evolve freely (that is, without exogenous impositions) they will tend to coincide with informal rules as time goes by, that is, for a fixed level of θ^{nf}, $\theta^{f} \to \theta^{nf}$ during a finite time *t*.

3. The steady state

We can now characterize the steady states according to the expected level of formal and informal institutions.

Lemma 1

Given an expected institutional vector θ^{e} then $\tau^{a} \gtreqless \tau^{b}$ when $z_t \lesseqgtr z^{*}\left(\theta^{e}\right)$.

(**Proof:** *see* Appendix).

Lemma 2

Each institutional combination $\theta^{e}=(i,j)$, with $b \leq i \leq a$ and $b \leq j \leq a$, generates a unique and different stable steady state $z_{i,j}=z^{*}(i,j)$ with $i=\theta^{f}$ and $j=\theta^{nf}$. However, given the assumptions on institutions, we only consider institutional situations with $\theta^{f}=a,b$ and $\theta^{nf}=a,b$; thus the following relations hold:

1. $z_{a,a}=1/2$.
2. $z_{b,b}<1/2$; $z_{b,b}<z_{ba}$; $z_{b,b}<z_{ab}$.
3. $z_{a,b}<1/2$, $z_{b,a}<1/2$, $z_{a,b} \lesseqgtr z_{b,a}$.

(**Proof:** *see* Appendix).

The stable steady state $z_{b,a}$ can be excluded from the analysis inasmuch as, given the hypothesis on the formation mechanism of institutions; tolerance is not possible on the level of informal institutions when the proportion of tolerant individuals is in the minority.

For the moment, we also exclude from the analysis the study of convergence towards the equilibrium point $z_{a,b}$, since this can be reached only with intervention on a regulatory level that imposes tolerance through formal rules. This aspect will be discussed in detail in Section 4.1, which further analyses the role of policy in the dissemination of tolerance.

Proposition 1 (intolerance trap): As Bisin, and Verdier (1998), we assume that the cost function has the quadratic form $C\left(\tau^{i}\right)=\frac{\left(\tau^{i}\right)^{2}}{2}$ [45], $z_0 \neq \{0,1\}$ and that agents have rational expectations. We further indicate with

[45] It can be easily verified that this function of cost respects all the properties hypothesized at the beginning and ensures $0 \leq \tau^{i} \leq 1$ being $0 \leq U^{ii}-U^{ij} \leq 1$.

z_{t+1}^{ij} the proportion of tolerant individuals at time $t+1$ if at time t the expectations are $\theta^e = (i, j)$ where $i = a, b$ and $j = a, b$.

Thus:

1. z_t converges to z_{bb} if $z_t < 1/2$;

2. if $z_t > 1/2$ then

2.1 z_t converges to z_{aa};

2.2 z_t converges to z_{bb} only if z_t is sufficiently close to 1/2 such that $z_{t+1}^{bb} < 1/2$.

(**Proof:** *see* Appendix).

The multiplicity of stable steady states depends on the possibility of having different institutions that are able to influence adult expectations on the future utility of their children and therefore the amount of educational effort exercised by them.

Only in one case does the educational effort of the tolerant agent exceed that of the intolerant agent i.e. when $z_t < z_{bb}$. In this case, however, the only rational expectation is (b,b) which determines the convergence to $z_{bb} < 1/2$.

In general, the equilibrium point z_{aa} or at least a proportion of tolerant individuals $z_t > 1/2$ can never be attained under the assumption of rational expectations if $z_0 < 1/2$.

The 'resistance' of the equilibrium point with intolerance is strongly linked to the fact that the intolerant individual assigns a maximum utility loss to preferences that are different from her own, i.e. $U^{ba} = -1$; for this individual the difference $U^{bb} - U^{ba}$ that determines her educational effort τ^b is always maximum. Only a sufficiently low value of z_t, i.e. $(z_t < z_{bb})$ can guarantee that $\tau^a > \tau^b$. In all other cases, the educational effort of the intolerant individual tends to prevail, trapping the system in a state where the proportion of tolerant individuals can at most be equal to the proportion of intolerant individuals $(z_t \le z_{aa} = 1/2)$[46]. This consideration is far from absurd when you consider that in reality the fundamentalist attitude of intolerant individuals leads them to strongly defend their positions (that is, to exert considerable educational efforts to conserve their ideas), even in social contexts where tolerance seems to be a custom, and this would explain why intolerance is so persistent.

Nevertheless, even in a best-case scenario, with the equilibrium proportion of tolerant individuals equal to $z_{aa} = 1/2$, a resumption of convergence towards the 'bad' steady state is still possible. In this situation, any expectation $(i, j) \neq (a, a)$ would provoke an immediate reduction of the proportion of tolerant individuals with $z_{t+1}^{ij} < 1/2$. The expectation will be confirmed given that $\forall (i, j) \neq (a, a)$ $z_{ij} < 1/2$ and the system will start to converge again towards z_{bb}.

This phenomenon is also possible due to the proportion of tolerant individuals being above 1/2, provided that the pessimistic expectations (b,b) or (a,b) are able to bring that proportion, as early as in the next period, to below 1/2.

A high tolerance steady state is fragile. A change in expectations is enough to take the system back to bad equilibrium. Once the proportion of tolerant individuals has become the minority, the system is no longer able to re-converge towards the 'good' equilibrium, not even in the presence of positive expectations since these will never be confirmed.

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[46] If we were to also permit the intolerant individual to assign positive weights to the institutional dimension (i.e., $a_{3b} < 1$) we would have $z_{aa} = \frac{1}{1 + a_{3b}^2} > 1/2$ i.e., an increase in the share of tolerant individuals in equilibrium. That affirmed in proposition 1 would still be valid. However, in this case the system could converge to z_{aa} if $z_{t+1}^{aa} > 1/2$ even with $z_t < 1/2$.

4. Policy implications

As demonstrated in Proposition 1, under the hypothesis of rational expectations the steady state to which the system converges depends on the initial proportion of tolerant agents. Moreover, under appropriate hypotheses, society is unable by itself to exit from the 'intolerance trap'; if $z_t < 1/2$, the proportion of tolerant agents remain a minority even in the future.

The model suggests two possible policy measures aimed at increasing the proportion of tolerant agents in the population:

1. introduction of formal rules that penalize intolerant behaviour;
2. educational development of the younger generations.

With the first measure, the steady state becomes $z_{ab} > z_{bb}$ giving rise to an increase in the proportion of tolerant agents in equilibrium.

In fact, we hypothesize a majority share of intolerant individuals characterize the system, $z_t < 1/2$, and that the government announces an institutional reform imposing tolerance for the subsequent periods. This measure will apply only to formal institutions so that agents' expectations will be $\theta^e = (a,b)$ from then onwards, and z_t will converge to $z_{ab} > z_{bb}$. Given that $z_{ab} < 1/2$, intolerant individuals will nevertheless remain in the majority; the action was unable to change the preferences of society enough so that, although sanctioned by law, intolerance will continue to be practiced by the majority of individuals. The system will converge again to z_{bb} as soon as the legislation in favour of tolerance is withdrawn. This type of intervention is not very effective in the long term. Tolerance, in fact, is the result of a cultural process whose evolution involves several generations. It is therefore unreasonable to think of influencing the nature and preferences of individuals through legal provisions that contrast the customs that are prevalent in society.

The second measure consists in the institutions' direct efforts in educating new generations in tolerance.

We have thus far considered the possibility of modifying a society's predisposition to tolerance through regulatory action imposing tolerant behaviour. However, these interventions do not significantly condition the educational process that regulates the transmission of preferences.

In this regard, it is appropriate to evaluate the effect of government policies aimed at spreading tolerance through the educational system. This type of policy, unlike the preceding, has a direct impact on the processes of preference transmission, inasmuch as the government's efforts are integrated with the educational efforts of parents.

Following Hauk-Marti (2002) we hypothesize that when the parent's educational effort is unsuccessful, there is a probability ρ that the individual becomes tolerant thanks to the education received in schools. If even this is unsuccessful in defining the preferences of the individual, then she will assume the preferences of a subject chosen randomly from the population.

The transition probabilities thus become:

$$P_t^{a,a} = \tau_t^a + (1-\tau_t^a)(z_t(1-\rho)+\rho) \qquad (18)$$

$$P_t^{a,b} = (1-\tau_t^a)(1-z_t)(1-\rho) \qquad (19)$$

$$P_t^{b,b} = \tau_t^b + (1-\tau_t^b)(1-\rho)(1-z_t) \qquad (20)$$

$$P_t^{b,a} = (1-\tau_t^b)(z_t(1-\rho)+\rho) \qquad (21)$$

generating the following dynamic equation:

$$z_{t+1} - z_t = (1-z_t)\{z_t(1-\rho)(\tau_t^a - \tau_t^b) + (1-\tau_t^b)\rho\} \qquad (22)$$

The stable steady states are $z=1$ and $z=0$ if $\rho=0$.

If an internal equilibrium exists, then $\tau^b > \tau^a$.

With $\rho=1$ the system converges to 1. Thus, due to continuity, there must be $0<\rho<1$ such that $z_{t+1}-z_t>0$ for any $z<1$.

More precisely, $z_{t+1}-z_t>0$ if $\rho > \dfrac{z_t\left(\tau^b-\tau^a\right)}{1+z_t\left(\tau^b-\tau^a\right)-\tau^b} \equiv \Omega$.

Immediately verifying that $\partial\Omega/\partial z_t > 0$ and that for $z_t=1$, $\Omega=\tau^b(1)$. So it is sufficient that the government exercises an educational effort $\rho > \tau^b(1)$ so have a growing proportion of tolerant individuals[47].

The educational effort towards tolerance exercised by the government must never cease, even when $z_t > 1/2$. The discontinuity ($\rho=0$) would make the system converges (at best) to z_{aa} where we have already witnessed that a worsening of expectations would plunge the system back towards intolerance.

The lesson is that tolerance can spread in society only if governments agree on permanent dissemination through direct interventions in the educational processes of new generations. Schools at every level, information, politics and religious institutions must be vigilant and continually educate on tolerance. The social system cannot autonomously guarantee, i.e. relying only on the role of families, the stable establishment of tolerance as a consolidated and permanent principle over time.

5. Conclusion

Building on recent efforts on the evolutionary dynamics of fundamentalism and cultural transmission, the present paper concentrates on issues relating to the formation and stability of attitudes towards tolerance and intolerance. The dynamic equation of the model demonstrates that a degenerate distribution of the population (whereby agents are all tolerant or all intolerant) is dynamically unstable. Moreover, under some conditions and for a specific institutional asset a unique non-degenerate stationary distribution exists (in which both tolerance and intolerance co-exist in the population), and this distribution is locally stable.

Finally, we studied the dependence of the population dynamics on institutional changes and policy interventions showing that tolerance cannot be disseminated through formal rules but require that authorities act directly on the educational processes of new generations. In this sense, it is recommended that the government carries out an educational effort through schools in an attempt to predispose young people towards tolerance. Furthermore, intolerance is a persistent attitude; it can not be totally ruled out from society and tends to reemerge also in social contexts that are characterized by a widespread respect for diversity as soon as the public educational commitment (mainly through schools) stops being sufficiently effective.

However, the assumption that the different predispositions to tolerance do not have effect on the economic opportunities of agents is somewhat limited. Further developments of the model should remove this assumption, in order to apply the analysis to contexts where agents belonging to different social groups interact not only in relation to cultural conditioning but also in real and actual business transactions.

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APPENDIX

The proofs we develop in this section follow the same methodology used by Hauk-Marti (2002).

Considering the dynamic equation of population $z_{t+1} = z_t + z_t(1-z_t)(\tau_t^a - \tau_t^b)$; we note that it has three rest points: i) $z=0$, ii) $z=1$ and iii) $z=z^*$ with $\tau^a = \tau^b$.

Deriving the dynamic equation with respect to z_t we obtain

$$\frac{\partial z_{t+1}}{\partial z_t} = 1 + (1-2z_t)(\tau^a - \tau^b) + z_t(1-z_t)\left(\frac{\partial \tau^a}{\partial z_t} - \frac{\partial \tau^b}{\partial z_t}\right).$$

Then

$$\left.\frac{\partial z_{t+1}}{\partial z_t}\right|_{z_t=0} = 1+\tau^a > 1 \text{ given that } (z_t=0) \Rightarrow (\tau^b = 0)$$

$$\left.\frac{\partial z_{t+1}}{\partial z_t}\right|_{z_t=1} = 1+(-1)(-\tau^b) > 1 \text{ given that } (z_t=1) \Rightarrow (\tau^a = 0)$$

then points $z=0$ and $z=1$ are not stable.

To evaluate the stability of point $z^*(\theta^e)$, rewrite the derivative of the dynamic equation as

$$\frac{\partial z_{t+1}}{\partial z_t} = 1 + (1-2z_t)(\tau^a - \tau^b) + z_t(1-z_t)\left(\frac{-\beta\Delta^a}{C''(\tau^a)} - \frac{\beta\Delta^b}{C''(\tau^b)}\right)$$

given $\Delta^a = \dfrac{C'(\tau^a)}{\beta(1-z)}$ e $\Delta^b = \dfrac{C'(\tau^b)}{\beta z}$;

thus

$$\frac{\partial z_{t+1}}{\partial z_t} = 1 + (1-2z_t)(\tau^a - \tau^b) + \left(z_t\frac{-C'(\tau^a)}{C''(\tau^a)} - (1-z_t)\frac{C'(\tau^b)}{C''(\tau^b)}\right).$$

Evaluating this derivative in $z_t = z^*$, i.e. considering $\tau^a = \tau^b$ and given $C' < C'' \ \forall \tau$ we have

$$\left.\frac{\partial z_{t+1}}{\partial z_t}\right|_{z_t=z^*} = 1 - \left(\frac{C'(\tau)}{C''(\tau)}\right) \in (0,1)$$

and conclude that $z_t = z^*$ is asymptotically stable. ■

Lemma 1: Given that $U^{aa}(\theta^e) > U^{ab}(\theta^e)$ and $U^{bb}(\theta^e) > U^{ba}(\theta^e)$, by the first order condition of the parent maximization problem, each type of agent chooses a positive educational effort, $\tau^a > 0$ and $\tau^b > 0$.

To obtain point $z^*(\theta^e)$ we have to consider that $\tau^1 > \tau^2$ implies $C'(\tau^a) > C'(\tau^b)$. Thus $\beta(\Delta^a)(1-z) > \beta(\Delta^b)z$ and hence $z < \dfrac{\Delta^a}{\Delta^a - \Delta^b}$, with $\Delta^i = U^{i,i}(\theta^e) - U^{i,j}(\theta^e)$, $i,j = a,b$ and $i \neq j$.■

Lemma 2: Let $m_{h,k}^i$ be the tolerance shown by an individual of type *i* when the tolerance at institutional level is $\theta^f = t_h$ and $\theta^{nf} = t_k$; let $U_{h,k}^{i,j}$ be the expected utility that a parent of type i associates with a type *j* child, being the expectation $\theta^f = t_h$ and $\theta^{nf} = t_k$.

Maximization of the utility function gives the following:

- for type t_a: $m_{aa}^a = 1$; $m_{ab}^a = 1-a_2$; $m_{ba}^a = 1-a_1$; $m_{bb}^a = a_3$.
- for type t_b: $m^b = 0 \ \forall \theta^e$.

from which, given the assumption of imperfect empathy, we obtain:

for type t_a:

$U_{aa}^{aa}=0$	$U_{aa}^{ab}=-1$
$U_{ab}^{aa}=-a_2(1-a_2)$	$U_{ab}^{ab}=-(1-a_2)$
$U_{ba}^{aa}=-a_1(1-a_1)$	$U_{ba}^{ab}=-(1-a_1)$
$U_{bb}^{aa}=-a_3(1-a_3)$	$U_{bb}^{ab}=-a_3$

for type t_b:

$U^{bb}=0$ and $U^{ba}=-1 \ \forall\theta^e$

We can now obtain the value of the different stationary points shown in lemma 2:

$$z_{aa}=\frac{1}{2},$$
$$z_{bb}=\frac{a_3^2}{a_3^2+1},$$
$$z_{ab}=\frac{(1-a_2)^2}{(1-a_2)^2+1},$$
$$z_{ba}=\frac{(1-a_1)^2}{(1-a_1)^2+1}$$

and given these, proving points 1) 2) and 3) of Lemma 2 is straightforward. ■

Proposition 1

From the assumption of proposition 1, we can verify $z_{aa}=1/2$ and $\partial z_{t+1}/\partial z_t>0 \ \ \forall z_t\in(0,1)$. This latter condition ensures that the convergence occurs without oscillations around the equilibrium point. Thus:

1. if $z_t<1/2$ and $z_{t+1}<1/2 \ \ \forall\theta^e$ and the only rational expectations are $\theta^e=(b,b)$; from lemma 1 z_t converges to z_{bb}.

2. if $z_t>1/2$ then:

a. expectations $\theta^e=(a,a)$ are always rational since $\forall z_t>1/2$, we have $z_{t+1}^{aa}>1/2$. From lemma 1 z_t converges to z_{aa}.

b. There is a $\bar{z}>1/2$ such that if $1/2\le z_t<\bar{z}$ then $z_{t+1}^{bb}<1/2$, to thus verify the expectations $\theta^e=(b,b)$.

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