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THE ECONOMICS OF CULTURAL TRANSMISSION AND SOCIALIZATION

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We have collaborated on the study of cultural transmission for more than a decade, while socializing our own children. Many have helped and encouraged us over the years, many more than we can thank here. We owe special thanks however to D. Acemoglu, A. Alesina, G.S. Becker, J. Benhabib, L.L. Cavalli Sforza, P.A. Chiappori, E. Glaeser, E. Ok, A. Postlewaite, J.A. Scheinkman and to our co-authors on this topic, J. Olivier, E. Patacchini, M. Thoenig, G. Topa, Y. Zenou. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

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ABSTRACT

Cultural transmission arguably plays an important role in the determination of many fundamental preference traits (e.g., discounting, risk aversion and altruism) and most cultural traits, social norms, and ideological tenets (e.g., attitudes towards family and fertility practices, and attitudes in the job market). It is, however, the pervasive evidence of the resilience of ethnic and religious traits across generations that motivates a large fraction of the theoretical and empirical literature on cultural transmission. This article reviews the main contributions of models of cultural transmission, from theoretical and empirical perspectives. It presents their implications regarding the long-run population dynamics of cultural traits and cultural heterogeneity, the world's geographical fragmentation by ethic and religious traits, at any given time. Finally, the paper reviews the empirical literature which estimates various properties of cultural transmission mechanisms as well as the population dynamics of specific traits.

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1 Introduction

Preferences, beliefs, and norms that govern human behaviour are partly formed as the result of heritable genetic traits, and partly transmitted through generations and acquired by learning and other forms of social interaction. As a consequence cultural transmission is an object of study of several social sciences, such as evolutionary anthropology, sociology, social psychology, and economics. In this paper we define culture to represent those components of preferences, social norms, and ideological attitudes which

> depend upon the capacity for learning and transmitting knowledge to succeeding generations. *Merriam Webster'sonline dictionary.*

Cultural transmission arguably plays an important role in the determination of many fundamental preference traits, like discounting, risk aversion and altruism.[1] It certainly plays a central role in the formation of cultural traits, social norms, and ideological tenets, like e.g., attitudes towards family and fertility practices, and attitudes in the job market. Relatedly, distinct cultural traits determine how individuals interpret and react to common (e.g., strategic) choice environment.[2] It is, however, the pervasive evidence of the resilience of ethnic and religious traits across generations that motivates a large fraction of the theoretical and empirical literature on cultural transmission. In the U.S., for instance, persistent ethnic and religious differentiation in what social scientists until the 1960s expected to turn into a 'melting pot', are very well documented. In fact, immigrants all over the world generally strive to maintain various traits of the culture of the country of origin. Several ethnic and religious communities in the U.S., e.g., Orthodox Jews, even observed a *cultural renaissance* after being declared *endangered*. Outside the United States, Basques, Catalans, Corsicans, and Irish Catholics in Europe, Quebecois in Canada, and Jews of the diaspora have all remained strongly attached to their languages and cultural traits even through the formation of political states which

[1] The decomposition of the cultural (or environmental) and genetic effects on cognitive and psychological traits is the object of a large literature, typically referred to as *nature/nurture*, which spans from behavioral genetics to the social sciences. Sacerdote (2010), in this *Handbook*, surveys this literature. The role of evolutionary selection in the formation of preferences is surveyed by Robson and Samuelson (2010) for this *Handbook*.

[2] See e.g., Henrich, Boyd, Bowles, Camerer, Fehr, and Gintis (2004) for cooperative behavior in 15 small scale societies; Cameron, Chauduri, Erkal, and Gangadharan (2009) for a corruption game in Melbourne, Delhi, Jakarta, Singapore. In this *Handbook*, Fernandez (2010) surveys the *does-culture-matter?* literature in detail.

did not recognize ethnic and religious diversity. Similarly, e.g., in Africa, various forms of tribal distinction persisted and even thrived after the creation of overarching national institutions. Finally, various measures of social capital display very long-run histeresis, of the order of hundreds of years: historical events like the constitution of free-city-state in the Middle Ages, the quality of political institutions in the nineteenth century Europe, the slave trade in West Africa, Ottoman domination, all have effects which seem to persist up until the present.

In this paper we concentrate on intergenerational transmission of culture. We conceptualize cultural transmission as the result of interactions between purposeful socialization decisions inside the family ('direct vertical socialization') and other socialization processes like social imitation and learning which govern identity formation ('oblique and horizontal socialization'). Cultural traits are then endogenous in this context. But how to think about agents who choose their children's and/or their own preferences? Is it even logically consistent to think of agents choosing their own preferences? Which preference order applies to this choice? George Stigler and Gary Becker's famed *De gustibus non est disputandum* paper addresses some of this methodological questions. They favor postulating identical meta-preferences ordering each agent actual preferences. This methodological standpoint has generated a rich and interesting literature and several important applications; see Becker (1996) and Becker and Murphy (2000) for book-length surveys. On the other hand, by restricting the determinants of heterogeous preferences across agents to differences in the technologies which constrain preference choices, this class of models is at a loss e.g., to deal with cultural transmission. How to explain, for instance the widespread observation of purposeful actions by parents to limit their children integration into extraneous dominant cultures? In turn, these models can hardly produce the resilience of ethnic and religious traits we tend to observe.

Bisin and Verdier, in a series of papers, deviating from identical meta-preferences, introduce a fundamental friction in parental altruism, *imperfect empathy,* which is sufficient to sustain a theory of cultural transmission by biasing parents towards their own cultural traits. More specifically, *imperfect empathy* requires that while parents are altruistic with respect to their children, they evaluate their choice using their own (the parents' - not the children's) preferences. For instance, religious parents care about the social and economic success of their children, but would regret their having to accept secular norms and attitudes to achieve it. These models of cultural transmission have implications regarding the determinants of the persistence of cultural traits and

more generally regarding the population dynamics of cultural traits. The persistence of cultural traits or, conversely, the cultural assimilation of minorities, is determined by the costs and benefits of various family decisions pertaining to the socialization of children in specific socio-economic environments, which in turn determine the children's opportunities for social imitation and learning.

This article reviews the main contributions of models of cultural transmission, from theoretical and empirical perspectives. It presents their implications regarding the long-run population dynamics of cultural traits, and discusses the links between the economic and other approaches to cultural evolution in the social sciences as well as in evolutionary biology. Furthermore, it discusses extending the economic theory of cultural transmission to the analysis of several important aspects of the dynamics and propagation of beliefs and values.

2 Theoretical studies

The first formal theoretical contributions to modeling of cultural transmission are due to Cavalli-Sforza and Feldman (1981) and to Boyd and Richerson (1985), who apply models of evolutionary biology to the transmission of cultural traits. Their analysis contains a simple elegant stylized model of the cultural transmissionmechanism, together with a clear terminology, which are extensively adopted by most of the subsequent literature.

Consider a *dichotomous cultural trait* in the population, $\{a, b\}$. Let the fraction of individuals with trait $i \in \{a, b\}$ be q^i. *Reproduction* is *a-sexual* and each parent has one child. Cultural transmission is the result of *direct vertical* (parental) socialization and *horizontal/oblique socialization* in society at large.[3] More specifically,

i) direct vertical socialization to the parent's trait, say i, occurs with probability d^i;

ii) if a child from a family with trait i is not directly socialized, which occurs with probability $1 - d^i$, he/she is horizontally/obliquely socialized by picking the trait of a role model chosen randomly in the population (i.e., he/she picks trait i with probability q^i and trait $j \neq i$ with probability $q^j = 1 - q^i$).

[3] *Horizontal* socialization refers to socialization resulting from interactions between members of the children population, while *vertical* socialization is due to interactions between children and members of their parents' population. This distinction turns out to be relatively unimportant in the literature.

The cultural transmission mechasnism introduced by Cavalli Sforza and Feldman (1981) is then summarily represented by the following system of equations for P^{ij}, the probability that a child from a family with trait i is socialized to trait j:

$$\begin{aligned} P^{ii} &= d^i + (1-d^i)q^i \\ P^{ij} &= (1-d^i)(1-q^i) \end{aligned} \tag{1}$$

Bisin and Verdier (2000, 2001) introduce parental socialization choice in Cavalli Sforza and Feldman (1981)'s model. As a consequence, direct socialization probabilities, d^i, d^j, are endogenously determined. Parental socialization choice is motivated by *imperfect empathy*, that is a form of altruism biased towards the parents' own cultural traits: parents care about their children's choices, but they evaluate them using their own (the parents' - not the children's) preferences.

More specifically, let X denote an abstract choice set, comprising all choices relevant to an individual's economic and social life. Cultural traits are represented by preferences: each individual (parent or child) chooses $x \in X$ to maximize $u^i : X \to \Re$, for cultural trait $i \in \{a, b\}$. Let V^{ij} denote the utility to a cultural trait i parent of a type j child, $i, j \in \{a, b\}$. Then

Imperfect Empathy: For all i, j, $V^{ij} = u^i(x^j)$, *where* $x^j =$ $argmax_{x \in X}\ u^j(x)$.[4]

As long as V^{ii}, V^{ij} are independent of q^i, imperfect empathy implies $V^{ii} \geq V^{ij}$, with $>$ for generic preferences $u^i(x)$, $u^j(x)$. More generally, when individuals interact socially, V^{ii}, V^{ij} will be a function of q^i. This case is studied in Section 2.4.

When $V^{ii} \geq V^{ij}$ parents have an incentive to socialize their children to their own cultural trait. But socialization requires parental resources, e.g., time spent with children, private school tuition, church contribution, and so on. Let $C(d^i)$ denote socialization costs, where d^i is the probability of direct socialization of parents with trait i to the i trait. The value of parental socialization choice is then represented by:

$$W^i(q^i) = \max_{d^i \in [0,1]} -C(d^i) + P^{ii}V^{ii}(q^i) + P^{ij}V^{ij}(q^i), \quad \text{s. t. 1), and 2)}\ .^5$$

Assuming for simplicity quadratic socialization costs, $C(d^i) = \frac{1}{2}\left(d^i\right)^2$, we obtain

$$d^i = d(q^i, \Delta V^i) = (1-q^i)\Delta V^i, \tag{2}$$

where $\Delta V^i = V^{ii} - V^{ij}$ measures the relative value of child with the same cultural trait as the parents; we refer to ΔV^i as the *cultural intolerance* of trait i.

[4] To avoid trivial cases, we assume $x^a \neq x^b$.

[5] The socialization choice of parents is independent of their choice of $x \in X$. This is due to preference separability.

2.1 Population dynamics

Consider first Cavalli Sforza and Feldman (1981). The system of equations (1) for P^{ij}, the probability that a child from a family with trait i is socialized to trait j, imply the following dynamics of the fraction of the population with trait i, in the continuous time limit:

$$\dot{q}^i = q^i(1-q^i)\left(d^i - d^j\right). \tag{3}$$

Equation (3) is a simple version of the replicator dynamics in evolutionary biology for a two-trait population dynamic model. Formally, it is a *logistic differential equation.* If $(d^i - d^j) > 0$ cultural transmission represents a selection mechanism in favor of trait i, due to its differential vertical socialization. This selective mechanism is all the more powerful (i.e., the speed of selection is higher) when there is enough variation in the population, which is captured by the term $q^i(1-q^i)$, reflecting the variance of types in the population. We say that the stationary state of the population dynamics q^{i*} is *culturally homogeneous* if either $q^{i*} = 0$ or $q^{i*} = 1$. We say instead that q^{i*} is *culturally heterogeneous* if $0 < q^{i*} < 1$. Let $q^i(t, q_0^i)$ denote the solution path of the differential equation which describes the population dynamics, so that $q^i(t, q_0^i)$ is the value of q^i at time t when, at time $t = 0$, q^i takes the value q_0^i.

A first obvious result coming from (3), as in Cavalli Sforza and Feldman (1981), is the following:

Suppose (d^i, d^j) are exogenous and $d^i > d^j$.[6] *In this case, the stationary states of the population dynamics are culturally homogeneous. Moreover, $q^i(t, q_0^i) \to 1$, for any $q_0^i \in (0, 1]$. If instead $d^i = d^j$, $q^i(t, q_0^i) = q_0^i$, for any $t \geq 0$.*

In other words, the selective mechanism of cultural transmission, as modeled by Cavalli Sforza and Feldman (1981), can hardly explain the observed resilience of cultural traits(except in the knife hedge non-generic case in which $d^i = d^j$). Boyd and Richerson (1985) extend Cavalli Sforza and Feldman (1981)'s analysis to allow for frequency dependent direct socialization probabilities:

$$d^i = d(q^i),\ d^j = d(1-q^i),$$

generating more interesting and complex population dynamics. But in Boyd-Richerson (1985), while direct socialization probabilities are frequency dependent, they are nonetheless exogenous.[7]

[6] Obviously, the case $d^j > d^i$ is symmetric, as i and j are arbitrary.

[7] There is a lively interesting literature in anthropology and biology which studies cultural transmis-

Economic models of cultural transmission also predict frequency dependent socialization probabilities, but purposeful parental socialization decisions restrict the class of consistent frequency dependent socialization.The dynamics of the fraction of the population with cultural trait i is then determined by equation (3), evaluated at $d^i = d(q^i, \Delta V^i)$, $d^j = d(1 - q^i, \Delta V^j)$ as in (2):

Suppose (d^i, d^j) *are endogenously determined as* in equation (2). *The stationary states of the population dynamics are* $(0, 1, q^{i*})$, *where* q^{i*} *is culturally heterogeneous. Moreover, the culturally heterogeneous stationary state is globally stable, that is,* $q^i(t, q_0^i) \to q^{i*}$, *for any* $q_0^i \in (0, 1)$.

The economic model of cultural transmission in Bisin and Verdier (2001) predicts then cultural heterogeneity and is therefore consistent with the observed resilience of cultural traits. But how general is this result? What does explain culturally heterogeneity?

2.1.1 Cultural heterogeneity

Intuitively, cultural heterogeneity might obtain when parents belonging to a cultural minority face relatively higher incentives to socialize their children to their own trait. Formally, this is the case socialization mechanisms satisfy the following property.

Cultural substitution: for any $\Delta V^i > 0$, $d^i(q^i, \Delta V^i)$ *is a continuous, strictly decreasing function in* q^i, *and, moreover,* $d^i(1, \Delta V^i) = 0$.

Symmetrically, when direct vertical transmission acts as a *cultural substitute* to oblique transmission, parents have less incentives to socialize their children the more widely dominant are their values in the population. In the limit of a perfectly homogenous populations of type i, parents of type i do not directly socialize their children. As a consequence the socialization pattern moves the system away from full homogeneity: $q^i = 0$ and $q^i = 1$ are locally unstable stationary states of (3), and the basin of attraction of the unique steady state associated to heterogeneous population, q^{i*}, is the full interval $(0, 1)$. Bisin and Verdier (2001) show the following:

Cultural heterogeneity obtains generally whenever direct vertical socialization is a substitute to oblique/horizontal socialization.

When $d^i(q^i, \Delta V^i)$ is instead increasing in q^i, socialization efforts of parents of type

sion as the outcome of exogenous evolutionary rules. While we do not discuss this literature in detail as it exudes from our purposes, we refer the reader to e.g., Henrich (2001), Gallo, Barra, and Contucci (2009), and Enquist, Ghirlanda, Eriksson (2010).

i are typically larger the more frequent their trait in the population. Direct vertical and oblique transmissions are linked in some degree by cultural complementarity in this case. Strong enough forms of cultural complementarity can drive the dynamics of the distribution of the traits in the population towards homogeneity.

We illustrate the role of cultural substitution versus complementarity in the population dynamics of cultural traits with two examples of different socialization mechanisms from Bisin and Verdier (2001).

Cultural substitution example: It's the family. Suppose children are exposed simultaneously to their parent's trait, say i, and to the trait of an individual picked at random from a restricted population, composed of a fraction τ_2^i of agents with trait i (the population of neighbors, friends, school peers, and teachers). The parent's direct socialization effort is denoted $\tau_1^i \in [0,1]$, and controls the children's internalization of the parent's trait. If the two traits match (i.e., if the child internalizes his parent trait, i, and the trait of the individual in the restricted population is also i), then the child is socialized to trait i. Otherwise, with probability $(1-\tau_1^i\tau_2^i)$, the child picks a trait from the population as a whole. The probability that a child of a type i father is directly socialized (by exposure to the parent and to the restricted pool) is then:

$$d^i = \tau_1^i \tau_2^i$$

Suppose both the direct socialization effort, $\tau_1^i \in [0,1]$, and the segregation effort, $\tau_2^i \in [0,1]$, are chosen by parents. If preferences and socialization costs satisfy some regularity assumptions (see Bisin and Verdier, 2001), direct vertical and oblique transmission are substitutes for such transmission mechanisms and the long run state of the population dynamics is culturally heterogeneous.

Cultural complementarity example: It takes a village. Suppose children are first exposed simultaneously to the parent's trait and to the trait of a role model from the population with which he/she is matched randomly. If the parent and the role model are culturally homogeneous, the child is directly socialized to their common trait, otherwise the child is matched a second time randomly with a role model from the population, and adopts his/her trait. Vertical and oblique transmission are not cultural substitutes in this example. With quadratic socialization costs, in this case,

$$d(q^i, \Delta V^i) = (q^i)^2(1-q^i)\Delta V^i.$$

This socialization effort is clearly non monotonic in q^i and exhibits a range of q^i for

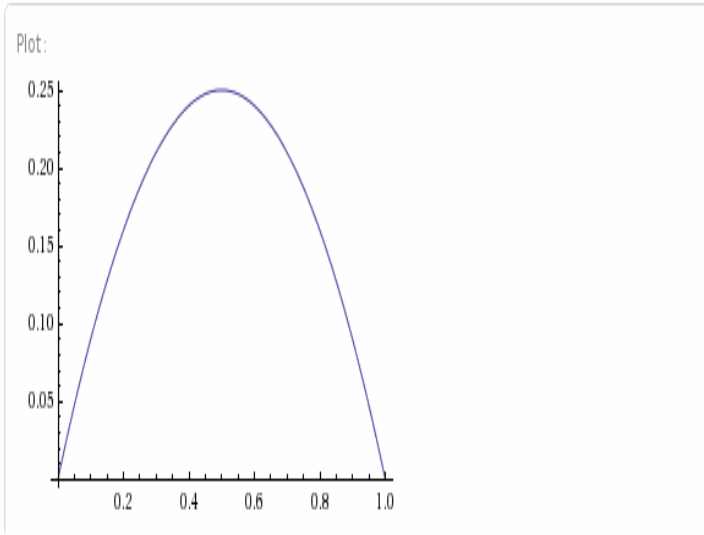


Figure 1: Dynamics with cultural substitution in Cavalli Sforza and Feldman (1981): $\dot{q}^i$ as a funcion of q^i.

which there is cultural complementary[8].

A simple analysis of the population dynamics implies that

$$q^i(t, q_0^i) \to 0, \ \textit{for any } q_0^i \in [0, q^{i*});$$
$$q^i(t, q_0^i) \to 1, \ \textit{for any } q_0^i \in (q^{i*}, 1], \ \textit{for } 0 < q^{i*} < 1.$$

and that the stationary state of the population dynamics is culturally homogeneous.

Summarizing, the economic cultural transmission model in Bisin-Verdier (2000, 2001) allows for population dynamics of the distribution of cultural traits which converge to an heterogeneous distribution, which can be therefore providing an explanation of the observed resilience of e.g., ethnic and religious traits. This is the case, in particular, when direct and oblique socialization mechanisms are culturally substitutes. Figures 1 and 2 illustrate the starkly different population dynamics in the leading models in Cavalli Sforza-Feldman (1981) and in Bisin-Verdier (2000, 2001):

2.2 Socialization mechanisms

The cultural transmission model we described abstracts from many important details regarding socialization mechanisms. Direct socialization probabilities are the results of

[8] Indeed $\frac{\partial d(q^i, \Delta V^i)}{\partial q^i} \gtreqless 0$ as $q^i \lesseqgtr \frac{2}{3}$.

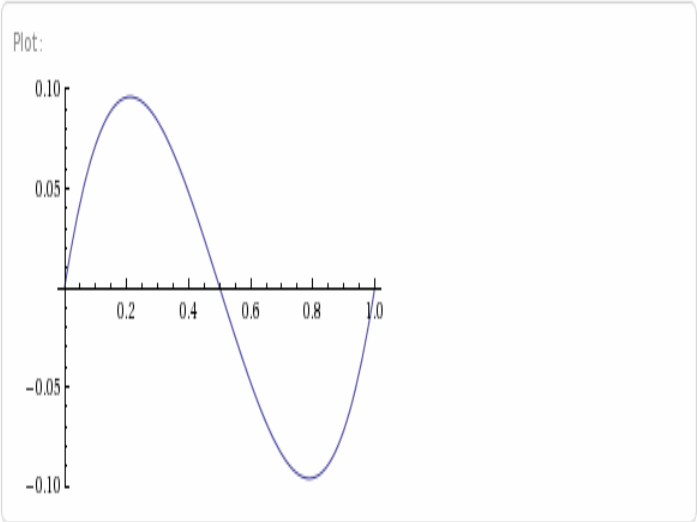


Figure 2: Dynamics with cultural substitution in Bisin and Verdier (2001): $\dot{q}^i$ as a funcion of q^i.

several different effort choices of parents, e.g., in terms of time and resources dedicated to their children. But socialization effort is more effective e.g., when the parents in the family share the cultural trait to socialize the children to, when teachers in school, other adults and the children peers all reinforce the socialization effort of parents. Socialization is a fundamental family activity and as such it might motivate individuals to prefer homogamous marriages (along relevant cultural traits) and particular fertility patterns. It also might motivate families to the consideration of various cultural aspects when choosing schools for their childern, when choosing the neighborhood where they reside in, when choosing with civil and social organizations they are member of, and so on. More generally, parental socialization requires the active participation of the children themselves, who ultimately form their identities and preferences in the social environment they interact with. This in turn motivates parents to pro-actively intervene in shaping their children social environment, once again through the choice of schools, neighborhood, peers, and so on.

In this section we survey the theoretical contributions to the cultural transmission literature whose main focus is to expand the analysis to consider several different socialization mechanisms.

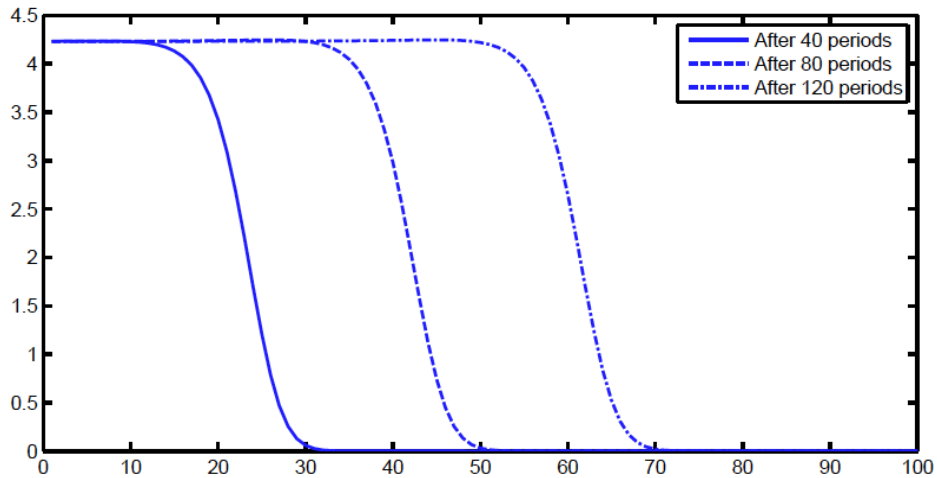


Figure 3: Stationary constant traveling wave: Each curve represents the wave at a time t, with the variable l on the x-axis

2.2.1 Geographic spread

Cultural traits diffuse geographically, e.g., because the population carrying the trait moves, typically while expanding economically or militarily. Let l denote the distance (e.g., the radial distance in two dimensions) from an initial location. Let $q(l,t)$ denote the fraction of agents of type i at location l. Rendine, Piazza, and Cavalli Sforza (1986), extending the cultural transmission model to geographic diffusion (in the continuous time approximation) obtain the following partial differential equation

$$\frac{\partial q^i}{\partial t} = q^i(1-q^i)(d^i - d^j) + m\frac{\partial^2 q^i}{\partial l^2} \tag{4}$$

where m is the diffusion coefficient. This equation, known in evolutionary genetics as Fisher-Kolmogorov equation, has a constant traveling wave solution

$$q^i(l,t) = w^i(l - \alpha t)$$

which is monotonic and satisfies $\lim_{z\to-\infty} w^i(z) = 1$ and $\lim_{z\to\infty} w^i(z) = 0$. Figure 3 illustrates the dynamics associated to a stationary constant traveling wave, for $m = .001$ and $d^i - d^j$ equal to .5.

Furthermore, for any initial condition $q^i(l,0)$ satisfying regularity conditions which

appear natural in this context,[9] $q^i(l,t)$ evolves to a travelling wave with speed $\alpha = 2\sqrt{(d^i - d^j)m}$.This asymptotic solution can be accurately approximated as

$$w^i(z) \approx \frac{1}{1+e^{\frac{z}{\alpha}}};$$

see Murray (1989), p. 283.

The geographical spread model assumes diffusion on the part of only population i and, most importantly, it assumes away any interaction between the two populations. These extensions are possible, though an analytic characterization of the resulting dynamics has yet to be derived.[10] Suppose at any location l at time t live two interacting populations, characterized by their distinct cultural traits, a, b. Let their density be denoted, respectively, $Q^a(l,t)$ and $Q^b(l,t)$ respectively.[11] Suppose population Q^a diffuses geographically, while population Q^b does not. Furthermore, assume the populations interact socially, at any location l. The result of such interactions is the adoption of trait Q^a on the part of individuals of type Q^b at an instantaneous rate proportional to $Q^a(l,t) \cdot Q^b(l,t)$. Finally, suppose that the highest sustainable population density at any location l and time t are, respectively, P^a and P^b. Under these assumptions, the dynamic population equations (in the continuous time approximation) are a version of the Lotka-Volterra equation for interaction geographically structured populations,[12]

$$\begin{aligned} \frac{\partial Q^a}{\partial t} &= \alpha_a Q^a(1 - \frac{Q^a}{P_a}) + \gamma Q^a Q^b + m\frac{\partial^2 Q^a}{\partial l^2} \\ \frac{\partial Q^b}{\partial t} &= \alpha_b Q^b(1 - \frac{Q^b}{P_b}) - \gamma Q^a Q^b \end{aligned} \tag{LV}$$

To the best of our knowledge nobody has studied the cultural transmission model with geographic diffusion when $d^i - d^j$ is a function of q^i, as in the economic model. Based on the analysis of Murray (1989), ch. 11.5 (especially p.304), we conjecture existence and stability (for appropriate initial conditions) to a monotonic travelling wave $w^i(z)$ such

[9] The condition are the following:

$$q^i(l,0) \geq 0 \text{ and continuous in } l, \;\; q^i(l,0) = \begin{cases} 1 \text{ if } l \leq l_1 \\ 0 \;\text{ if }\; l \geq l_2 \end{cases} \quad \text{for some } l_1 < l_2.$$

For speed of advance $\alpha = \frac{5}{\sqrt{6}}\sqrt{(d^i - d^j)m}$ the solution $w(z)$ can be obtained analytically.

[10] See Aoki et al. (1996) for numerical solutions.

[11] Clearly,

$$q^i(l,t) = \frac{Q^i(l,t)}{Q^a(l,t) + Q^b(l,t)}, \quad i = a, b.$$

[12] For an introduction to these reaction-diffusion systems, see Murray (1989), ch. 12, 14,15.

that $\lim_{t\to\infty} w^i(z) = q^{i*}$, $0 < q^{i*} < 1$. Similarly, nobody has studied the Lotka-Volterra model with endogeneous $\alpha_a, \alpha_b, m, \gamma$.

2.2.2 Homogamous marriages

Marriages are formed in the marriage market anticipating their role in the direct socialization of children. Bisin and Verdier (2000) study a marriage market in which homogamous marriages (that is, marriages in which spouses share the same cultural trait) are valued because they are more effective socialization mechanism. The simplest model is developed under the extreme assumption that only homogamous marriages are endowed with a direct socialization technology. In this case, the expected utility of child of for a type i parent in an heterogamous marriage, not endowed with a direct socialization technology, is simply

$$W^{i,Het}(q^i) = q^i V^{ii} + (1 - q^i)V^{ij}.$$

The corresponding expected utility for a type i parent in an homogamous marriage,

$$W^{i,Hom}(q^i) = \max_{\tau^i} [d^i + (1 - d^i)q^i]V^{ii} + (1 - d^i)(1 - q^i)V^{ij}] - C(d^i),$$

depends on the parent's socialization choice. As a consequence, the option to socialize children provided by homogamous marriages is valued by individuals in the marriage market:

$$W^{i,Hom}(q^i) - W^{i,Het}(q^i) \geq 0.$$

The marriage market is then modeled to allow each individual to affect the probability to be married homogamously. Suppose the marriage market contains a restricted pool in which marriages, if they occur, are homogamous (churches, ethnic clubs, and various other cultural institutions may serve this purpose). An individual of trait i can enter the restricted pool and marries homogamously with probability α^i, which is chosen at a cost $H(\alpha^i)$. With probability $1 - \alpha^i$ the individual enters instead a common pool, composed of all individuals who have not been matched in marriage in their own restricted pools, and is married there with a random match. Let A^i be the fraction of individuals of type i who are matched in their restricted pool. The probability of homogamous marriage of an individual of type i is given by

$$\pi^i(\alpha^i, A^i, A^j, q^i) = \alpha^i + (1 - \alpha^i)\frac{(1 - A^i)q^i}{(1 - A^i)q^i + (1 - A^j)(1 - q^i)}. \tag{5}$$

An individual with trait i chooses $\alpha^i \in [0,1]$, for given A^i, A^j,q^i, to maximize

$$\pi^i(\alpha^i, A^i, A^j, q^i)\left[W^{i,Hom}(q^i) - W^{i,Het}(q^i)\right] - H(\alpha^i). \tag{6}$$

The maximization of (6) for each agent of type i provides an optimal α^i as a function of A^i, A^j and q^i. Under convexity and regularity assumptions, Bisin and Verdier (2000) show the existence of a unique symmetric Nash equilibrium of the marriage game, where all individuals of type i choose the same marital segregation effort $\alpha^i = \alpha^i(q^i)$ and $A^i = \alpha^i(q^i)$. At equilibrium, the probability of homogamous marriage for agents of type i is then $\pi^i(q^i) = \pi^i(\alpha^i(q^i), \alpha^i(q^i), \alpha^j(q^j), q^i)$. The population dynamics, in turn, are:

$$\dot{q}^i = q^i(1-q^i)\left(d^i\pi^i - d^j\pi^j\right), \tag{7}$$

evaluated at $d^i = d^i(q^i)$ and $\pi^i = \pi^i(q^i)$. The selective forces for cultural transmission, therefore, account for the differential "effective" efforts of vertical transmission, $d^i\pi^i$, which reflect the fact that only homogamous marriage can successsfully bias the transmission of their cultural trait.

Bisin and Verdier (2000) show that at equilibrium, when homogamous marriages act as a socialization mechanism, cultural substitution applies to this "effective" vertical cultural transmission $d^i\pi^i$:

For any $0 < q^i < 1$ and for $i \in \{a, b\}$, in equilibrium, i) the probability of matching in the restricted pool for agents of type i, $\alpha^i(q^i)$, and the direct socialization probability of homogamous families of type i, $d^i(q^i)$, are strictly positive; ii) the homogamy rate of the population of type i is greater than the homogamy rate associated with random matching, $\pi^i(q^i) > q^i$; and iii) the probability of successful socialization for a family of type i is greater than the oblique socialization rate, $P^{ii}(q^i) > q^i$. Furthermore, iv) $\alpha^i(q^i)$ and $d^i(q^i)$ are decreasing in the fraction of the population with trait i, q^i.

As a consequence, the population dynamics of the trait distribution, when homogamous marriages act as a socialization mechanism, induce a stationary distribution which is culturally heterogeneous:

The culturally homogeneous stationary states of the population dynamics, $(0,1)$, are locally unstable. There always exists a culturally heterogeneous stationary state, q^{i*}, which is locally stable, that is, such that $q^i(t, q_0^i) \to q^{i*}$, for any q_0^i in an appropriate neighborhood of q^{i*}.[13]

[13] If the culturally heterogeneous stationary state q^{i*} is unique, $q^i(t, q_0^i) \to q^{i*}$, globally, for $q_0^i \in (0,1)$.

In summary, in an environment in which individuals search for homogamous marriages for their benefits in terms of socialization, the cultural substitution properties of socialization mechanisms are preserved.

2.2.3 Fertility

Fertility, as an endogenous choice of parents, also interacts with socialization, if for no other reason that socialization costs naturally incvrease with the number of children to socialize. Consider for instance the cultural transmission model, extended to allow for parental choice of reproductive pattern. Let $N^i \geq 0$ denote the number of children chosen by parents with trait i, at cost $c(N^i)$. To better illustrate the effects of endogenous fertility, consider the extreme case in which direct socialization is exogenous. In this case, parents of type i then choose $n^i \geq 0$ to maximize:

$$-c(N^i) + N^i(P^{ii}V^{ii} + P^{ij}V^{ij}),$$

where $P^{ii}V^{ii} + P^{ij}V^{ij}$ can be interpreted as the expected *quality* of one child,[14] and is independent of N^i. It follows then that the parents of a cultural majority will choose relatively high fertility rates, since in this case their children are of high expected quality, that is, they will inherit their trait with high probability. The choice of reproduction patterns, as a consequence, will tend to introduce cultural complementarity in the socialization mechanism: $N^i(q^i)$ will tend to be increasing.

But more generally, fertility will interact with direct socialization, at least because total socialization costs increase with the number of children, and hence parents, when choosing direct children socialization, incur a classic quantity/quality (of children) trade off. Assuming for simplicity socialization costs are linear in N^i, parents of type i choose $d^i \in [0,1]$, and $N^i \geq 0$ to maximize:

$$-c(N^i) - N^i C(d^i) + N^i(P^{ii}V^{ii} + P^{ij}V^{ij}) \tag{8}$$

where P^{ii} and P^{ij} are as in (1). The dynamics of the distribution of traits in the population is then determined by

$$\dot{q}^i = q^i(1-q^i)\left(d^i n^i - d^j n^j\right),$$

where $n^i = \frac{N^i}{N^i+N^j}$ and d^i are determined at equilibrium. Bisin-Verdier (2001) show that, under some regularity conditions, with endogenous fertility:

[14] See Becker and Lewis (1973) for this terminology.

The stationary states of the population dynamics are $(0, 1, q^{i*})$*, where* q^{i*} *is culturally heterogeneous. Moreover, the culturally heterogeneous stationary state is globally stable, that is,* $q^i(t, q_0^i) \to q^{i*}$*, for any* $q_0^i \in (0, 1)$*.*

In other words, the quantity/quality trade-off is sufficient to re-establish the dynamics associated to cultural substitution, over-riding the cultural complementarity due to endogenous fertility.

2.2.4 Self-segregation

The socialization model we introduced interacts direct vertical transmission in the family with oblique transmission, in society at large: if a child not directly socialized, he/she picks the trait by random matching in society at large (i.e., trait i with probability q^i and trait j with probability $q^j = 1 - q^i$). More generally, however, the cultural composition of society is at least partly under the control of parents: they in fact choose schools, neighborhood, peers, and so on. Abstracting from details, the transmission probabilities could be more generally written as,

$$\begin{aligned} P^{ii} &= d^i + (1 - d^i)Q^i \\ P^{ij} &= (1 - d^i)(1 - Q^i), \end{aligned} \tag{9}$$

where the composition of the social environment of the child, Q^i, could be specified as a function of the population share q^i and a costly parental intervention, say s^i. Examples of a model along these lines are Bisin-Verdier (2001; Section 2.2.2, *Do not talk to strangers*) and Saez Marti and Sjogren (2008).

2.2.5 Identity formation

While parents directly make various socialization choices to influence the preference formation of their children, vertical socialization is nonetheless in general limited by the children's role in forming their own cultural *identity*. An interesting literature in economics is rapidly emerging, stirred by the contribution of Akerlof and Kranton (2000).[15] This literature evolved with particular emphasis on the formation of oppositional identities, namely situations where minority individuals adopt cultural categorizations and prescriptions defined in opposition to the categorizations and prescriptions of the mainstream group. Akerlof and Kranton (2000) discuss how a student's primary motivation

[15] See also Akerlof and Kranton (2010).

is his or her identity and the quality of a school depends on how students fit in a school's social setting. Austen-Smith and Fryer (2005) focus on the tension faced by individuals between signalling their type to the outside labor market and signalling their type to their peers: signals that induce high wages can be signals that induce peer rejection. Relatedly, Battu, Mwale and Zenou (2007) show that some ethnic minorities may reject the majority's norms of behavior even if this implies a penalty in the labor market.[16]

More generally, the study of ethnic identity formation has a long theoretical and empirical tradition in social sciences with Cross (1991), Phinney (1990), Ferdman (1995) in developmental psychology, Stryker (1980) in symbolic interactionist sociology, Tajfel (1981), Tajfel and Turner (1979), Turner et al. (1987) in social psychology, and Brewer (2001) in political psychology. Abstracting from many specific details, two opposing views characterize the theoretical analysis of identity formation in the social sciences. A first group of social scientists argues that ethnic identity is reduced by assimilation and contact across cultures.[17] Underlying this reasoning is the basic principle that group identity is driven by a motive for inclusiveness and *cultural conformity*. The alternative view considers that ethnic minorities are motivated in keeping their own distinctive cultural heritage to generate a sense of positive *distinctiveness* from individuals who are part of that group.[18] According to this view, the group identity formation is motivated by a *cultural distinction* mechanism that allows individuals to reduce the psychological costs associated with cultural differences.[19]

When identity formation is characterized by cultural distinction, social interactions across groups might induce the formation of stronger oppositional identities on the part of minorities. An interesting example is Darity, Mason and Stewart (2006). They study a formal model of the relationship between wealth accumulation and racial identity to evaluate the persistence of racial identity as a social norm. More precisely, they consider a large population of agents divided into two groups distinct by a racial characteristic

[16] See also, for instance, Cook and Ludwig (1997), Ferguson (2001), Fryer (2004), Fryer and Torelli (2005), Patacchini and Zenou (2006).

[17] *Assimilation theories*, in political science and sociology (Gordon, 1964; Moghaddam and Solliday 1991), *contact theory* in social psychology (Allport, 1954) are the prominent theories of this line of thought.

[18] These ideas have been expressed by the theories of *multiculturalism* (Glazer and Moynihan, 1970; Taylor and Lambert, 1996), and *conflict* (Bobo, 1999).At a broader level, this view is also related to the *social identity theory* in social psychology (Tajfel, 1981; Turner, 1982; and Abrams and Hogg, 1988).

[19] *Cultural distinction*, as defined here, is a property of individual preferences. It is related but distinct from *cultural substitution* (see Section 2), which is a property of socialization mechanisms.

(e.g., colour of skin, shape of eyes, etc..) that cannot be changed by deliberate choice. Individuals however differentiate themselves also along an endogenous dimension, their racial identity. *Individualists* attempt to live a race-free life, even though their exogenous social group characteristic is in fact observable. *Racialists*, on the other hand, chooses to identify strongly with their social group. In each time period, individuals are randomly matched in pairs and interact in socio-economic activities. Agents' productivity in this interaction depends on the mutual compatibility of their identities. Racialists are altruistic toward members of their own social group, but antagonistic toward members of the other group. Individualists, on the other hand, are neither altruistic nor antagonistic toward any agent they interact with, socially. Within each social group, the division between individualists and racialists evolves endogenously. The population frequencies evolve in response to average payoffs by category, according to a standard replicator dynamics. The paper provides conditions on intra-group and inter-group interactions, matching parameters, and population initial conditions, such that a racialist or individualist identity norm dominates in each group.

The replicator dynamics mechanism of identity formation is exogenously assumed in Darity, Mason and Steward (2006). Bisin, Patacchini, Verdier, and Zenou (2010) model instead the economics of identity formation, along the lines of the cultural transmission literature. Also, they they offer an explicit formal definition of cultural distinction and complementarity to develop their different implications regarding identity formation. Consider for simplicity the case of a child socialized to a minority cultural trait, i. Minority individuals have psychological costs $C(I^i, q^i)$ of interacting with the majority that depend both on identity I^i and the fraction q^i of individuals of group i in the neighborhood. These psychological costs can be reduced by identity formation I^i.

More precisely, consider that identity I^i can take two possible discrete values (i.e., $I^i \in \{0, 1\}$). The intensity υ^i with which a cultural trait i is adopted by children is then simply the probability of acquiring the minority identity (after successful parental socialization), $\upsilon^i = prob\{I^i = 1\}$, and it is modeled as a choice of the agent. The utility cost of developing identity υ^i, $J(\upsilon^i)$ is increasing and convex, in the same units of the psychological costs $C(I^i, q^i)$.

The psychological costs of interactions can only be felt by individuals that do not acquire a strong ethnic identity (i.e., in the case $I = 0$). Formally $C(I^i, q^i)$ takes the simple form:

$$C(I^i, q^i) = (1 - I^i)c(1 - q^i).$$

The two polar cases, cultural distinction and cultural conformity, are then simply captured as follows:
Cultural distinction: $c(1-q^i)$ *is increasing in the proportion of the majority* $1-q^i$.
Cultural conformity: $c(1-q^i)$ *is decreasing in* $1-q^i$.

The identity formation choice of an individual has then different properties in the two cases. In particular, Bisin, Patacchini, Verdier, and Zenou (2010) show that:
The distinctive characteristics of cultural distinction is that identity υ^i *is decreasing in* q^i, *for* q^i *large enough.*

Bisin, Patacchini, Verdier and Zenou (2009) extends the theoretical analysis of this paper by studying explicitely interacting cultural transmission and identity formation. They also draw the population dynamics implications of the model and show that both cultural substitution and cultural distinction induce resilience and persistence of minoritarian traits. More specifically, in Bisin, Patacchini, Verdier and Zenou (2009), after being socialized to a particular trait (directly or indirectly), the intensity with which an individual identifies to that trait (i.e., his cultural *identity*) is his personal choice, that is, it is not transmitted by the family. Choosing the intensity of an identity is conceptualized as a form of cultural distinction. Specifically, parents decide how much to invest in socializing their children to their own ethnic trait anticipating the possible peer effects favoring assimilation and their children's future identity choice. Formally, the optimal parental transmisssion effort d^i and child identity intensity effort υ^i are the solution of the following problem :

$$\max_{\nu,d} \; -P^{ii}(d,q^i)(1-\upsilon^i)c(1-q^i) - \left[1-P^{ii}(d,q^i)\right]c(1-q^i) - H(d) - J(\upsilon^i)$$

with $P^{ii}(d,q^i)$ given by (1).

As a result, the identity of an individual turns out to notably depend on the ethnic composition of the neighborhood in which he is raised and his personal negative experiences related to ethnicity. The prevalence of an oppositional culture in the minority group can be sustained if and only if there is enough cultural segmentation in terms of role models, the size of minority group is large enough, the degree of oppositional identity it implies is high enough, and the socio-economic opportunity cost of the actions it prescribes is small enough. The model also identifies sufficient conditions on economic fundamentals such that ethnic identity and socialization effort are more intense in mixed rather than in segregated neighborhoods.[20]

[20] Finally the model also allows for attitudes of the majority group, e.g., racism, which might induce

2.3 Multidimensional cultural traits

The cultural transmission model we described only refers to a single dichotomous cultural traits, abstracting from several interesting issues related to the cultural space. In fact cultural traits are often multidimensional. For instance a religious trait is composed of common ethical values and common preferences along many dimensions, from food to art. Religious traits also come in different forms, one for each reference religious denomination. Furthermore, cultural traits can in general be adopted with different intensity along different dimension. E.g., an individual can share most values of the Catholic church while feeling unease with the mandate for priests' celibacy.

While the model of cultural transmission has not been extended to account for several of these richer cultural spaces, the case of cultural traits taking many different forms has been exhaustively studied by Montgomery (2009).[21] When the leading model of economic cultural transmission is extended to a N traits, the population dynamics is

$$\dot{q}^i = q^i \left(d^i - \sum_{j=1}^{N} d^j q^j \right)$$
$$d^i = \sum_{j=1}^{N} q^j \Delta V^{ij},$$

where $\sum_{j=1}^{N} q_j = 1$ and $\Delta V^{ij} = V^{ii} - V^{ij}$.[22] While Montgomery (2009) studies more general environments, it is pedagogically convenient to restrict the analysis to the symmetric case, where $\Delta V^i j = \Delta V^i k$, $\forall j, k \neq i$, and hence traits can be ranked in terms of their cultural intolerance. Abusing notation, we let then $\Delta V^i j \equiv \Delta V^i$ and, without loss of generality, we order traits so that

$$\Delta V^1 \geq \Delta V^2 \geq \ldots \geq \Delta V^N.$$

its reaction to forms of oppositional identity of the minority. As it turns out, racism by the majority and minority integration present natural complementarities that may give rise to social multiplier effects and/or multiple social steady state equilibria.

[21] See also Bisin-Topa-Verdier (2009); but Montgomery (2009)'s results are stronger.

[22] In a more recognizable matrix form:

$$\dot{\mathbf{q}} = diag\left(\mathbf{q}\right) \ \left(\mathbf{\Delta q} - \mathbf{q}'\mathbf{\Delta q}\right),$$

where $\mathbf{q} = \begin{bmatrix} \\ q^i \end{bmatrix}$ and $\mathbf{\Delta} = \begin{bmatrix} \\ \Delta V^{ij} \\ \\ \end{bmatrix}$.

Let F_k denote a k-dimensional subsets of $\{1, \ldots, N\}$. We say that a stationary distribution supports F_k, and we denote it $q(F_k)$, if it is contained in the appropriate simplex:

$$q(F_k) \in \{q \in S^N \ \mid \ q^i = 0, \text{ for } i \notin F_k\}.$$

A cultural group i is not supported by a stationary state if it is not intolerant enough relatively to the other groups:

A stationary distribution which supports F_k exists iff

$$\Delta V^i > [k-1]G^{F_k}, \ \forall i \in F_k \tag{10}$$

where $\frac{1}{G^{F_k}} \equiv \sum_{i \in F_k} \frac{1}{\Delta V^i}$.

G^{F_k} can be in fact considered a measure of the cultural intolerance of the traits belonging to F_k; e.g., if $\Delta V^i = \Delta V$ for all $i \in F_k$, $G^{F_k} = \frac{\Delta V}{k}$.

Montgomery (2009), exploiting techniques developed for the *replicator dynamics* in evolutionary game theory, proves that culturally heterogeneous stationary distributions tend to be supported in the N-trait case as well:

Any culturally homogeneous distribution, $q(F_1)$ is locally unstable. Furthermore, the stationary distribution $q(F_{k^*})$, where F_{k^*} is the largest subset of cultural groups $\{1, \ldots, N\}$ which is supported by a stationary distribution, is globally stable.[23]

A simple corollary of this result is that,

If

$$\sum_{i=1}^{N} \frac{1}{\Delta V^i} > \frac{N-1}{Min_i\{\Delta V^i\}}, \tag{Symmetry}$$

there is a unique globally stable stationary state $q(F_N)$.

Note that this condition is stricter for larger N: in the limit, for $N \to \infty$, it requires symmetric preferences across cultural groups: ΔV^i independent of i. This corollary then identifies symmetry of the parents' preferences for children as a factor which facilitates the stability of heterogeneous stationary distributions of traits in the population.

So far only cultural transmission models with a discrete number of traits were presented. There is however a well established tradition in evolutionary biology and anthropology to consider continuous traits models of cultural transmission. These models postulate a dynamics of cultural traits which is driven by exogenous linear mixing; see e.g., Cavalli-Sforza (1973), Otto, Christiansen and Feldman (1994). More specifically, let $B^i(t)$ denote the value of trait i associated to a representative individual at time t; and let . Formally, $B^i(t)$ is a stochastic process whose dynamics is governed by

[23] Since $\Delta V^1 > \Delta V^2 > \ldots > \Delta V^N$, $F_k = \{1, \ldots, k\}$.

$$\dot{B}^i = (1 - d^i)\left(\bar{B} - B^i\right) + \varepsilon^i$$

where ε^i is an independently and identically distributed random shock with zero mean and constant variance σ; and d^i is an exogenous parameter which represents the speed of adjustment of the process to its the mean. More complex and interesting models along these lines are discussed in Boyd and Richerson (1985).

Extending the analysis to the case of of endogenous cultural transmission is a non-trivial exercise. Keeping track of the time evolution of the mean and the variance of the distribution of continuous traits, a central insight of these approaches is to derive conditions for the long term persistence of cultural variation in the population. Bisin and Topa (2003) suggest a model of endogenous transmission in a continuous trait setting which assumes that the value of the trait of a child of type i, B^i is constructed as a weighted average between a target value B^{*i} and the mean value of the trait in the population $\overline{B}$,

$$\dot{B}^i = (1 - d^i)\left(\overline{B} - B^{*i}\right) + \varepsilon^i$$

As in the discrete trait model, parents could spend effort to isolate the influence of friends, peers, and society at large on their children's value of the trait, that is, by choosing d^i, which is then interpreted as the direct vertical socialization choice of parents and is assumed costly (with cost $C\left(d^i\right) = \frac{1}{2}(d^i)^2$, for simplicity). Socialization preferences would depend on the context. For instance, suppose agents of type i consider the trait favorably (i.e., parents like their children to possess the trait in the highest expected value). Parents of type i would then maximize utility by solving

$$\max_{d^i} \; E\left(B^i\right) - C(d^i)$$
$$s.t. \; \dot{B}^i = (1 - d^i)\left(\overline{B} - B^{*i}\right) + \varepsilon^i$$

The solution of the problem is $d^i = (B^{*i} - \overline{B})$, and parental socialization effort satisfy a form of *cultural substitution*: it declines with the influence of the social environment as captured by the mean value of trait in the population, $\overline{B}$. The target B^{*i} might for instance correspond to the maximum possible value of the trait given the family characteristics of type i. Suppose, by means of illustration, that the target value B^{*i} is directly related to the cultural trait value of the parent:

$$B^{*i} = aB^i, \quad a > 0.$$

This could be the case, e.g., if parents had a limited or costly technology to set the socialization target based on their own cultural trait value, B^i.

Interesting socialization preferences in this context are studied by Pichler (2009), who lets parents explicitly choose also the socialization target B^{*i}.[24] As an illustration, consider the following special case of Pichler (2009)'s model. Assume parents of type i face a disutility which increases in the distance between the value of the trait of their children, B^i, and the socialization target they set. Assume also that socialization costs are higher the larger the distance between the target and the parents' own trait value, and quadratic for simplicity, $C\left(d^i, B^{*i} - B^i\right) = \frac{1}{2}\left(B^{*i} - B^i\right)^2 + \frac{1}{2}\left(d^i\right)^2$. Fixing exogenously d^i, the parental socialization problem is

$$\max_{B^{*i}} -\frac{1}{2}E\left(B^i - B^{*i}\right)^2 - C\left(d^i, \left(B^{*i} - B^i\right)\right)$$
$$s.t.\ \dot{B}^i = \left(1 - d^i\right)\left(\overline{B} - B^{*i}\right) + \varepsilon^i$$

and, B^{*i} is a weigthed average of B^i and $\overline{B}$. As a consequence, once again, cultural substitution obtains. This is the case also when direct socialization d^i is chosen optimally by parents.

In either Bisin and Topa (2003) and Pichler (2010), the dynamics of B^i is characterized by a non-linear stochastic different equation with a (global) interaction term, $\overline{B}$, of the form

$$\dot{B}^i = f(B^i, \overline{B}) + \varepsilon^i,$$

for some map f. Conditions for existence and uniqueness of a long - non degenerate ergodic distribution in cultural traits can be obtained. Results on ergodicity for stochastic processes in this class, with (local and global) interactions have been obtained, e.g., by Follmer and Horst (2001) and Horst and Scheinkman (2006).[25]

In the simple case of Bisin and Topa (2003), for example, the inter-generational dynamics of the trait is characterized by the following stochastic non linear dynamic difference equation:

$$B^i_{t+1} = \left(aB^i_t - \overline{B}_t\right)\left(aB^i_t - \overline{B}_t\right) + \overline{B}_t + \epsilon^i_t.$$

and the study of ergodicity requires tracking the evolution of $\overline{B}_t$ as well as of the variance,

[24] Along these lines is also the work in progress of Panebianco (2010) and Vaughan (2010).

[25] More generally, for stochastic stability and ergodicity of non-linear stochastic difference equations, see the classic treatment in Meyn and Tweedie (2009).

of B_t^i.[26]

The previous models are specific in many dimensions. It would be important to extend this approach to more general structures of cultural traits and processes of cultural transmission.

2.4 Cultural transmission and social interactions

In the cultural transmission models we described so far, parental socialization depends on the parents' relative value of child with the same cultural trait as theirs, ΔV^i, which we referred to as the *cultural intolerance* of trait i. In fact the ΔV^i's have been treated as exogenous preference parameters in the theoretical work we have surveyed up to this point. In many contexts of interest, however, this is too restrictive an assumption. The endogeneity of ΔV^i can originate in many different environments. For instance, when individuals interact on markets,their indirect utility may depend on economic variables such as prices and incomes or policy outcomes that depend on the type of society and therefore the distribution of cultural traits that prevails in such society. Similarly, in strategic and matching interactions contexts, the payoffs that an individual may obtain is likely to be influenced by the distribution of cultural traits in the population. In all these situations, it reasonable to expect cultural intolerance, ΔV^i, to be endogenous.

While the implications of the endogeneity of ΔV^i for socialization and population dynamics need be derived case-by-case, a reduced form analysis is however useful, to clarify what to look for in the examples. Suppose for instance that each individual (parent or child) chooses $x \in X$ to maximize $u^i(x, q^i)$, for $i \in \{a, b\}$ so that, under *imperfect empathy*, direct parental socialization for types i depends on $\Delta V^i(q^i) = u^i(x^i, q^i) - u^i(x^j, q^i)$. The first fundamental implication of the endogeneity of ΔV^i is the following:
When cultural intolerance ΔV^i depends on q^i, imperfect empathy does not necessarily imply that $\Delta V^i(q^i) \geq 0$.
In fact, socialization to the parents' trait might put the children at a disadvantage in the child social environment, represented by q^i. While *imperfect empathy* is manifested as a preference on the part of parents for sharing their cultural traits with their children, such a preference depends on the economic and social conditions which parents expect for their children. Different economic and social conditions could in principle lead parents

[26] Tahbaz-Salehi and Karahan (2008) study a dynamic process determined by preferences for assortative marriages along cultural lines and cultural transmission as averaging across parents. Not surprising melting pot is a possible stationary state in this model.

to socialize their children to a trait different than their own.

Furthermore, when cultural intolerance is endogenous, the dynamic system for the evolution of cultural traits can be written as:

$$\dot{q}^i = q^i(1-q^i)\left[d(q^i, \Delta V^i(q^i)) - d(q^j, \Delta V^j(q^j))\right]$$

While *cultural substitution* is still sufficient to guarantee population dynamics which converge to cultural heterogeneity, an additional assumption on $\Delta V^i(q^i)$ is necessary to produce direct socialization maps $d^i(q^i)$ satisfying cultural substitution:

Strategic substitution: The social environment is characterized by strategic substitution if,

$$\frac{\partial}{\partial q^i}\Delta V^i(q^i) < 0.$$

It is easy to see then that, if direct and oblique socialization mechanisms are culturally substitutes then:

In a social environment characterized by strategic substitution, the stationary states of the population dynamics are $(0, 1, q^{i*})$*, where* $0 < q^{i*} < 1$*. Moreover,* $q^i(t, q_0^i) \to q^{i*}$*, globally, for any* $q_0^i \in (0, 1)$*.*

Strategic substitution guarantees that cultural minorities will face relatively larger gains from socialization, independently of the socialization mechanism. In the case of strategic complementarity, on the contrary, cultural minorities face smaller (even possibly negative) socialization gains. Depending on the strength of cultural substitution, therefore, in this case minorities might or might not assimilate culturally to the majority.

Strategic substitution example: Preferences for status. An example of strategic substitution is the case of preferences for social status studied by Bisin and Verdier (1998). Suppose the expenditures on conspicuous consumption necessary to achieve a given level of social status increase with the fraction of individuals in the population who care about status. In this case the socialization gains to preferences for status are higher the smaller is the fraction of the population sharing these preferences. In this context therefore, strategic substitution obtains and hence socialization mechanisms will tend to satisfy cultural substitution.

Strategic complementarity example: Corruption. An interesting example of strategic complementarity, albeit only for a subset of parameter values, is represented by Hauk and Saez Marti (2000)'s study of the cultural transmission of ethical values regarding corruption. Honest and potentially dishonest agents interact. Each agent is randomly matched to a principal, who in turn assigns him/her to either a project with a high

payoff to the principal if the agent is honest, but more conducive to corrupt behavior, or to a safe project whose payoff is low but independent of corruption. Furthermore, the principal can, at a cost, acquire a signal on the values of the agent he/she is matched to. In this environment, a parent's intolerance towards different values regarding corruption will depend on the strategy of principals in the population, e.g., acquiring the signal and separating project assignments or pooling all agents into the same project. The strategy of principals, in turn depends on the distribution of values in the population of agents. Let σ^p denote the pooling strategy to associate the safe project to all agents and σ^s the separating strategy of offering the high payoff project to all agents who have been signaled as honest. Let also i denote honest agents. Hauk and Saez Marti (2000) show that, under particular assumptions about the role of honesty and corruption in the agents' payoffs from strategic interactions, each principal's optimal strategyinvolves acquiring the signal and separating project assignments when honest agents are a large enough fraction of the population:

$$\sigma(q^i) = \begin{cases} \sigma^s & \text{if } q^i > q^* \\ \{\sigma^s, \sigma^p\} & \text{if } q^i = q^* \\ \sigma^p & \text{if } q^i < q^* \end{cases}$$

Since honest agents have higher payoff on average when principals choose the separating strategy, the socio-economic interaction in this environment is essentially one of *cultural complementarity*, and the population dynamics is biased away from cultural heterogeneity: under specific assumptions, Hauk and Saez Marti' (2000) find two locally stable distributions of the population, one corresponding to low corruption and the other to high corruption.

Several papers explore the transmission of various distinct cultural traits along the lines of this section: developing a model of the specific socio-economic interaction of interest, obtaining a reduced form for $\Delta V^i(q^i)$, applying the cultural transmission model to study the population dynamics.[27] A non-exhaustive list include: Olcina and Penarrubia (2004) for other-regarding preferences in hold-up contexts; Escriche, Olcina, and Sánchez (2004) for family-related preferences and gender labor market discrrimination; Francois

[27] Some other papers also investigate cultural transmission without the imperfect empathy assumption. See for instance Lindbeck and Nyberg (2006) for the transmission of work norms and social insurance, Epstein (2006) for transmission of extremism; Kuran and Sandholm (2008) for cultural hybridization, Corneo and Jeanne (2009) for a theory of tolerance formation, Dessi (2008) and Adriani.and Sonderegger (2009) for information-based theory of intergenerational transmission of values.

(2002), Francois and Zabojnik (2005) and Estrella López (2003) for social capital; Saez-Marti and Zenou (2005) and Senik and Verdier (2007) for work values and ethnic labor market discrimination; Francois (2006) and Bidner and Francois (2009),for the evolution of informal institutions; Frot (2008) for cultural transmission through friendship formation; Hiller (2008a) for preferences for autonomy and work organization; Hiller (2008b) for pro-social preferences and corporate culture; Baudin (2008) for fertility; Ponthiere (2008) for lifestyles transmission and longevity; Melindi Ghidi (2009) for political ideology; Correani, Di Dio, and Garofalo (2009) for tolerance; Frot (2009) and Michaud (2008) for work values and social/unemployment insurance. We cannot discuss them in any detail, for obvious space limitations. We chose to select instead a few papers which focus on general important themes regarding the interactions of cultural transmission with trade, institutions, and collective action mechanisms.

2.4.1 Cultural transmission and trade

An interesting class of models studies strategic substitution in the context of trade models where standard *Walrasian price effects* obtain on demand. Theanalysis of these models is mostly relevant, for instance, in the case of international trade of e.g., ethnic goods. The following simple 2×2 exchange economy illustrates the argument. Suppose agents have all the same endowment vector $\omega = (\omega_l)_{l=1,2}$, differing instead in their preferences over the two goods: agents of type $i = 1$ do prefer good 1 (resp. good 2) more (less) than agents of type $i = 2$. For instance, assume agents i have well behaved preferences $u^i(x_1, x_2)$ such that, $\forall x_1, x_2$,

$$\frac{\partial u^1(x_1, x_2)}{\partial x_1} > \frac{\partial u^2(x_1, x_2)}{dx_1}, \quad \frac{\partial u^2(x_1, x_2)}{\partial x_2} > \frac{\partial u^1(x_1, x_2)}{dx_2}.$$

Under these assumptions, it is straightforward to show that strategic substitution obtains: the larger the fraction q^i of individuals with preference trait i, the larger the total demand and the market clearing price for good i, the smaller the cultural intolerance of parents ofg type i.

The market clearing relative priceof good 1, p, will be determined by the market clearing condition:

$$z(p) = q^1 x_1^1(p) + (1 - q^1) x_1^2(p) - \omega_1 = 0, \tag{11}$$

where $z(p)$ is the total excess demand for good 1 in the economy and $x_1^i(p)$ is the individual i's demand function for good 1. From equation (11) it is clear that the

price p is a function $p(q^1)$. Indeed, given that individuals of type 1 do prefer good 1, $p(q^1)$ will, under general robust conditions, be an increasing function of q^1. When preferences of individuals of type 1 (respectively type 2) are sufficiently biased towards good 1(respectively good 2), then one can show that $\Delta V^i(q^i)$ is decreasing in q^i and strategic substitution obtains. Cultural heterogeneity will tend to apply preferences for ethnic goods in exchange economies. The same results obtaion, *a fortiori,* in production economies with increasing marginal costs.

Olivier, Thoenig, and Verdier (2008), on the other hand, model cultural goods, in general, as goods that generate a group-identity externality: keeping goods' prices constant, the larger the size of the group sharing the same culture, the larger the utility benefit to identify to that cultural group, and the larger also the cultural intolerance ΔV^i. In this context, the strategic substitution effect on ΔV^i arising from Walrasian price effects is compensated by strategic complementarities due to the group-identity externality. As such, this effect promotes cultural homogeneity.

More generally, strategic complementarities and cultural homogeneity in trade economies will typically hold, e.g., with increasing returns in production and market power. An example is provided by Thoenig, Maystre, Olivier and Verdier (2009) who study the transmission of a preference for a specific differentiated good whose varieties are produced under monopolistic competition. In this context, the larger the size of the group with a preference for the good, the larger the market size and the entry of firms producing differentiated varieties of that good. Increased varieties in turn makes it relatively more attractive to acquire and transmit preferences for this good, leading once again to strategic complementarity.

2.4.2 Cultural transmission and institutions

Another interesting class of models studies strategic substitution in socio-economic environments in which individual randomly matched to interact strategically. Consider for instance the case of an ethical norm which imposes a psychological cost when an individual does not play cooperatively in situations like e.g., the *Prisoner's Dilemma* (these are also called *norms of pro-sociality).*[28] If individuals are matched randomly to interact, the gains to transmit the norm for pro-sociality tend to be higher when many

[28] Bowles (2001) and Bowles and Gintis (1998, 2002, 2003) develop also cultural evolutionary models of norms of cooperation but in contexts with exogenous cultural transmission and standard replicator dynamics.

individuals in the population share the norm, $\Delta V^i(q^i)$ is increasing; see Bisin, Topa, and Verdier (2004).

Relatedly, Tabellini (2009) studies the cultural transmission of a norm which imposes a psychological cost when an individual does not play cooperatively in situations like e.g., the Prisoner's Dilemma, but such that the cost declines in some measure of cultural distance of the opponent (e.g., costs are high only when the opponent is part of the family or of the tribe; accordingly, these norms have been called *norms of limited morality*, and in extreme case, *immoral familism*).[29] More precisely, Tabellini (2009), following Dixit (2004), considers a continuum of one period lived individuals uniformly distributed on the circumference of a circle. The density of individuals per unit of arc length is 1. Each individual is randomly matched with another located at distance y with probability $g(y) > 0$. Two matched individuals observe their distance and play a prisoner's dilemma game. Besides material payoffs, each individual enjoys a psychological benefit d that decays with distance at exponential rate $\theta > 0$: the pyschological gain of playing cooperation against an opponent located at distance y is $de^{-\theta y}$. Two types of player are characterized by different decay parameters θ_i $(i = 1, 2)$ with $\theta_2 > \theta_1$. Hence a *general morality* player, with $i = 1$, values cooperation more than a *limited morality* player, with $i = 2$, at any positive distance y.

For a given fraction q^1 of general morality players, the equilibrium is such that individuals play cooperatively only with opponents which are close enough in cultural space (namely individuals of type i play cooperative when matching with individuals at a distance $y \leq Y_i$). Obviously, the distance cut-off is higher for individuals who have adopted a general morality, as opposed to a limited morality, norm: $Y_2 < Y_1$. Moreover, the upper threshold $Y_1 = Y_1(q^1)$ depends positively on the fraction of general morality players q^1 in the population. This is the case because when playing, individuals do not observe their opponent type. Hence general morality players bear the risk of cooperating against cheating opponents, specifically when $y > Y_2$. A larger fraction of general morality players reduces this risk, inducing conversely a larger range of matches over which cooperation can be sustained. This element generates therefore a strategic complementarity in the Prisoner's Dilemma game: individuals are more willing to cooperate the higher the fraction of general morality individuals in the population.

Extending Bisin, Topa, and Verdier (2004), Tabellini (2009) embedds this prisoner's

[29] The distinction between norms of limited or general morality is due to Banfield (1958)'s study of Lucania, in the South of Italy. See also Platteau (2000).

dilemma structure into a version of the cultural transmission model with imperfect empathy. A parent's of type i at time $t-1$ evaluates his child of type j in the equilibrium of the matching game as

$$V^{ij} = u^j(\theta_j, q^1) + d\int_0^{Y_j} e^{-\theta_i z} g(z)dz$$

where $u^j(\theta_j, q^j)$ represents the expected equilibrium material payoff of a child of type j in the prisoner's dilemma game with random matching when the fraction of general morality agents is q^1. The second term is the parent's evaluation of his child's expected psychological benefits of cooperating in matches of distance smaller than Y_j. Note that because of imperfect empathy, this term is evaluated with the preference parameter θ_i of the parent. Specifically, the cultural intolerance of a general morality parent, ΔV^1, can be written as

$$\Delta V^1 = \underbrace{u^1(\theta_1, q^1) - u^2(\theta_2, q^1)}_{A} + \underbrace{d\int_{Y_2}^{Y_1} e^{-\theta_1 z} g(z)dz}_{B} \tag{12}$$

The first term, A, captures the difference in the expected material payoff between a limited and a general morality child. This term is negative, as general morality induces more cooperative behavior and is dominated by non-cooperation from a pure material payoff point of view. The second term, B, reflects instead the expected benefit of extending the scope of the child's cooperative behavior to a larger range of matches, evaluated with the parent's values, θ_1. This term is positive, as enlarging the scope of cooperative behavior increases the direct psychological benefit as perceived by the parent. Hence (12) reflects the tradeoff that a general morality parent faces in terms of cultural transmission of his values.

Importantly, ΔV^1 depends positively on the actual fraction q^1 of general morality individuals in the generation of the offspring. Indeed, a higher anticipated fraction of general morality agents in the children's generation makes cooperation less costly in terms of material payoffs and more worthwhile in terms of psychological benefits. In this context then, the gains from socialization to a general morality norm are higher in societies where such norms are prevalent and strategic complementarity obtains.[30]

[30] However, Tabellini (2009) shows that in his model $\Delta V^1 > 0$, namely that the non-economic benefits of cooperation as perceived by general morality parents always outweight the material costs. The model

2.4.3 Cultural transmission and collective action

An important feature of cultural transmission processes, especially in the case of socio-economic interactions, is that group size effects and parents' expectations about the dynamics of these group sizes have strong implications for socialization choices. Issues of collective action and coordination of expectations within and across cultural groups arise then naturally and are important determinants of the type of long run social outcomes that may prevail in society. Collective action mechanisms for cultural transmission and socialization include, e.g., parties, churches, communities, lobbies, and clubs.

A few papers consider such collective mechanisms in detail. In a series of papers, Gradstein and Justman (2002, 2005) consider the role of education in promoting a common culture within society. In particular, Gradstein and Justman (2002) consider the implications of the cultural content of education for economic growth. Specifically they show that when different cultural groups separately determine the social content of their school curricula, excessive polarization may result which leads to less than optimal growth. On the other hand, the optimal trajectory involves school curricula converging towards a middle ground. The authors then investigate how different modes of political implementation of centralized schooling through representative democracy can lead to excessive polarization in some cases and overly rapid homogenization in others.

Dixit (2009) also considers the role of education in the transmission of values and norms, though the focus of the paper is on norms of pro-sociality. In this context, school financing is a collective action problem addressed by majority voting. More precisely, the model considers an economy where final output is produced using two complementary inputs a public good and private individual effort. The public good comes from contributions of individuals. If individuals have a *pro-social component in their preferences* that internalizes the welfare of others to some extent, a larger quantity of the public good is provided. More specifically, consider a society populated by n individuals, labeled $i \in \{1, ...n\}$. Each individual can exert two types of efforts: private

therefore displays positive incentives to transmit the general morality norm across generations and under specific assumptions on the transmission mechanism which bias the process somewhat towards the general morality trait, the population dynamics converges to a distribution which contains a positive fraction of individuals sharing the general morality norm, nothwithstanding strategic complementarity.

x_i, and public z_i. The income of individual i is given by

$$y^i = (1 + \overline{z})x^i, \text{ with}$$
$$\overline{z} = \frac{1}{n}\sum_{i=1}^{n} z^i$$

A selfish individuals with utility

$$u^i(y^i, x^i, z^i) = y^i - h(x^i + z^i),$$

for regular convex cost of effort $h(x^i + z^i)$, will choose $z^i = 0$ at equilibrium (provided n is large enough). An individual with *pro-social* preferences of the form

$$v_i = u_i + \gamma \sum_{j \neq i} u_j, \ \gamma > 0$$

might instead more efficiently choose $z^i > 0$; e.g., when γ is large enough.

Consider a society in which parents are (perfectly) altruistic towards their own children, discounting their utility at rate δ. In this case, parents might collectively choose to socialize them to pro-social preferences, that is, to a $\gamma > 0$, even if socialization is costly, e.g., because of school contributions. Dixit (2009) discusses different socialization outcomes, depending on whether parents have themselves pro-social preferences. When parents are selfish, the preferred level of education γ of any dynastic parent is positive if parental altruism is strong enough, that is, δ large enough. In this case, if parents have homogeneous preferences so that any collective choice mechanism induces the same socialization outcome, children will be socialized by schools to norms of pro-sociality.[31]

Several interesting contributions to the literature focus on a specific collective action mechanism, *majority voting*, in different political economy environments. Bisin and Verdier (2000) considers the cultural transmission of preferences for a good whose provision is determined by voting, e.g., a public good. For any generation, socialization preferences depend on the parents' expectations regarding the political aggregation of the distribution of preferences in their children's population, which will vote on public good provision. On the other hand, the outcome of voting in any period depends on the present distribution of traits in the population, which in turn is determined by past

[31] Assuming that parental altruism is increasing in income, the intergenerational transmission of pro-sociality might remain stuck in a poverty trap where collective action is determined by relatively poor agents who would rather not invest in schools favoring the transmission of norms of pro-sociality and hence, in turn, inducing a higher growth of income.

parents' socialization. Under perfect foresight assumptions, the dynamics of the distribution of preferences, and of political outcomes, depends very much on initial conditions. For unbalanced initial preference distributions, the dynamics display a tendency to homogeneity in the long run distribution of preferences, while for relatively balanced initial distributions, the dynamics display multiple equilibrium paths generated by self-fulfilling expectations. These paths have very different long run consequences in terms of both cultural values and policy outcomes.[32]

Tabellini (2009)'s model of cultural transmission of morality norms, discussed before, also allows for voting on the constitution of external legal enforcement institutions. In this setting Tabellini (2009) shows how formal enforcement mechanisms may interact differentially with local and general morality norms. Under majority rule voting, inefficient legal institutions may lead to an equilibrium path where such inefficiency reduces the gains to transmit norms of general morality across generations, which in turn reinforces the political support for an inefficient legal system.

Another example regarding the interaction of cultural transmission and voting is Bisin and Verdier (2005), which investigates the relationship between transmission of work ethic and redistributive policies. The paper shows how heavily redistributive policies, like e.g., welfare states policies, limit the gains for transmitting work ethic norms, which in turn induce political support for the welfare state (and eventually its own demise, as redistribution is moot as long as work ethic norms disappear in the population).

More precisely, the paper considers preferences for work ethic in a context in which income redistribution is obtained through simple majority voting. Agents have quasi-linear preferences over consumption, c, and hours worked, l:

$$u^i(c, l) = c + \theta_i v(1 - l), \qquad \text{with } \theta_i > 0.$$

for some well behaved preference for leisure map v. Agents differ in terms of their preferences for leisure, parametrized by the marginal rate of substitution of leisure in term of consumption, θ^i, for $i \in \{1, 2\}$. Agents of type 1 are characterized by lower preferences for leisure at the margin, $\theta_1 < \theta_2$, that is, by a better *work ethic*.

Before-tax income is redistributed in each period, and redistribution decisions are taken by majority voting of the mature generation under the constraint that the work

[32] The fact that equilibrium paths are highly dependent on self-fulfilling expectations provides a role for ideologies as programmatic coordination expectation devices that help to select a particular path of cultural values and political power structure in society.

ethic parameter θ_i is private information of individual agents, that is, it is not observable in the labor market (see Mirlees, 1973, for the pioneering analysis of redistribution in economies with adverse selection). Let $R^i(q^1_{t+1})$ and $l^i(q^1_{t+1})$ denote respectively the after tax income and induced work effort of an individual of type i following the optimal redistributive scheme voted in period $t+1$, which depends on the fraction of agents with a work ethic, q^1_{t+1}.

When agents of type i represent the majority of the population, they vote for an income redistribution scheme which is incentive compatible with the work behavior of private agents and maximizes their representative utility. Bisin and Verdier (2005) show that in this context, minorities have no socialization incentives:

$$\Delta V^i(q^i_{t+1}) = 0, \text{ for } q^i_{t+1} < 1/2.$$

On the contrary, the socialization incentives of the majority are strictly positive and increasing in the fraction of the other (minority) group

$$\Delta V^i(q^i_{t+1}) \text{ is decreasing in } q^i_{t+1}, \text{ for } q^i_{t+1} > 1/2$$

Direct socialization d^i has the therefore the following form:

$$d^i = \begin{cases} (1-q^i_t)\Delta V^i(q^i_{t+1}) & \text{if } q^i_{t+1} \geq 1/2 \\ 0 & \text{if } q^i_{t+1} < 1/2 \end{cases},$$

as minority agents have no incentives to spend resources to socialize their children to their own work ethic norm.

Bisin and verdier (2005) characterize the path q^i_t of the population dynamics as well as the equilibrium level of redistribution and taxation starting from an initial fraction q^i_0 of individuals of type i. They show in particular that, when one preference type is strongly majoritarian in society, then the politics of redistribution lead to a homogenization towards that preference. On the contrary, when the initial distribution of preferences for leisure is sufficiently balanced and diversified, then the dynamics of the evolution of preferences may follow various paths depending on the type of self-fulfilling expectations individuals coordinate on at equilibrium.

Very limited is the theoretical research studying cultural transmission and other collective choice mechanisms, like religious organizations, firms, political parties, armies, gangs, etc. Interestingly, such institutions might have different objective functions and operate by means of different socialization strategies, including prices, weapons, ideas

and belief-manipulations. An example is provided by Dessi' (2005) which studies collective memory as the outcome of belief-manipulation on the part of nation-states when individual have imperfect memory.

Also, different modes of socialization, individual versus collective, may compete with each other. For instance, state propaganda may compete with direct family socialization. These interactions in turn may affect the policies and social actions undertaken by future generations, leading in the long run to different socio-cultural trajectories. Looking at how such socialization organizations and their different modes of functioning can be integrated in cultural transmission models remains an avenue for future research.

2.5 Cultural transmission of beliefs

Cultural transmission relates more generally to the transmission of cultural traits, values, preferences. In practice, , in the models we surveyed, cultural transmission pertains to the transmission of preferences: cultural traits and values are projected in the space of preference traits.

Parental socialization choice is motivated by *imperfect empathy*: if the parent and the child have different cultural trait, say i and j, respectively, the child chooses the $x^j \in X$ which maximizes $u^j(x)$, and the parent evaluates this choice by $u^i(x^j)$.

In fact, in many instances of interest, we can think of cultural transmission as the transmission of beliefs, or ideologies. That is, preferences are identical across agents, but different cultural types have a different model of the socio-economic environment.[33] Guiso, Sapienza, and Zingales (2008) build a simple model of the transmission of beliefs about trustworthiness, motivated by the literature we survey in this chapter. It is pedagogically convienent however here attempt at a generalization which better highlights how cultural transmission models can be adapted to study the transmission of beliefs. We only sketch a model, avoiding details to be filled in in another venue.

Let X denote an abstract choice set, comprising all choices relevant to an individual's economic and social life. Let $\theta \in \Theta$ denote a parameter unknown to agents. Each individual has preferences represented by $u : X \times \Theta \to \mathbb{R}$. Individuals have distinct probability distribution over θ. Let p_t^i denote the probability distribution shared by all individuals (parents and childeren) of type $i \in \{a, b\}$ at time t. At time t, children of

[33] For example, an interesting literature has attributed the support for the welfare state in Europe, and the lack of support in the U.S., to heterogeneous beliefs about the fairness of social competition and about what determines income inequality, individual effort or luck; see Alesina and Angeletos (2005).

type i choose $x \in X$ to maximize

$$E_{i,t}\left[u(x;\theta)\right] = \int_{\Theta} u(x;\theta) dp_t^i.$$

They then observe the realization of a signal of θ, ζ^i and update to the posterior p_{t+1}^i which they enter time $t+1$ with.

Let V^{ij} denote the utility to a type i parent of a type j child, $i, j \in \{a, b\}$. Analogously to imperfect empathy, we require

Imperfect learning: For all $i, j \in \{a, b\}$, $V^{ij} = E_{i,t}\left[u(x^j;\theta)\right]$, *where* $x^j = \arg\max_{x \in X} E_{j,t}\left[u(x;\theta)\right]$.

Learning is imperfect in the sense that agents of type i disregard the information which has lead individuals of type j to p_t^j, and viceversa. As long as V^{ii}, V^{ij} are independent of q^i, imperfect updating implies $V^{ii} \geq V^{ij}$, with $>$ for generic utility function $u(x;\theta)$.

Applying the economic socialization model to this general environment is now straighforward, and, with quadratic socialization costs,

$$d^i = d(q^i, \Delta V^i) = (1 - q^i)\Delta V^i.$$

As an illustration, suppose $\Theta = \{\theta_0, \theta_1\}$ and, abusing notation, p_t^i is the probability, according to the posterior of agents of type i, that $\theta = \theta_0$. The signal ζ takes value in Θ, and is distributed so as to assign probability $p > \frac{1}{2}$ to the true value of θ, which we take to be θ_0 without loss of generality.

In this simple learning environment, trivially, each type's posterior converges to the truth,

$$p_t^i \to 1,^{34} \text{ for any } i \in \{a, b\},$$

and as a consequence,

$$\Delta V^i \to 0.$$

In this environment it is of interest to study the dynamics of the *average beliefs* in the population,

$$b(t, q_0^i, p_0^i, p_0^j) = q_t^i p_t^i + (1 - q_t^i) p_t^j.$$

It follows that

Average beliefs converge to the truth, $b(t; q_0^i, p_0^i, p_0^j) \to 1$. *Direct vertical socialization slows down convergence.*

[34] Formally, the notion of convergence is convergence in probability, as from the Martingale Convergence Theorem. We choose here an imprecise notation in the advantage of simplicity.

It should be clear that, as in the case of cultural transmission, endogenous cultural intolerance, $\Delta V^i(q^i)$, could drastically affect the dynamics. In the particular case of the transmission of beliefs of trustworthiness, as in Guiso, Sapienza, and Zingales (2008), the untrustworthy type, say type j, does not engage in social interaction and hence does not receive any signal. As a consequence, type j individual do not learn, $p_t^j = p^j$. Furthermore, the trust game is characterized by strategic complementarity (the more trustworthy individuals in the population, the higher their incentives to socially interact):

$$\Delta V^i(q^i), \text{ with } \frac{d\Delta V^i(q^i)}{dq^i} > 0.$$

It is straighforward in this case to construct examples where, by selecting appropriate initial conditions (q_0^i, p_0^i, p^j), we obtain average beliefs which do not converge to the truth and a population of trustworthy types which tends to vanish,

$$b(t; q_0^i, p_0^i, p^j) \to p^j, \quad q^i(t; q_0^i, p_0^i, p^j) \to 0.$$

3 Empirical studies

As we noted in the Introduction, cultural transmission as a field of study in the social sciences is largely motivated by the observation that cultural traits in general, and religious and ethnic traits in particular, tend to be quite resilient in the population. The fundamental manifestation of this phenomenon is cultural heterogeneity, the world's geographical fragmentation by ethic and religious traits, at any given time. It is then appropriate to start a survey of empirical studies of cultural transmission by substantiating this observation. We should also stress at the outset, however that cultural heterogeneity is not a curiousum of culture studies. It is heavily correlated to many relevant socio-economic phenomena (from the provision of public goods to civil wars), so much so that the fractionalization index is now a constant feature e.g., of growth regressions; see Alesina and La Ferrara (2005) for a survey.

Similarly, the recent debate over the *clash of civilization,* as spurred by Huntington (1992), has been informed by the study of ethnic and religious diversity and by different measures of ethnic and religious fractionalization. For instance, using genetic distance as a proxy for ethnic diversity, Spolaore and Wacziarg (2010) obtain the surprising result that a one standard deviation increase in genetic distance between two populations is associated to a 23% reduction in the probability of conflict between them from 1816 and 2000.

3.1 Cultural heterogeneity

The categorization and analysis of different cultural traits is the object of study of cultural anthropology, as a separate discipline. Ethnology, in particular, concerns the comparison and contrast of different cultural traits catalogued by ethnographic studies. Referring to any manual of cultural anthropology like, e.g., Rapport and Overing (2007), for a more in-depth analysis and for references, it will suffice in this survey to report on aggregate measures of cultural heterogeneity along the ethnic and religious dimensions.

Ethnolinguistic diversity is documented by the ethnolinguistic fractionalization index, as computed from the classifications based on the *Atlas Narodov Mira*, the *Encyclopedia Britannica,* or *the Ethnologue database.*[35] Consider a country j with $i = 1, ...N$, ethnolinguistic groups, each representing share s_{ij} in the country's population. The fractionalization index of country j takes values from 0 to 1 (with 1 corresponding to maximal fractionalization) and is defined as:

$$ELF_j = 1 - \sum_{i=1}^{N} s_{ij}.$$

Figure 4 reports the distribution of the fractionalization index by country according to the Ethnologue database.

As an illustration, Chad, with an index close to 1, has 135 languages spoken inside its borders.

But even an impressionistic look at the heterogeneity of languages spoken around the world is striking. See e.g., the case of Asia in Figure 5, where each red dot represents the geographic center of a distinct language.

Other fractionalization indexes, e.g., indexes of ethnic, language, and religion fractionalization, display a similar picture, as shown in Table 1. In particular it is notable that religious fractionalization is higher than ethnolinguistic fractionalization as well as both etnhic and language fractionalization measured distinctly.

[35] The *Ethnologue database* e.g., contains 6,909 language descriptions organized by continent and country; see Lewis (2009). Of course we are side-stepping here the difficult *what-is-a-language* issue. This is perhaps appropriate since we are aiming at an impressionistic look

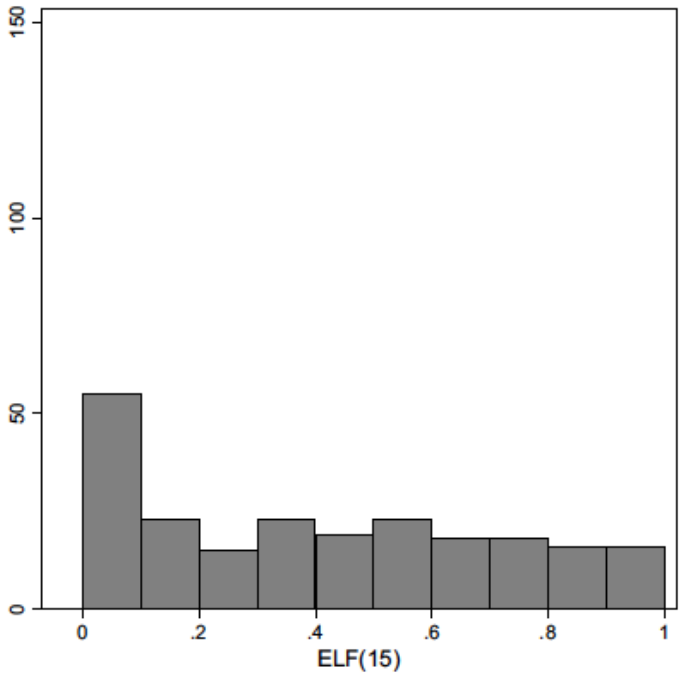
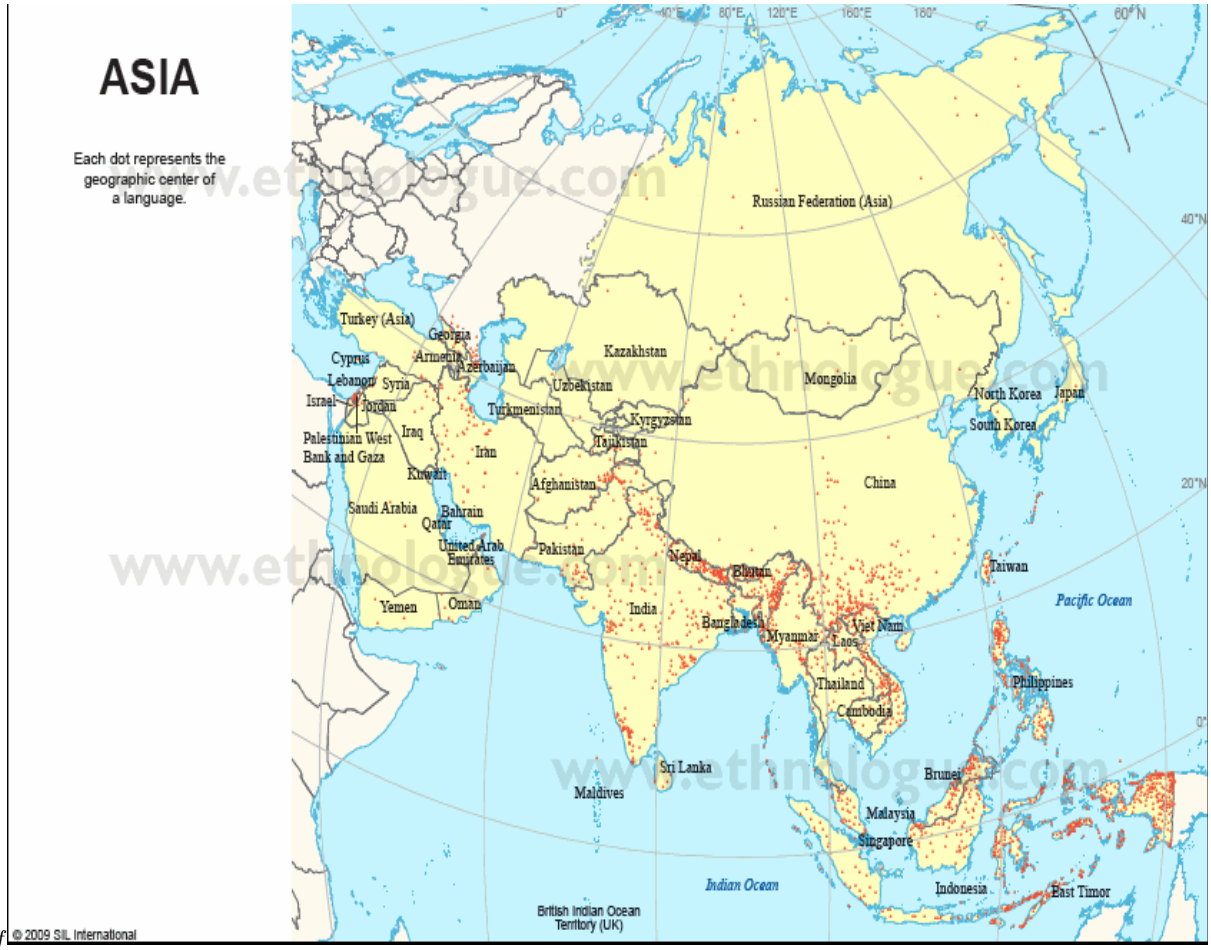


Figure 4: Cross-Country Distribution of the Ethnolinguistic Fractionalization Index. Source: Desmet, Ortuno-Ortin, and Wacziarg (2009).

of

Asia



5.pdf

Figure 5: Languages spoken in Asia. Source: www.Ethnologue.com

Variable	# of Observations	Sample Mean
Religion	198	0.439
Ethnic	180	0.435
Language	185	0.385
ELF	112	0.418

Table 1: Sample Means of Fractionalization Indexes. Source: Alesina, Devleeschauwer, Easterly, Kurlat, and Wacziarg (2003).

Even limiting the analysis to the main religions fractionalization is substantial. The Encyclopedia Britannica World Book 1999's list of ten major religions, in Figure 6, contains seven religious denominations (which themselves can be subdivided in several different denominations: like e.g., Chirstians in Catholics, Orthodox, Coptic, and others) and three very heterogeneous aggregations: Chines folk religions, Ethnic religions, New-religions.[36]

Cultural heterogeneity is not only a property of ethnic and religious traits. Tabellini (2008), for instance, constructs a cross-country index of social values, an aggregate of trust and respect, specifically, obtained from World Value Surveys data (waves 1981, 1990, 1995, 2000). The index is normalized to take values in $[0, 1]$, e.g., almost 0 for Brazil and 1 for Sweden. This index also show substantial dispersion across the world, as seen in Figure 7.

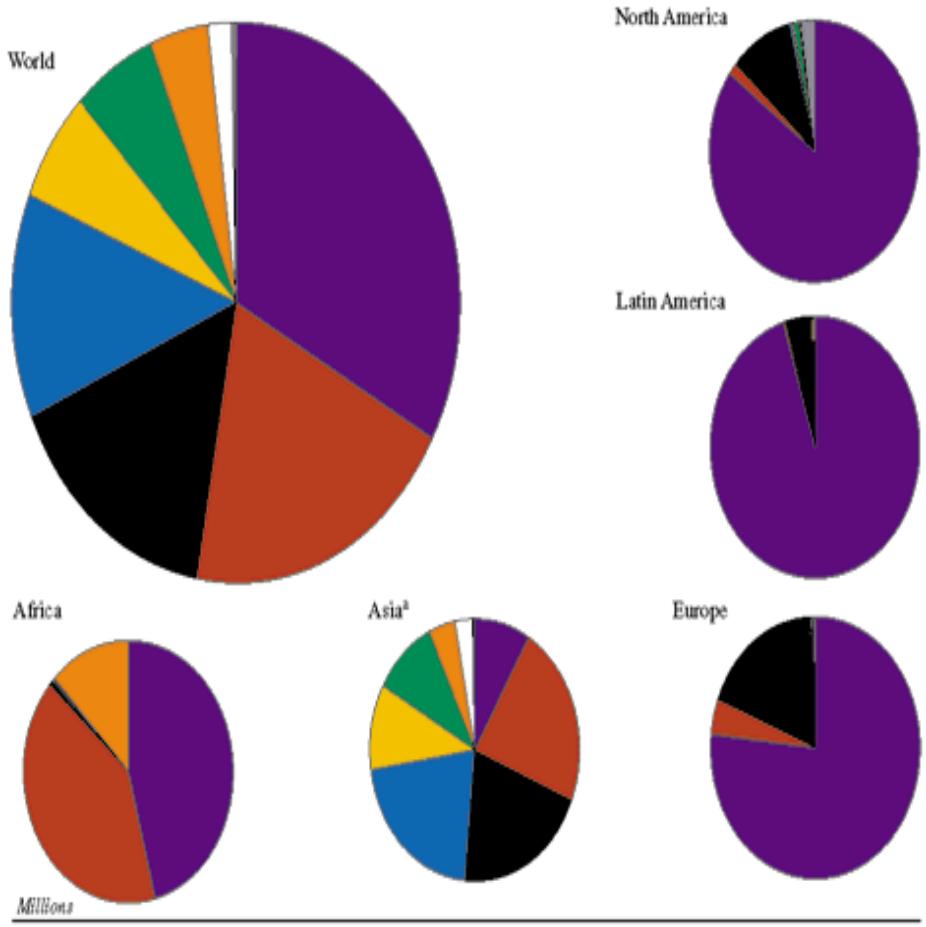
3.2 Resilience of cultural traits

As we noted the resilience of cultural traits and cultural heterogeneity are two sides of the same coin. It is not surprising then that the evidence regarding the resilience of ethnic and religious traits across generations is quite pervasive and it nicely complements the evidence on cultural heterogeneity. For instance, the fast assimilation of immigrants into a 'melting pot', which many social scientists predicted until the 1960s (see, for example, Gleason, 1980, for a survey), simply did not materialize. Moreover, the persistence of 'ethnic capital' in second- and third-generation immigrants has been documented by a vast literature on immigration and ethnic capital (see e.g., Borjas, 1992), and recently also by "epidemiological" studies on culture (see e.g., Fernandez and

[36] The tenth group is Atheism and non-religion.

chart

Worldwide Adherents of Selected Major Religions, Mid-1998



	Africa	Asia[a]	Europe	Latin America	North America	World
Christians	356.27	308.19	558.73	462.97	256.88	1,943.04
Muslims	315.00	812.25	31.40	1.62	4.35	1,164.62
Atheists and nonreligious	4.90	726.13	131.44	17.97	29.07	909.51
Hindus	2.41	755.85	1.38	0.79	1.27	761.70
Chinese folk religionists	0.03	377.86	0.25	0.18	0.84	379.16
Buddhists	0.14	349.07	1.52	0.62	2.45	353.80
Ethnic religionists[b]	97.20	148.45	1.26	1.23	0.42	248.56
New-Religionists[c]	0.03	98.60	0.16	0.60	0.76	100.15
Jews	0.23	4.24	2.53	1.12	6.00	14.12
Confucianists	0	6.23	0.01	0	0	6.24
Total	776.21	3,586.87	728.68	487.10	302.04	5,880.90

Source: Encyclopedia Britannica World Book, 1999.
[a] Asia includes Middle East and Central Asia.
[b] Followers of local tribal, animalistic, or shamanistic religions.
[c] Followers of primarily crisis or syncretistic religions and movements, all founded since 1800 and most since 1995.

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Figure 6: Major religions. Source: Encyclopedia Britannica.

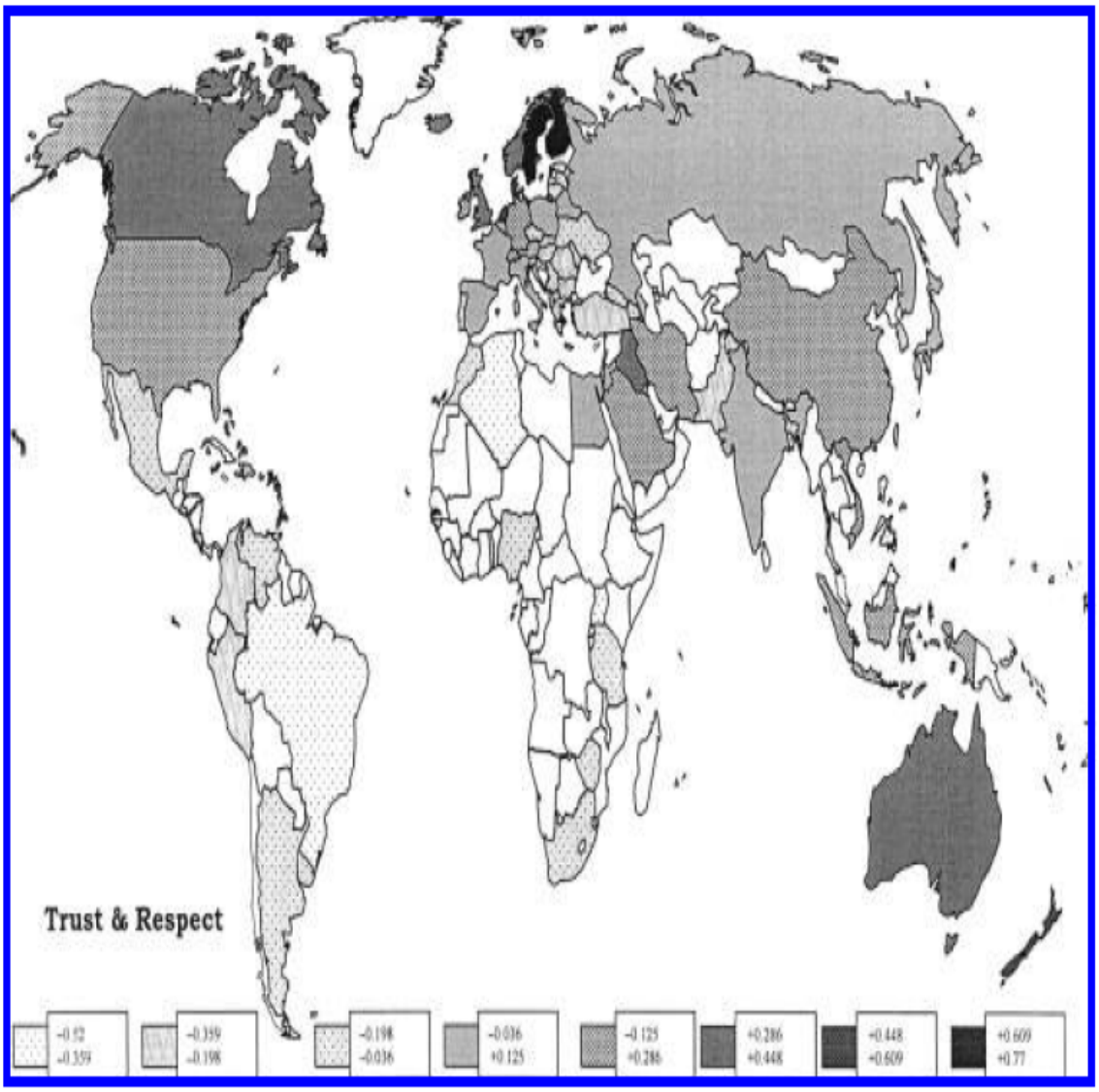

Figure 7: Trust and Respect index by country. Source: Tabellini (2008).

Fogli, 2004, and Giuliano, 2006). Orthodox Jewish communities in the United States constitute another example of the strong resilience of culture (see Mayer, 1979, and the discussion of a 'cultural renaissance' overcoming the predicted complete assimilation of Jewish communities in New York in the 1970s). Outside the United States, Basques, Catalans, Corsicans, and Irish Catholics in Europe, Quebecois in Canada, and Jews of the diaspora have all remained strongly attached to their languages and cultural traits even through the formation of political states which did not recognize their ethnic and religious diversity. Most recently, several empirical studies have documented that immigrants in Europe, and especially so those of Muslim faith, appear to integrate culturally at very slow pace; see Algan-Bisin-Manning-Verdier (2010) for a comprehensive analysis of the data. Finally, various measures of social capital display very long-run histeresis, of the order of hundreds of years: for instance, Guiso, Sapienza and Zingales (2007, 2008) reconduct the contemporary variation of social capital in Italy to the experience of free-city-state in the Middle Ages, Tabellini (2005, 2008a, 2008b) links cross-country variation in measures of trust to the quality of political institutions in the nineteenth century, Nunn and Wantchekon (2008) link variation in measures of trust in West Africa to the slave trade, Grosjean (2009) finds a cross-regional relationship between institutional corruption in the present and an history of Ottoman domination.

It is convenient to organize empirical studies of cultural transmission along two main dimensions. The first distinguishes *population dynamics studies* from *socialization studies*; while the second one distinguishes *structural* and *non-structural methodologies*.

Population dynamics studies aim at measuring directly the resilience of cultural traits, the speed of cultural transmission. *Socialization studies* aim instead at identifying the most relevant properties of socialization mechanisms, e.g., cultural substitution vs. complementarity, which the theory suggests are related to the resilience of cultural traits.

A large part of the empirical work on cultural transmission adopt a *structural methodology*, linking estimates to the theoretical models we surveyed. *Structural population dynamics studies*, for instance, exploit the observation of the population dynamics of a trait in history, a time series of q_t^i, to estimate the speed of transmission, $\frac{q_{t+1}^i - q_t^i}{q_t^i}$, as well as direct socialization rates $(d^i - d^j)$ from a discrete time version of the population dynamics equation (3). The time series of the population dynamics q_t^i is obtained from archelogical anthropology and/or historical and ethnographic data. Methods from evolutionary genetics and historical linguistics have also been exploited to produce time

series of the population dynamics.

Structural socialization studies typically exploit instead the observation, at a time t, of a cross section of population distributions by trait as well as socialization rates P^{ii}, P^{ij}, P^{ji} to estimate the vertical socialization rates d^i, d^j as well as the deep preference parameters of the model, $\Delta V^i, \Delta V^j$, from a version of the cultural transmission equations, e.g., (1)

Finally, interesting empirical properties of cultural transmission are also uncovered by means of *non-structural methods*, as in the case of *historical case-studies* of population dynamics, *migration* and *epidemiological studies.*

3.3 Population dynamics

Let $t = 0, 1, ..., \infty$ index discrete time. The population dynamics equation for the leading cultural transmission model we have discussed, in the discrete time formulation adopted in empirical studies, is

$$q^i_{t+1} - q^i_t = q^i_t(1 - q^i_t)\left(d^i - d^j\right),$$

with parental socialization conditions

$$d^i = d(q^i_t, \Delta V^i) = (1 - q^i_t)\Delta V^i.$$

Identification of $d^i - d^j$ at time t only requires observing two datapoints from a sequence of population shares $\{q^i_t\}$ over time t. A longer sequence will in general allow the identification of the deep preference parameters of the model, ΔV^i, $i = a, b$.

Examples of this approach abound,[37] though in this literature parental socialization conditions are typically disregarded and $d^i - d^j$ is assumed constant over time. In this case, the population dynamics displays logistic growth:

$$q(t) = \frac{q(0)}{(1 - q(0))e^{-(d^i - d^j)t} + q(0)}.$$

Stark (1984, 1997), for instance, adopts this method to estimate the spread of the Mormon church and of early Christianity in the Roman empire.[38] In the case of early Christianity, population shares from 40 to 350 *C.E.* (Common Era) are obtained from

[37] Cite technological adoption studies

[38] In fact, Stark's estimates are based on exponential rather than logistic growth. The exponential equation is a reasonable approximation to the logistic for q^i close to 0, as is the case in both his application.

secondary sources and are imprecisely estimated. The resulting estimates of $d^i - d^j$ are .43 per decade for Mormons and .4 for Christians.

Botticini and Eckstein (2004, 2007) study the cultural transmission of preferences for education to explain the historical occupational choices of Jews in favor of urban skilled trades rather than farming. They argue that preferences for education constitute a component of Judaism since the reform after destruction of the Temple in 70 CE and as such have been directly transmitted across generations. Botticini and Eckstein (2004) provide a wealth of historical evidence for the transmission of preferences for education by Jews from the first century to the eight century, when the occupational transition and urbanization of Jews occurs. Such evidence includes rabbinical discussions and rulings in the Talmud regarding education and teachers, demographic data (e.g., education levels among Jewish farmers before the 8th century), archeological findings on the building of synagogues in farming villages in Eretz Israel between the 3rd and 5th century. Furthermore, consistently with cultural substitution, high socialization rates have been historically supported as Judaism represented a minority in the Diaspora, even more so after the transition to urban occupations, in which education is an advantage.[39] Using Botticini and Eckstein (2007)'s data on population shares and voluntary conversions of Jews a small negative $d^i - d^j$, of the order of $-.007, -.003$ per decade, depending on the region, can be estimated from the 2nd to 7th century. Such negative net socialization rates are due, according to Botticini and Eckstein (2007), to the cost of socializing children to Judaism (which required educating them) in subsistence farming economies. While socialization rates for the period between the 9th and the 12th century cannot be estimated for the difficulty of taking into account of massacres and forced conversions of Jews, Botticini and Eckstein (2007) provide evidence suggesting institutional reforms in favor of education, e.g., mandatory primary schooling for boys, and positive net socialization rates (with no voluntary conversions).

A related approach, extended to account for geographic diffusion, has been adopted in series of pathbreaking papers by L.L. Cavalli Sforza and his coauthors[40] to study the Neolithic transition in Europe.[41] Let $l = -\infty, ..., 0, ..., \infty$ index discrete location x_l. In

[39] Kuznet (1960, 1972) provides an explanation of the occupational history of the Jews which also relies the economics of minorities (cultural substitution, in our terminology), but where the cultural trait transmitted is the occupation itself.

[40] The first paper is Ammerman and Cavalli Sforza (1971). An early book length treatment is contained in Ammerman and Cavalli Sforza (1984).

[41] These studies exploit method and concepts from biology, linguistics, and archelogical anthropology. A complete survey would require space and competence we do not possess. We feel content with

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Figure 8: The spread of early farming in Europe. Source: Ammerman and Cavalli Sforza (1984).

this context, population dynamics in the model is governed by the discrete time analogue of (4):

$$q^i_{t+1,l} - q^i_{t,l} = q^i_{t,l}(1 - q^i_{t,l})(d^i - d^j) - mq^i_{t,l} + \frac{m}{2}\left(q^i_{t,l-1} + q^i_{t,l+1}\right) \tag{13}$$

where m is the diffusion coefficient. Identification of $d^i - d^j$ at time t at location l only requires observing $q^i_{t,l}$ at two points in time t for three locations l. More generally, a whole sequence $\left\{q^i_{t,l}\right\}$ over both l and t indentifies separately ΔV^i, $i = a, b$, and m. A longer sequence will in general allow the identification of the deep preference parameters of the model, ΔV^i, $i = a, b$. As we noted in the previous section, however, the dynamics of (13) converges to a travelling wave with constant speed $\alpha = 2\sqrt{(d^i - d^j)m}$,which is then identified by data on a sequence of dates t at which locations l first displays $q^i_{t,l} > 0$.

This is the method adopted by Ammerman and Cavalli Sforza (1971, 1984), exploiting radio carbondating estimates of early farming in 53 archeological sites (from Clarke, 1965). First of all they document that the statistical relationship between the advent of farming at a site and the distance of the site from the ancient city of Jericho, considered the the center of diffusion of farming, is consistent with a constant radial speed of diffusion, as assumed by the diffusion model (13). The radial speed of advance is then approximately estimated at 25 km per generation (see Figure 8, taken from Ammerman and Cavalli Sforza (1984) and based on more extensive later data confirming this finding).[42]

Independent estimates of the parameters $(d^i - d^j)$ and m can be obtained from archeological, historical, and anthropological data. Ammerman and Cavalli Sforza (1984) exploit a range of estimates of the rate of growth of early human establishments in a geographical location for $d^i - d^j$ and of the mean square distance between the birth location of spouses in early farmer's populations for m. Their preferred calibration has

examples which illustrate these methodologies and some of their results.

[42] Gkiasta, Russell, Shennan, and Steele (2003) re-examine Ammerman and Cavalli Sforza (1971)'s regression with data on 508 Neolithic sites and 207 Mesolithic sites, prodicing a slightly higher radial speed estimate of radial speed of 32.5 km per generation.

$d^i - d^j = .5$ (equivalent to 2.7% population growth per year) and $m = .04$ (equivalent, using the diffusion interpretation, to a mean square distance between the birth location of spouses of 31 km). A wave of advance moving radially at a a speed of 25 km per generation is quite in accordance with the model at this calibration.

Subtle identification problems when fitting the geographical diffusion model with data on the advent of farming need be addressed, however, to provide an answer to some of the more fundamental questions regarding cultural transmission: Which transmission mechanisms are responsible for the spread of Neolithic culture (including e.g., sedentary dwellings) and farming technologies? Did the adoption of a dominant technology, farming, require cultural trasmission in the form of parental socialization? In other words, a wave of advance of farming could be obtained simply by technological adoption, without any intermarriage across farmers and hunters and without any movement of people. It becomes then of interest to distinguish adoption through cultural transmission and intermarriage (what the literature refers to as *demic diffusion*) from a simple technological adoption process.

To address this identification issue, Rendine,Piazza, and Cavalli Sforza (1986) calibrate a discretized version of the geographic spread reaction-diffusion dynamics in (**??**). Let $Q^i_{l,t}$ be the number of people of type i in location l at time t and $Q^j_{l,t}$ be the number of people of type j in location l at time t. The discrete population dynamics satisfy the following Lotka-Volterra equations,

$$Q^i_{l,t+1} - Q^i_{l,t} = \delta_i Q^i_{l,t}(1 - \frac{Q^i_{l,t}}{P_i}) + \gamma Q^i_{l,t} Q^j_{i,t} - m Q^i_{l,t} + \frac{m}{2}\left(Q^i_{l-1,t} + Q^i_{l+1,t}\right)$$
$$Q^j_{l,t+1} - Q^j_{l,t} = \delta_j Q^j_{l,t}(1 - \frac{Q^j_{l,t}}{P_j}) - \gamma Q^i_{l,t} Q^j_{l,t}.$$

The parameter m captures then demic diffusion, through intermarriage, while γ represents technological adoption. The identification issue involves then distinguishing the effects of γ and m on the simulated population dynamics and on the geographical spread. In their simulation Rendine, Piazza, and Cavalli Sforza (1986) pick time units t to represent a generation (25 years). Thery also set locations l to span a (two dimensional) map of Europe (hence velocity in the simulation need be intepreted as radial velocity) so that the distance between two adjacent locations is 156 km. Initial conditions are set so that $t = 0$ is 400 generations (10,000 years) ago, by the advent of farming in the fertice crescent, $l = 0$ is the location of the city of Jericho, so that geographical distance is measured as kilometers from Jericho. At $t = 0$ Jericho and the adjacent

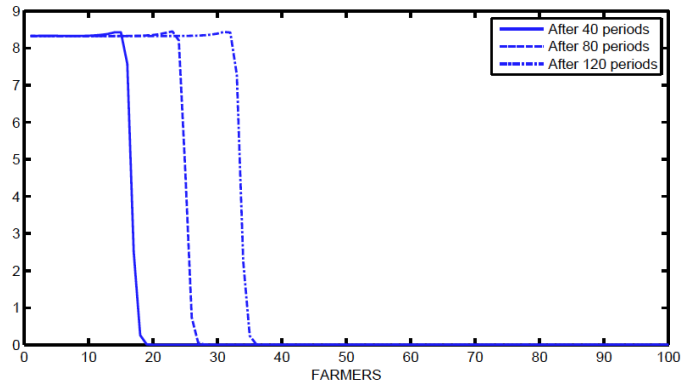

Figure 9: Evolution of farmers

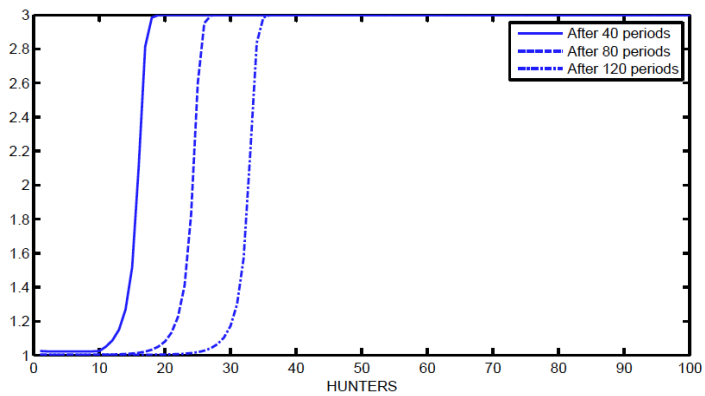

Figure 10: Evolution of hunters

locations filled to capacity with farmers, $Q^i_{l,0} = P_i, Q^j_{l,0} = 0$, $l = -1, 0, 1$, and the rest of Europe with hunterer-gatherers $Q^i_{l,0} = 0, Q^j_{l,0} = P_j$, $i > 1$ and $l < -1$. Furthermore, the calibrated parameters are chosen, as in Ammermann and Cavalli Sforza (1984), from archeological, historical, and anthropological data. Let i denote farmers and j denote hunterer-gatherers. Farmer societies are assumed much denser than hunter-gatherers, $P_i = 8$ and $P_j = .3$ (in thousands), and much faster growing, $\delta_i = .5$ (equivalent to 2.7% population growth per year) and $\delta_j = .25$. Furthermore the migration rate is $m = .04$, as in Ammermann and Cavalli Sforza (1984). We have reproduced here, in Figures 9 and 10, Rendine, Piazza, and Cavalli Sforza (1986)'s simulations.[43]

Rendine, Piazza, and Cavalli Sforza (1986) argue convincingly that γ and m cannot

[43] Thanks to Giorgio Topa for help with the simulation of the Lotka-Volterra system.

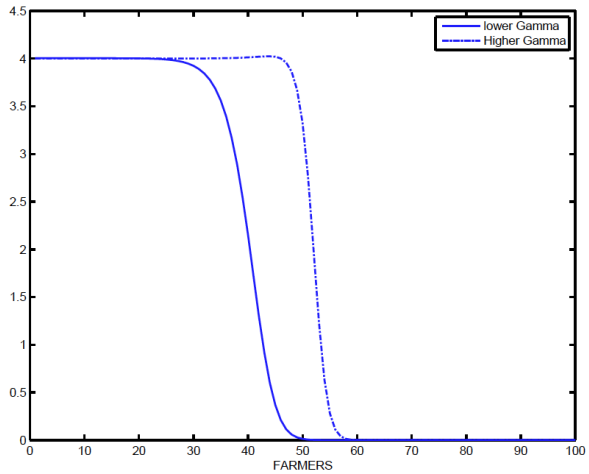

Figure 11: Comparative statics exercise on the steepness of the wave of advance with respect to γ.

be identified with data on the speed the wave of advance. But an interesting property of diffusion models is that the faster is the wave the less steep is the wave front (that is, the shorter is the minimal distance between loci with $q^i > 0$ and loci with $q^i = 0$). The following simulation, in Figure 11, makes it clear that in fact γ and m could be identified with more detailed data on the wave, in particular with data on its steepness at the boundary: keeping the migration rate m constant, a higher γ induces a steeper wave at the boundary, that is, a assimilation of hunters from their first interaction with farmers at any location.

Rendine, Piazza, and Cavalli Sforza (1986) pioneer instead a different methodology to identify γ and m, which exploits theory and data on genetic evolution. Since only marriage involves genetic admixture, superimposing a genetic evolution model to the population dynamics of equation (13), allows in principle to identify the relative components of diffusion due to marriage and to technological adoption with data on genetic heterogeneity by location at any point in time.[44] Consider a dyploid gene, that is a

[44] An important related literature exists on gene-culture coevolution. Its main focus, however, is the evolution of traits which share genetic and cultural aspects, as in the case of adult lactose absorption and drinking the milk of domesticated animals; see Aoki, Shida, and Shigesada (1996) for an application to the spread of agriculture, and Aoki (2001) and Feldman and Laland (1996) for recent surveys. For some important applications of this literature to the nature-nurture question, see Cavalli Sorza and Feldman (1973) and Otto, Christialsen, and Feldman (1995).

gene with two alleles, g, g'. Let $q_{l,t}^{i,g}$ (resp. $q_{l,t}^{j,g}$) denote the fraction of individuals in the i population with allele g at location l at time t (resp. the fraction of individuals in the j population with allele g at location l at time t). Naturally, $q_{l,t}^{i,g} = 1 - q_{l,t}^{i,g'}$ and $q_{l,t}^{j,g} = 1 - q_{l,t}^{j,g'}$. Assume that marriages are necessarily homogamous with respect to each population i, j. In this context, gene frequences change over time as a consequence of geographical spread, as long as adjacent location have different gene frequences. More precisely, we can express the dynamic gener frequency as follows:

$$q_{l,t+1}^{i,g} = \frac{1}{Q_{l,t+1}^{i}} \left[\begin{array}{c} \delta_l Q_{l,t}^{i}(1 - \frac{Q_{l,t}^{i}}{P_i}) q_{l,t}^{i,g} + \gamma Q_{l,t}^{i} Q_{l,t}^{j} q_{l,t}^{j,g} + \\ + \frac{m}{2} \left(Q_{l-1,t}^{i} q_{l-1,t}^{i,g} + Q_{l+1,t}^{i} q_{l+1,t}^{i,g} \right) - m Q_{l,t}^{i} q_{l,t}^{i,g} \end{array} \right]. \tag{14}$$

Gene frequences are $\frac{1}{2}$ for any gene at $t = -N$ (N not reported) and they are left subject to drift only, in a population of hunterer-gatherers, up to the advent of farming at $t = 0$, when it then follows (14). Simulating the population dynamics jointly to their genetic evolution produces a geographical gradient in gene frequencies (*genetic cline*, in the literature) consistent with the observed geographical gradient, from the Middle east to Europe, associated to 20 diallelic genetic forms for which data was available (these inlcude e.g., the Rh as well as the HLA genes). Different simulations with smaller diffusion parameter m, even when compensated by a larger technological adoption parameter γ, apparently generate too flat genetic clines. This is interpreted as evidence that demic diffusion (and intermarriage), as opposed to technological adoption, has played a fundamental role in the Neolithic transition.

More recently, phylogenetic methods from evolutionary biology have been adapted, along the lines of Rendine, Piazza, Cavalli Sforza (1986), in sophisticated studies of cultural and physical migration as well as of historical linguistics; see Cavalli Sforza, Menozzi, and Piazza (1994), Forster and Renfrew (2006), Peregrine, Peiros, and Feldman (2009). Also, for a more critical overview of this literature, sharing similar methods, see Rogers and Cashdan (1997) and Borgerhoff Mulder, Nunn, and Towner (2006).

3.3.1 Long term persistence

An important recent literature has documented the long term persistence and long lasting effects of institutions on socio-economic outcomes.[45] For instance, Acemoglu, Johnson, and Robinson (2001), following North and Thomas (1973) and North (1990a,b),

[45] Several fascinating papers explore the role of genetic evolution and especially of genetic diversity in explaining the variation in populations' economic and demographic success; see Galor and Moav (2002), Galor (2005), Ashraf and Galor (2010).

study protection of property rights and limitations on the power of the executive, while La Porta, Lopez de Silanez, Shleifer and Vishny (1999) study legal origin. Others, like e.g., Tabellini (2007), following Bainfield (1958), attribute the persistence of institutions to indicators of individual values and beliefs, such as trust and respect for others. Guiso, Sapienza, and Zingales (2008), following Putnam (1993), stress instead the long lasting effects of istitutions, the constitution of free city-states in medieval Italy in their study, on values and beliefs like trust. Relatedly, Durante (2009) documents the effects of historical institutions favoring cooperation and social insurance on trust in Europe. Other striking and interesting examples of long term persistence of values and institutions include the effect of the slave trade on trust (Nunn and Wantchekon, 2008), of Ottoman domination on corruption (Grosjean, 2009), of a history of civil conflict and violently play in soccer (Miguel, Saiegh, and Satyanath, 2008), of the Chinese writing system on the adoption of collective values (Mo, 2007), of medieval family systems on various indicator of demographic and economic development (Duranton, Rodríguez-Pose, and Sandall, 2007), of prevalence of herding on a "culture of honor" (Grosjean, 2010), of pogroms in 1349 in Germany (following the Black Death) on various measures of anti-Semitism in the 20's and 30's (Voigtländer and Voth, 2010), of early historical use of animal plough agriculture on female labor force participation (Alesina, Giuliano, and Nunn, 2010).

The motivation of these papers typically consists in identifying a *cause* of present day values and institutions which are conducive to economic growth: Is it *institutions*? Is it *values*? Or, *culture*? To this end it is not sufficient, while nonetheless very interesting, to document the statistical correlation between past institutions, values, and cultural traits and present-day socio outcomes. To identify causal effects the various measures of possible original institutions, values, and cultural traits are instrumented in a regression of present-day socioeconomic outcomes. For instance, settlers' mortality instruments for protection of property rights and limitations on the power of the executive in Acemoglu, Johnson, and Robinson (2001), since in countries with high settler's mortality colonial institutions where designed to extract value rather than to induce growth. Tabellini (2007) instead instruments culture and values in the distant past in Europe with within country variation in literacy rates at the end of the 18th century and other indicators of political institutions between the 17th and the 19th century, so as to implicitely control for political institutions, which do not vary within countries. Guiso, Sapienza, and Zingales (2008) instrument the constitution of a free city-state in medieval Italy with

dummies indicating cities which were the seat of a bishop before the turn of the millenium (typically, cities which were more independent from the Holy Roman Empire) and cities with an Etruscan origin (typically, cities enjoying a strategic military defense position). Finally, Durante (2009) instruments historical institutions favoring cooperation and social insurance with historical year-to-year variability in precipitations and temperature.

A different approach to the long term persistence of institutions, one that, by recognizing the endogeneity and interdependence of institutions, values, and culture, would exploit more directly the structural implications of cultural transmission models. We are not aware of any papers which systematically investigate culture and institutions adopting this approach. For instance Tabellini (2008), while explicitely modeling the interaction of values and political institutions, as we have seen, does not exploit the structural restrictions of the model but rather documents the statistical correlation between a measure of self-reported trust for U.S. citizens (from GSS survey data) and indicators of political institutions in their ancestor's country between the 17th and the 19th century. Similarly, Guiso, Sapienza, and Zingales (2008) model explicitly the transmission of beliefs, but document the persistence of trust (from both World Value Survey data as well as from German Socio Economic Panel data) without linking it structurally to the medieval political institutions in Italy the effects of which motivate their analysis.

An exemplary advantage of the adoption of structural methods to the empirical analysis of long term persistence of values, e.g, in Guiso, Sapienza, and Zingales (2008)'s data on Italian cities, would consist in exploiting the important aspect that values seem to persist *at the level of geographical units* even after centuries of intense migration patterns, e.g., across cities in Italy. This has, in principle, important un-exploited implications on the nature of the mechanism which governs the transmission of values.

Bisin and Verdier (2005) also do not attempt at a structural empircal analysis of their model of the interaction between the cultural transmission of norms of work ethic and the institutions of the welfare state. However, Ljunge (2010) represents an important step in this direction, tackling directly the implication of Bisin and Verdier (2005)'s model that, under initial conditions not unlike the socio-economic environment of northern Europe in the 70's, the political support for the welfare state will tend to intensify over time while work ethic norms will weaken. Using registry data on individual panels over the period 1974 to 1990 in Sweden, Ljunge (2010) estimates that exposure to the institutions of the welfare state can account for a large fraction of the younger generations' higher

Figure 12: Sick leave participation rate by cohort in Sweden. Source. Source: Ljunge (2010).

demand for social insurance benefits, the discretionary take up of sick leave benefits, in particular; see Figure 12.[46]

Another step in the direction of evaluating empirically the structural implications of cultural transmission in a socio-economic environment where institutions and culture, values, and beliefs are jointly determined is contained in Doepke and Zilibotti (2007) and in Fernandez-Villaverde, Greenwood, and Guner (2010).

Doepke and Zilibotti (2007) propose and provide empirical evidence for a theory of the success of the middle class during the British Industial Revolution, which relies on the reinforcement between its cultural traits favoring patience and a work ethic and the technology and market institution of early capitalism. In their model, altruistic parents shape their children's preferences, in partucular with regards to their patience and the work ethic. Parents' incentives to invest in their children patience increases in the steepness of the children's future income profile. At the same time, a relatively patient child

[46] For other recent important work along these same lines, see Alesina, Algan, Cahuc, and Giuliano (2010) on the interactions between family values and regulation of labor market; and Nannicini, Stella, Tabellini, and Troiano (2010) on the interaction between norms of generalized trust and political accountability in election.

will tend to favor professions characterized by a steep income profile. Relatedly, parents whose children will rely mostly on labor income will tend to socialize them to a strong work ethic and children with a strong work ethic will work harder and obtain high labor income. In this context, society will tend to become endogenously stratified into *social classes* defined by occupations and their associated preferences: artisans, craftsmen, and merchants will tend to be patient and will display a strong work ethic, while the landed upper class will tend to cultivate tastes for present concumption and leisure. The advent of the *spirit of capitalism*, and the new technologies associated with the Industrial Revolution, is the shock which selects the preferences of artisans, craftsmen, and merchants in Doepke and Zilibotti (2007). The model is shown to be consistent with several important historical facts regarding i) the predominantly middle class origin of the first industrialists; ii) the lack of involvement of landowners in the financing of new enterprises; iii) the catching-up of the wealth of non-landed entrepreneurs in manufactoring, commerce, and finance, with respect to the landed upper class.

While Doepke and Zilibotti (2007) informally argue for the consistency of their model with some statitical regularities pertaining to the Industrial Revolution, Fernandez-Villaverde, Greenwood, and Guner (2010) take more formally and directly their model of the Sexual Revolution to data. The Sexual Revolution in the U.S. is manifested by the fraction of women who have engaged in premarital sex by age 19: such fraction went from 6% in 1900 to about 75% nowadays. Importantly, the change in sexual behavior has been accompanied by a corresponding, while lagged, change in values regarding pre-marital sex: for instance, 15% of women in 1968 had a permissive attitude toward premarital sex, when 40% of 19 year-old females had experienced it; this attitude spread to 45% by 1983, when 73% of 19 year olds had had pre-marital sex. Fernandez-Villaverde, Greenwood, and Guner (2010)'s model interacts parental socialization with the children's choices regarding pre-marital sex and a marriage market equilibrium. Pre-marital sex, in the model, is costly because it possibly induces out-of-wedlock births which affect negatively marriage prospects. The model is calibrated and, when its reaction to a technological which drastically improves the contraceptive technology (thereby reducing the probability of out-of-wedlock births as a consequence of pre-marital sex) is simulated, it is shown to account for both the sexual revolution as well as for the lagged increase in permissive attitudes toward pre-marital sex.

Finally, a series of contibutions study the effect of human genetic diversity between populations on different current economic variables of interest. Because genetic mixing

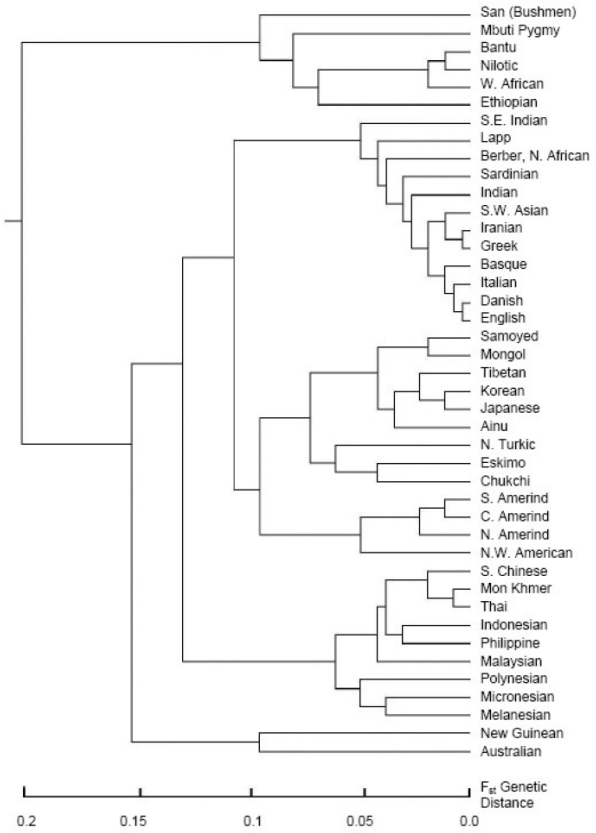

Figure 13: Genetic Distance Between 42 Populations. Source: Cavalli Sforza, Menozzi, and Piazza (1994).

across populations is an effect of heterogamous marriages and diffusion, as in the analyses of the Neolithic transition discussed in Section 3.3, genetic distance is appropriately interpreted as a proxy for cultural distance. This literature exploits data collected by Cavalli Sforza, Menozzi, and Piazza (1994; see pp. 75-76 and Figure 13 below) on allele frequencies in different populations. Genetic distance between two populations is measured as the probability that two alleles at a given genetic locus selected at random from the two populations will be different.[47]

In this literature, notably, Guiso, Sapienza and Zingales (2004) use genetic distance between European populations as an instrument for trust in trade gravity regressions.[48]

[47] The genetic loci sampled are chosen to be relatively neutral with respect to evolutionary selection.This measure of genetic distance can then also be interpreted as a measure of distance from the most recent common ancestors of the two populations.

[48] Giuliano, Spilimbergo, and Tonon (2006) however dispute the effect of genetic distance on trade

Desmet, Ortuno-Ortiz, and Wacziarg (2009) document the close relationship between genetic distance and cultural differences as measured by several answers to the World Values Survey regarding norms, values and cultural characteristics. Spolaore and Wacziarg (2009) construct worldwide measures of genetic distance between 137 countries and the U.S., considered to embed the technological frontier in 1995. and correlate them with income levels. In cross-countru regressions they document then a positive correlation between genetic distance from the frontier and income levels.

3.3.2 Immigration and Assimilation

The cultural transmission of ethnic and religious traits if often studied, somewhat indirectly, focusing on the behavior of immigrants. The dynamic pattern of cultural and socio-economic integration of immigrants to the receiving country contains evidence of the parental socialization (or lack thereof) to the traits which characterize their origin. Countless ethnographic studies have been produced about the immigrant experience in sociology and anthropology, at least since the photographic documentation about *How the other half lives*, in New York, by Jacob Riis in 1890.[49] Starting in the late 1950s and 1960s, many of them discredit the view that immigrants naturally assimilate in a melting pot and focus instead their struggles to socialize children to their ethnic and religious traits.

We concentrate in this survey on econometric studies of the integration pattern of immigrants. A fundamental tool of this analysis are assimilation indexes.[50] One such index has been recently proposed by Vigdor (2008). It measures the residual of the probability that an individual is an immigrant, appropriately rescaled from 0 to a 100 (maximal assimilation), when the probability is obtained under a linear probit prediction model. A measure of the speed of assimilation can then be ascertained from the graph in Figure 14, which reports the index as a function of *years in the U.S.* at different period in time (1900, 1910, 1920, 2006), that is, for different cohort of immigrants.

volume after controlling for geography.

[49] See e.g., the following *classic studies*, with no claims to exhaustivity whatsoever, W. C. Smith's *Americans in the Making* (1939), M. Hansen's *The Immigrant in American History* (1941), Whyte's *Street Corner Society* (1943), Handlin's *The Uprooted* (1951) and *Boston's Immigrants* (1959), J. Higham's *Strangers in the Land* (1955), O. Herberg *Protestant-Catholic-Jew* (1955), Glazer and Moynihan's *Beyond the Melting Pot* (1963), Gordon's *Assimilation in American Life* (1964), Mayer (1979).

[50] We generally prefer the word *integration* to the more charged *assimilation*. They are effectively synonyms, however, and we use the latter when so is done in the literature.

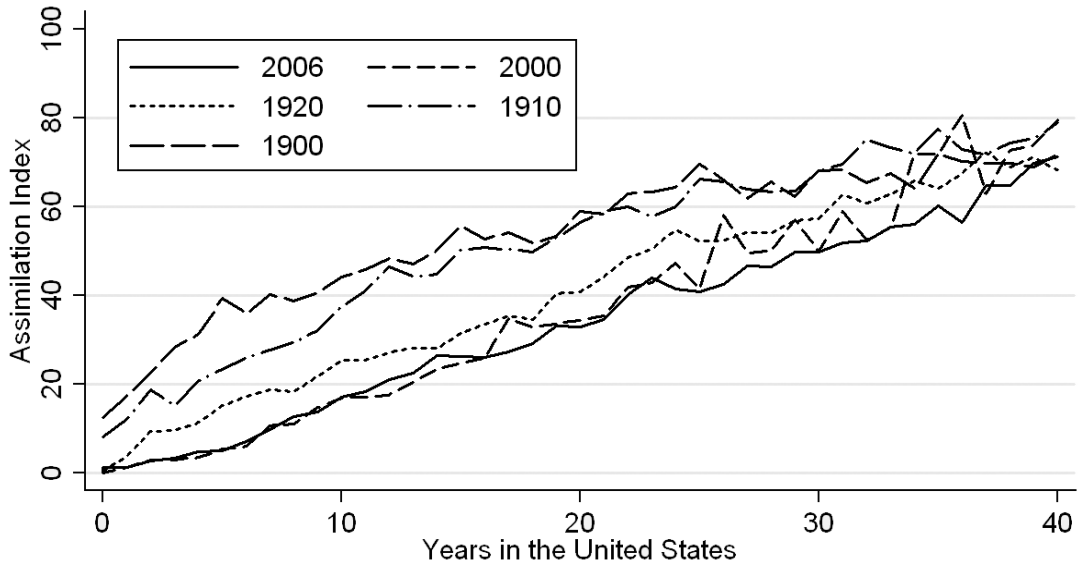

Figure 14: Assimilation by years in the U.S. Source: Vigdor (2008).

An extensive analysis of Census data from the point of view of Vigdor's assimilation index indicates that, for instance, immigrants in the U.S. in the past quarter-century have assimilated more rapidly than immigrants a century ago, even though Mexicans appear to assimilate at a slower rate than other immigrant groups before.

Other measures of integration are obtained by comparing first and second generation immigrants to natives of similar demographic and economic characteristics. Borjas (1995), for instance, studies residential segregation in Census 1970 and NLSY data. He documents a large variation in segregation rates across ethnic groups (first generation): e.g., 2.6% for Greeks, 2.2% for Jamaicans, 15.3% for Italians and 22.6% for Mexicans in the 1970 Census. Similarly, he documents a large variation in first-second generation differences in segregation rates: Italians go from 15.3% to 12.1%, Mexicans from 22.6% to 18.1%, while Cubans from 21.3% to 4.7%.

More formally, the integration literature typically relies on waves of cross sectional data (like e.g., Census data) to construct synthetic cohorts and distinguish integration from the effects of age at migration and cohort.[51] Consider a general trait y_i of an individual i in a fixed country j (the destination country). Let X_i represent individual specific controls and let I_k be a dummy taking value 1 if the individual is an immigrant

[51] See Borjas (1999) for a discussion of the identification problems arising when cohort effects are not accurately controlled for.

from country of origin k (and 0 for natives). The regression

$$y_i = \beta_0 + \beta_1 X_i + \\ \sum_k I_k \left(\begin{array}{c} \delta_k + \gamma_{1,k}\ age\ at\ migration + \gamma_{2,k}\ year\ of\ migration + \\ + \gamma_{3,k}\ length\ of\ stay \end{array} \right) + \varepsilon_i$$

identifies the speed of integration of immigrants from country k with $\gamma_{3,k}$, the coefficient of *length of stay*.[52] Furthermore, when data to distinguish second and third generation immigrants are available, let I_k be a first generation dummy, that is, 1 if the individual is a first generation immigrant from country of origin k (and 0 for second generation and natives); and let II_k be a second generation dummy, 1 if the individual is a second generation immigrant from country of origin k (and 0 otherwise).[53] In this case, the regression is:

$$y_i = \beta_0 + \beta_1 X_i + \\ \sum_k \left(\begin{array}{c} \delta_k + \gamma_{1,k}\ age\ at\ migration + \gamma_{2,k}\ year\ of\ migration + \\ + \gamma_{3,k}\ length\ of\ stay \end{array} \right) I_k + \varepsilon_i \\ + \sum_k \theta_k II_k$$

and θ_k identifies the second generation effect.

Following some variant of this methodology, measures of economic integration for the U.S. and Canada have been constructed using earnings, (log) wage rates, skills (see e.g., LaLonde and Topel, 1997 and Borjas, 1999, for surveys). Other measures of assimilation, which focus more on cultural dimensions, have been constructed using intermarriage rates (Pagnini and Morgan, 1990; Meng and Gregory (2002); Bisin, Patacchini, Verdier, Zenou, 2008), or English proficiency (see Chiswick and Miller, 1992), ethnically-revealing names (Arai, Besancenot, Huynh, and Skalli, 2009), civic participation (Aleksynska, 2007), ethnic job specialization (Mandorff, 2005), self-reported measures in survey data (Dustmann, 1996; Bisin, Patacchini, Verdier, Zenou, 2008; Manning and Roy, 2009).

A recent empirical literature has studied the behavior of immigrants with a different perspective. This literature, which goes by the name of *epidemiological approach*,[54] is

[52] We abstract here from several measurement issues which are dealt with in different ways in this literature, e.g., the definition of second generation and of couuntry of origin.

[53] Panel data are necessary to correct for the survivorship bias due to return migration and cohort heterogeneity; see e.g., Hu (2000).

[54] See Fernandez (2007) for a methodological discussion of the approach, as well as Fernandez (2010), in this Handbook for a more detailed survey.

motivated as an attempt to isolate cultural traits of the origin countries which affect the behavior of immigrants (including second generation immigrants) in the destination countries. In this sense, the literature provides evidence that *culture matters* (see Fernandez, 2010, in this Handbook for a survey). In the process of documenting that culture matters, however, these studies indirectly measure the persistence of ethnic and religious traits, which immigrants maintain from their original backgrounds.

Consider a sample of individuals born in country j, including natives and second generation immigrants from country of origin k. Consider a general trait y_i of an individual i in country j, and let Y_k be measure of the mean value of the trait in the country of origin. Ideally the mean Y_k should be measured at the beginning of the immigration wave to country j which resulted in the second generation immigrant population in the sample. In this case Y_k is interpreted to instrument from culture. The regression

$$y_i = \beta_0 + \beta_1 X_i + \sum_k \gamma_k Y_k + \varepsilon_{ij}$$

identifies the effects of country k's culture with γ_k, the coefficient of Y_k.[55]

Data regarding several behavioral traits of interest are have been collected and analyzed using the *epidemiological approach*; see Fernandez and Fogli (2006a,b) for female labor supply and fertility, Giuliano (2007) for living arrangements of 18-30-year-olds, Tabellini (2005) and Guiso, Sapienza, and Zingales (2006) for social capital, Algan and Cahuc (2006, 2007) and Tabellini (2008) for trust.

Statistics like the average speed of integration and the correlation between the speed of integration and the prevalence of the ethnic group in the country as a whole or in specific geographical areas like e.g., states, could be produced with the data employed in the epidemiological literature. They would give a better picture of cultural transmission of ethnic and religious traits.

While the immigration literature provides much needed empirical evidence on integration, results cannot be interpreted to indicate the (causal) determinants of the speed of integration. In particular, properly identifying the determinants of integration would require identifying cross-cultural variations in attitudes towards integration on the part of immigrants from the incentives to integration, which depend on the socio-economic conditions of the destination country.[56] Furthermore, this literature cannot address the important issue of changes in the speed of integration across generations, as little is

[55] In several instances the effects of culture are restricted to be equal across country of origin, $\gamma_k = \gamma$, for any k.

[56] Meng and Gregory (2002) address this issue for Australia by measuring the earning gap in favor of

known about third generations. Finally, the speed of integration depends on the cultural trait of interest, as for instance language assimilation is much faster than religious assimilation (Jasso, 2009).

3.4 Socialization

A large empirical literature in sociology and economics concerns socialization mechanisms directly. It addresses a few general questions, like, Are relevant cultural traits and preferences correlated across generations? Which socialization mechanisms are more responsible for cultural transmission?

The answer to the first question tends to be positive for many traits; from specific traits, like use of salt in food, to general preferences and attitudes, like generosity. Cavalli Sforza Feldman, Chen, and Dornbusch (1982) document high intergenerational correlations in a pool of Stanford students (and their parents) for many traits, including religious and political affiliation and attitudes, superstitions, and habits (including use of salt in food). Among the most interesting recent studies, high correlations are found in risk and discounting preferences (Arrondel, 2009), risk and trust attitudes (Dohmen, Falk, Huffman, and Sunde, 2006, on the 2003 and 2004 waves of the German Socio-Economic Panel), attitudes towards supporting own parents in old age (Jellal and Wolff, 2002a), attitudes towards supporting own children (Jellal and Wolff, 2002b), attitudes toward work, welfare, and individual responsibility (Baron, Cobb-Clark, and Erkal, 2008, from Youth in Focus Project data on Australian administrative social security records between 1993-2005), and generosity (Wilhelm, Brown, Rooney, and Steinberg, 2008). The relation between parents' and children's fertility behaviors is also very well documented; see e.g., Murphy and Knudsen (2002), Murphy and Wang (2001), Tymicki (2005) and the references therein. Similarly, a strong intergenerational correlation between gender role attitudes is also well documented (see Farre' and Vella, 2007, on a sample of mother-child pairs from the NLSY79; Fernandez, Fogli, and Olivetti, 2004, on a sample of mother-son pairs from the GSS). On the other hand, Cipriani, Giuliano, Jeanne (2007) find no correlation in attitudes towards cooperation in an experiments with young children (and their parents).

intermarried immigrants. Arai and Thoursie (2006) measure, for Sweden, the earning gap obtained by those immigrants who change their name to a more Swedish-sounding one. Avitabile, Clots-Figueras, and Masella (2009) relate immigrants' propensity to integrate to a more favorable citizenship legislation in Germany. See also Hatton and Leigh (2007) for a discussion of these issues.

With regards to the socialization mechanisms most responsible for cultural transmission, some of the stylized facts include the following: religious and ethnic traits are usually adopted in the early formative years of children's psychology, and family, peers and role models play a crucial role in determining their adoption (Clark and Worthington 1987, Cornwall 1988, Erickson 1992, Hayes and Pittelkow 1993); children of mixed religious marriages have weaker religious commitments and are less likely to conform to any parental religious ideology or practices (Hoge and Petrillo, 1978, Hoge, Petrillo and Smith, 1982, Heaton 1986, and Ozorak 1989); the effect of homogamy on socialization is strong, though it vanishes if socialization effort is controlled for (Hayes and Pittelkow, 1993); schools and other collective socialization mechanisms are perceived as effective socialization instruments (O'Brien and Fugita, 1991, for Japanese; Mayer, 1985, for Jews; Tyack, 1974, for Germans; and, more recently, Glazer, 1997, for African-Americans).

Of course, intergenerational correlations and revealed preferences for the ethnic composition of schools cannot be interpreted directly as measures of successful socialization, because of several daunting identification problems. In partcular, these include the issues associated to the nature/nurture problem (see Sacerdote, 2010, in this *Handbook* for a survey of the literature in economics and in behavioral genetics). Detailed empirical analyses of the properties of socialization mechanisms can nonetheless shed light on several fundamental questions arising in the study of cultural transmission, How is cultural heterogeneity explained? What are its determinants?

The theoretical work on cultural transmission we surveyed identifies *cultural substitution* between *vertical and oblique/horizontal transmission* as a general component of socialization mechanisms which induce heterogeneity, especially in socio-economic environments characterized by *strategic substitution*. Also, *cultural distinction* in identity formation mechanism of minorities acts in a related manner. Importantly, however, all these implications rely on the assumption of *imperfect empathy* and on the distinction between *vertical and oblique/horizontal transmission*.

Do we observe *imperfect empathy, vertical and oblique/horizontal transmission, cultural substitution, strategic substitution,* and *cultural distinction*? We next survey the empirical literature dedicated to address these specific questions.

3.4.1 Imperfect empathy

Evidence for *impure altruism* (a general form of *imperfect empathy*) is found in the empirical analysis of *inter vivos* transfers (see e.g., Altonji, Hayashi, and Kotlikoff,

1997, and Laferrere and Wolff, 2006). Survey data can also be taken to bear indirect light on the issue: in the response to NORC's General Social Survey's question, 'Which three of the qualities listed would you say are the most desirable for a child to have ?' 'obedience' is cited on average across the sample more than, (in order) 'self-control', 'success', 'studiousness', 'cleanliness', and less often only than 'honesty.'

3.4.2 Vertical vs. oblique/horizontal transmission

Boothand Kee (2009) estimate count data quantile regression models using the British Household Panel Survey to distinguish vertical and oblique transmission of fertility rates, finding strong evidence for substantial vertical transmission. Branas-Garza and Neuman (2007) exploit data from the International Social Survey Programme: Religion II (ISSP) on church attendance and prayer habits of parents in Spain and Italy to study the effect of a specific vertical transmission mechanism - exposure to religiosity - on fertility preferences and practice of children. The major finding is that such effect are pronounced, though maternal and paternal effects are different. Collado, Ortuno-Ortin, and Romeu (2005) introduce a novel methodlogy to identify vertical transmission in consumption choices, lacking consumption data for both parents and children. Analyzing the correlation between the geographical distributions of surnames and consumption choices, they conclude that the data suggest a very significant vertical transmission of preferences regarding food items and no vertical transmission for non-food goods. Aleksynska (2007) adopts the synthetic cohort methodology to study the cultural transmission of immigrants to the European Union with European Social Survey and World Values Survey data). In particular she is interested in determining whether the observed levels of immigrants' civic participation depends relatively more on the levels of natives' civic participation in the same countries or in the country of destination. Notwithstanding selection issues, the evidence in favor of country of destination effect suggests horizontal transmission leading to the solicit internalization of the norms of the host country. Uslaner (2008) similarly test wheather an individual generalized trust is relatively more transmitted from parents to children, obtained by ethnic heritage (where their grandparents came from), or by horizontal and oblique transmission (the proportion of people of different ethnic backgrounds in a state), finding strong evidence in favor of direct vertical socialization and ethnic heritage.

Many empirical studies concern the determinants of female labor force participation, to identify cultural components. Fernandez and Fogli (2005) show that the variation in

the work behavior of second-generation American women can be explained, in part, by the level of female labor force participation in their parents' country of origin. Moreover, Fernandez (2007b) shows that the attitudes towards women's work in the parental country of origin has important explanatory value for second-generation American women 's work behavior in the U.S. Fernandez, Fogli, and Olivetti (2004) identify a vertical transmission mechanism: sons of working mothers seem to diplay a prefererence for working wives, relatively to sons of non-working mothers. Fernandez (2007a) and Fogli and Velkamp (2007) find evidence for a horizontal transmission and learning in a variety of data, from calibration to survey and labor market data.

3.4.3 Marriage

Chiswick (2008) studies the determinants of ethnic intermarriage by means of a binomial logistic regression using 1980 US Census data. Interestingly, the paper constructs measures for the *availability ratios for potential spouses* and for *group size*. It then documents lower intermarriage rates the greater the availability ratio and the larger the size of the group, a property generally consistent with choice theoretic marriage markets. Evidence for homogamous marriage as a socialization mechanism can be indirectly gauged from the fact that most religious denominations include rules favoring homogamy (Smith 1996) and that most conversions are attributable to the desire of establishing homogamy (Greeley, 1979; Branas-Garza, Garcia-Munoz, and Neuman, 2007). Furthermore, Becker (2009) provides evidence, from the Preschool Education and Educational Careers among Migrant Children project on naming patterns of Turkish parents in Germany, that intermarriage strongly decreases the probability of Turkish names.[57]

A more detailed non-linear analysis of this dependence is necessary, however, to identify the properties of marriage as a socialization mechanism. Bisin, Topa, and Verdier (2004) attempt this endeavor, producing an empirical analysis of the endogenous marriage model in Section 2.2.2. Exploiting the geographic variation in the distribution of religious traits in the U.S., Bisin, Topa, and Verdier (2004) estimate the model by matching simulated inter-marriage rates π^{ij} and socialization rates P^{ij}, at a given moment in

[57] Evidence for marriage as socialization: most religious denominations include rules favoring homogamy (Smith 1996); most conversions are attributable to the desire of establishing homogamy (Greeley, 1979; Branas-Garza, Garcia-Munoz, and Neuman (2007).). Furthermore, Becker (2009) provides evidence from the Preschool Education and Educational Careers among Migrant Children project on naming patterns of Turkish parents in Germany, finding that intermarriage strongly decreases the probability of Turkish names.

time, with the corresponding empirical moments. The data are from the General Social Survey (GSS), 1972-1996, with respect to 4 religious groups: Protestants, Catholics, Jews, and the residual group, Others ($i, j = P, C, J, O$). The geographical unit of variation is a U.S. state (for 23 of them). Information on socialization rates P^{ij} was obtained from a special module on religion of the GSS. The structural parameters of the model are the intolerance parameters ΔV^{ij}, for any i and j, and the parameters of the cost functions for socialization and entrance in the restricted marriage pool. Furthermore, they test the model against different alternatives which restrict the role of marriage as a socialization mechanism, finding support for socialization as a major incentive for religious homogamy in marriage.

The observed intermarriage rates by religious trait in the U.S. data are a stark indication of the prevalence of religious homogamy. Figure 15 displays the probabililty of homogamous marriage, in the data, as a function of the religious shares, by U.S. state, for the four religious groups analyzed in the study (Protestants, Catholics, Jews, and Others).

Similarly, socialization rates are also very high, along the religious dimension; especially in homogamous marriages; see Table 2.

	Protestants	Catholics	Jews	Others
PP marriage	.9179	.0284	0	.0537
CC marriage	.0850	.8571	.0034	.0544
JJ marriage	.0370	0	.9259	.0370
OO marriage	.3231	.0462	0	.6308
PC marriage	.5116	.3140	0	.1744
PO marriage	.7100	.1000	0	.1900
CO marriage	.1667	.5000	0	.3333

NOTE.—Each cell reports the sample probability that a child in the row marriage is a member of the column religious group. P = Protestants, C = Catholics, J = Jews, and O = Others.

Table 2: Socialization rates for selected marriage types. Source: Bisin, Topa, and Verdier (2004).

Note that points on the 45°-line in the graph represent the marriage rates which would be obtained by random matching, by religious share. Datapoints above the 45°-line are then to be interpreted as raw evidence for the prevalence of homogamy.

The endogenous marriage model fits these data quite well, as illustrated by Figure 16 and Table 3 (see the paper for formal statistics).

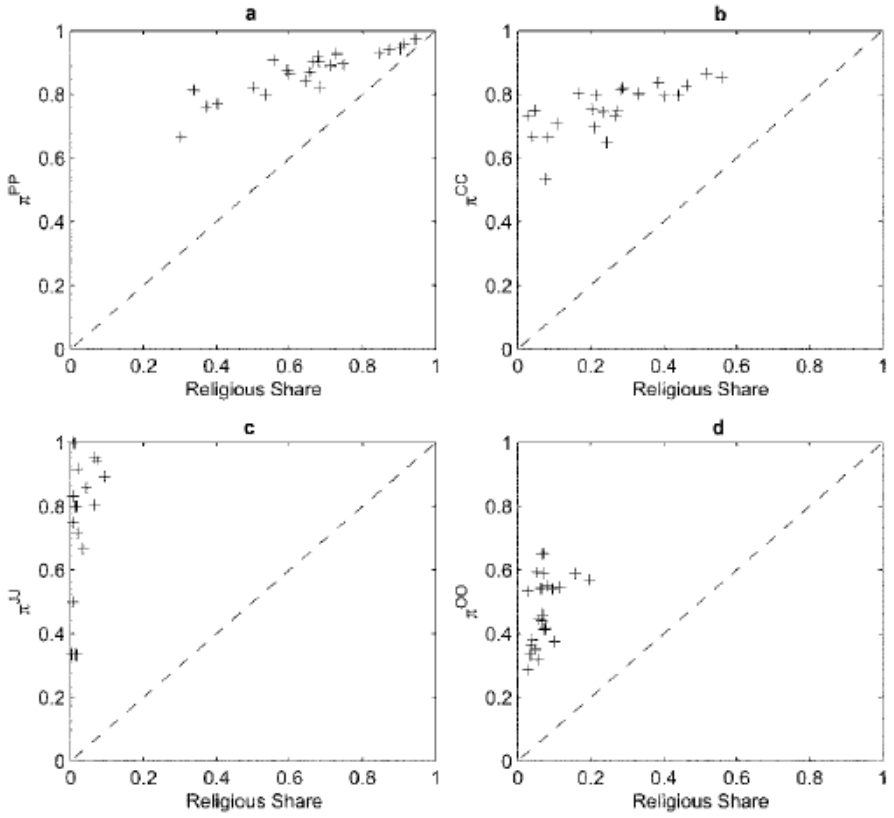

Figure 15: Probability of homogamous marriage as a function of the religious shares, by U.S. state. a: Protestants; b: Catholics; c: Jews; d: Others. Source: Bisin, Topa, and Verdier (2004).

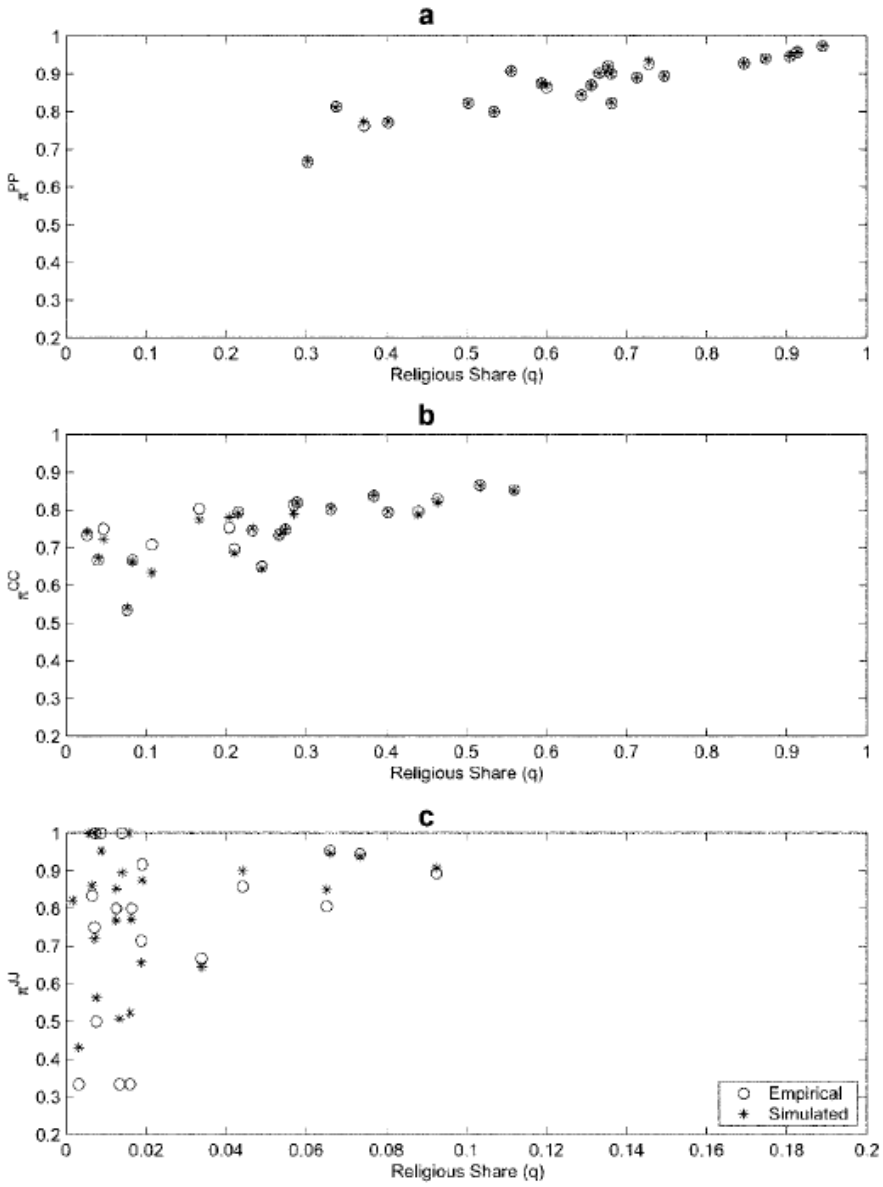

Figure 16: Fit of the endogenous marriage model: Homogamous marriage probabilities. a: Protestants; b: Catholics; c: Jews. Source: Bisin, Topa, and Verdier (2004).

	Protestants	Catholics	Jews	Others
	A. Empirical Frequencies			
PP marriage	.9179	.0284	0	.0537
CC marriage	.0850	.8571	.0034	.0544
JJ marriage	.0370	0	.9259	.0370
OO marriage	.3231	.0462	0	.6380
PC marriage	.5116	.3140	0	.1744
PO marriage	.7100	.1000	0	.1900
CO marriage	.1667	.5000	0	.3333
	B. Simulated Frequencies from the Model			
PP marriage	.9227	.0349	.0031	.0394
CC marriage	.1078	.8293	.0065	.0564
JJ marriage	.0308	.0220	.9291	.0180
OO marriage	.1472	.0712	.0078	.7738
PC marriage	.4855	.3409	.0165	.1571
PO marriage	.5168	.1378	.0131	.3323
CO marriage	.3051	.3425	.0192	.3333

NOTE.—Each cell reports the sample probability that a child in the row marriage is a member of the column religious group. P = Protestants, C = Catholics, J = Jews, and O = Others.

Table 3: Fit of the endogenous marriage model: Socialization rates. Source: Bisin, Topa, and Verdier (2004).

The significant positive intolerance parameters (with the exception of the parameter describing attitudes toward Jews of the residual group, Others)[58] estimated by Bisin, Topa, and Verdier (2004) are consistent with homogamous marriage to be perceived (and chosen) by agents as a socialization mechanism.

The estimated model of marriage and socialization is based on the behavioral assumption that marriage and socialization are endogenously determined as economic decisions of agents who have preferences for children with their own religious attitudes. But Bisin, Topa, and Verdier (2004) also formally assess the relevance of economic behavior to explain the observed socialization and marriage rates by conducting some statistical test to compare the performance of the model to several alternative specifications that make different behavioral assumptions; namely, a first specification in which marriage segregation choices are endogenous but socialization is exogenous, a second specification in which both marriage and socialization are exogenous, and a third specification in which the value of a homogamous marriage is exogenous and independent of the religious share. The rankings of the Sargan test of the overidentifying restrictions reported in the paper suggest that all three alternative models do not fit the data nearly as well as the baseline

[58] The most striking estimates are those describing the intolerance parameters of Jews, which are about four times as high as those of any other religious group.

model (p-values vary between .02 and .0017, compared with .11 in the baseline model estimate).[59]

In summary, parameter estimates in Bisin, Topa, and Verdier (2004) are consistent with Protestants, Catholics, and Jews having a strong preference for children who identify with their own religious beliefs and making costly decisions to influence their children's religious beliefs.

3.4.4 Neighborhood and school choice

Ioannides and Zanella (2007) study the determinants of household decisions to change residence, using geocodes to merge micro data from the PSID with data at the level of census tracts from the 2000 US Census. They identify parental concerns about children socialization, within neighborhoods and schools, off of households' revealed preferences over attributes of neighborhoods. They find strong evidence that households with children (but not those without) are more likely to move neighborhoods with commonly perceived characteristics which are more conducive to the transmission of parental cultural traits.

Relatedly, Kremer and Sarychev (2000) collect data to argue that school choice (as opposed to a public school system) is correlated with cultural segregation, as parents choose their children schools as part of their vertical socialization effort.

3.4.5 Collective socialization mechanisms

Evidence about the empirical relevance of collective socialization mechanisms, especially school, is sparse but not surprisingly clear-cut, at least for some specific traits like language; see e.g., Aspachs-Bracons, A., I. Clots-Figueras, and P. Masella, 2007, and Aspachs-Bracons, A., I. Clots-Figueras, J. Costa-Font, and P. Masella, 2008, for the Catalan and the Basque case. Hryshko, Luengo-Prado, and Sorensen (2006) find that, in the Panel Study of Income Dynamics, state-level compulsory schooling laws that boosted parents' education made children less risk averse through adulthood, suggesting an horizontal transmission mechanism operating through public schooling (for the parents) and associated to vertical socialization of children.

[59] A formal statistical test comparing the baseline to the alternative specifications requires a procedure to compare nonnested models. The results of one such test produced in the paper confirm the Sargan test rankings.

3.4.6 Cultural substitution

The literature addressing the issue of cultural substitution has typically a more structural flavor. Even without time series data the cultural transmission model can in fact be identified and estimated through cross sectional data on socialization frequencies across different populations.

Identification of cultural intolerances ΔV^i, requires the observation of socialization probabilities P^{ii}, P^{jj} at a point in time for different populations characterized by different population shares q^i. Several papers undertook this approach, whose main difficulty however consists in requiring the exogeneity of q^i. In fact, in empirically work, the populations are constituted by the residents of different geographic units, like counties, census tracts, or states. As long as individuals choose where to reside and base their choice on the cultural composition of the geographic unit, the the exogeneity of q^i is called into questions. Various data dependent methods to deal with this issue have been developed in the literature.

The first paper to structurally estimate an economic model of cultural transmission is Bisin, Topa, and Verdier (2004), which we discussed in Section 2.2.2. While the aim of the paper is to test the behavioral assumption that marriage and socialization are endogenously determined as economic decisions of agents, the structural estimates of the parameters of the model provide evidence which can distinguish between cultural substitution and complementarity. In particular, the parameter estimates for the cost of socialization and marriage segregation reveal a strong dependence religious shares which could be interpreted as partial evidence for some form of cultural complementarity. In fact, the estimated direct socialization as a function of the religious share is not negatively sloped in all the domain, as would be required for cultural substitution; see Figure 17.

Nonetheless it is clear from the figure that socialization rates of small religious minorities (with religious shares close to 0) are much higher than what random socialization in the population would imply (the same is true for marriage homogamy with respect to random matching, not reported here). To better understand the implications of the model estimates with respect to religious heterogeneity, Bisin, Topa, and Verdier (2004) simulate the population dynamics of the distribution by religious group, over time, using the estimated structural parameters and the empirical religious composition of several U.S. states as initial conditions.[60] Results are reported in Figure 18. Note that two

[60] The authors caution the reader that

> These simulations are only aimed at illustrating the implications of the estimation

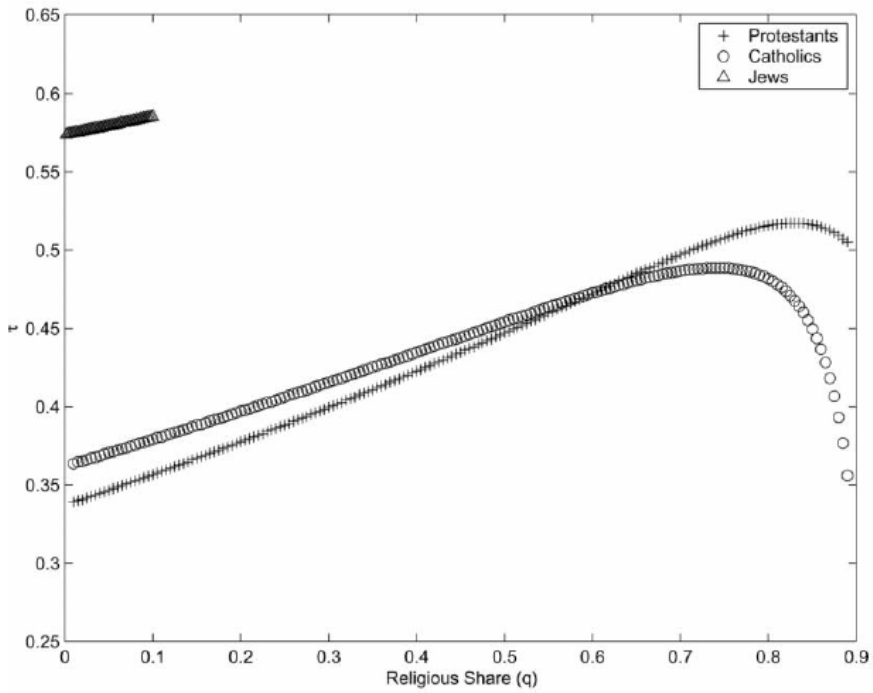

Figure 17: Socialization as a function of the religious share. Source: Bisin, Topa, and Verdier (2004).

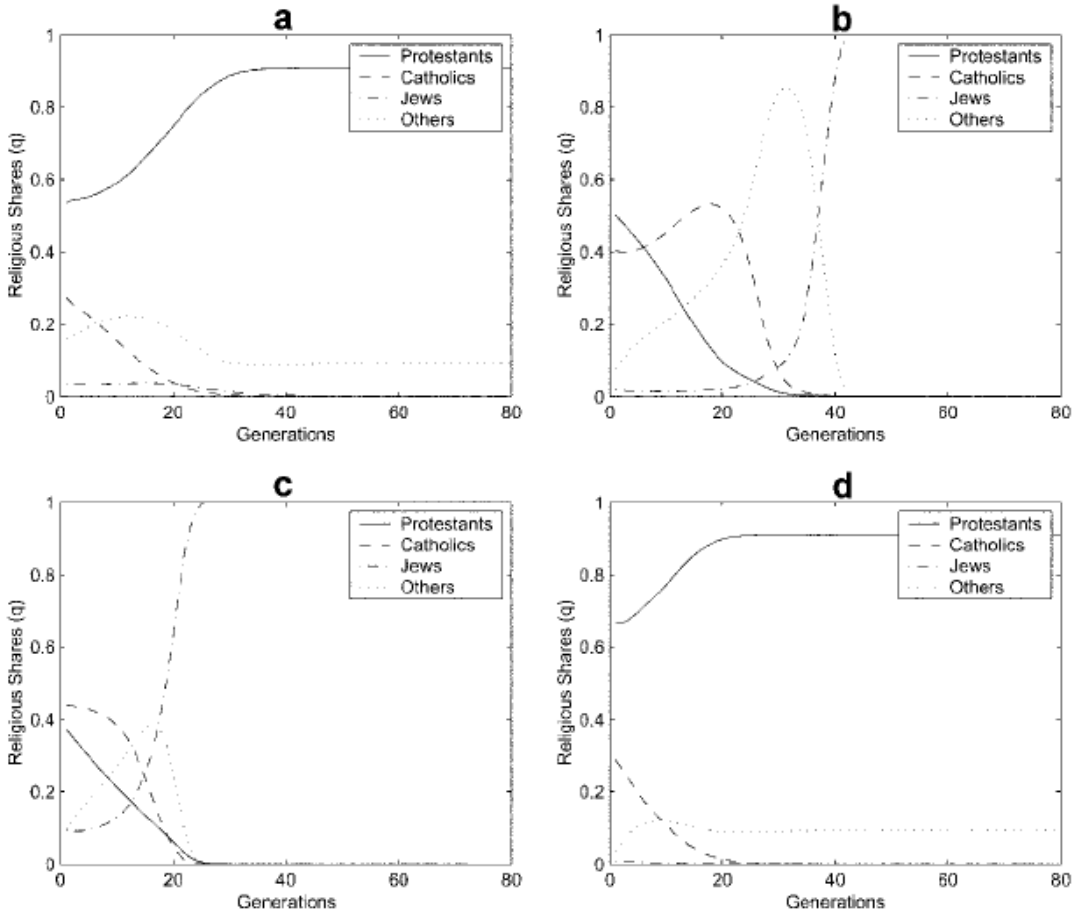

Figure 18: Simulated population dynamics. Initial conditions: a, California; b, Illinois; c, New York; d, Texas. Source: Bisin, Topas, Verdier (2004).

different stationary distributions of the population by religious trait are attractive for different sets of initial conditions: one has a large majority of Protestants (about 90 percent) and a minority of the residual group, Others (about 10 percent); the other is uniquely composed of Jews.

The simulations therefore support some cultural heterogeneity at the stationary state of the population dynamics. In particular, they are in stark contrast to those emerging from linear extrapolations of current trends: in particular, the *triple melting pot* (along the religious dimension) and the *vanishing of American Jews* hypotheses, suggested,

results and should not be interpreted as direct forecasts of the future prevalence of the different religious denominations; p. 645

respectively by Herberg (1955) and Dershowitz (1997) and often aired in the sociological literature, are not supported.

Namoro and Roushdy (2008) also test cultural substitution directly, on data on the preference for fertility of married Egyptian women. In particular, Namoro and Roushdy (2008) estimate structurally (1),

$$P^{ii} = d(q^i) + (1 - d(q^i))q^i,$$

for $i = l, h$, where l (resp. h) denotes the low (resp. high) fertility preference trait. Given data on q^i and P^{ii} (as well as on a series of covariates) across 26 administrative localities (Governatorates), $d(q^i)$ is estimated non-parametrically and the resulting negative slope is evidence for cultural substitution.

Cohen-Zada (2006) pursues an empirical analysis of U.S. county data (from Religious Congregations and Membership in the U.S. 2000 and various years of School and Agency Survey and Private School Survey) on Catholic and private school enrollment to explicitly test for cultural substitution, that is, to test whether the demand for separate religious schooling declines with the share of the religious minority. Cultural substitution is already evident from raw correlations, see Table 4, which displays an inverted U-shaped relationship between enrollment in Catholic schools and the share of Catholics in the population, by county.

Catholic share in the population	Number of observations	Average Catholic enrollment rate
0% - 10%	3352	0.527%
10% - 20%	1307	2.504%
20% - 30%	708	4.722%
30% - 40%	376	6.702%
40% - 50%	174	6.719%
50% - 60%	129	8.210%
60% - 70%	49	7.887%
70% - 80%	27	6.901%
80% - 90%	14	3.639%
90% - 100%	7	0.000%

Table 4: Enrollment in Catholic schools out of total enrollment. Source: Cohen-Zada (2006).

Patacchini and Zenou (2004) also speak to the identification of cultural substitution vs. complementarity. They study the vertical transmission of preferences for education, under the assumption that both educated and uneducated parents wish to transmit preferences for education to their children, so as to positively affect their educational attainment, but educated parents are most effective at doping so, other things equal. An important property of the data Patacchini and Zenou (2004) exploit, the UK National Child Development Study (NCDS), is that it allows them to construct a direct measure of parental socialization effort, based on qualitative information on the parent's interest in his/her child's education. Imputing a measure of neighborhood quality from Census data on the distribution of education levels by ward, Patacchini and Zenou (2004) can study the relationship between parental socialization effort and neighborhood quality. Assuming that residential location is exogenous, Patacchini and Zenou (2004) interpret their evidence that parents invest more in socializing their children when living in a high quality neighborhood as evidence for cultural complementarity. If residential location were endogenous, and parents moved to neighborhoods with desirable characteristics in terms of socialization, as e.g., documented by Ioannides and Zanella (2008) and Kremer and Sarychev (2000), then Patacchini and Zenou (2004)'s result would instead be consistent with cultural substitution, as parental effort and neighborhood choice could both represent distinct direct vertical socialization instruments. An additional interesting result of Patacchini and Zenou (2004) regards the differential socialization effort, on average, between high and low educated parents. Consistently with imperfect empathy joined with the assumption that educated parents are more efficient in socializing their children to preferences for education, low-educated parents significantly less time than their educated counterparts, other things equal, in socializing their offspring; in fact, in this case, only the quality of the neighborhood has a significant impact on their children's educational attainment.

This structural evidence for *cultural substitution* is also consistent with several empirical studies studying the link between identity and segregation. Using a nationally representative sample of more than 90,000 students from 175 schools who entered grades 7 through 12 in 1994 in the US (the National Longitudinal Study of Adolescent Health), Fryer and Torelli (2005) find that "acting white" behaviors among blacks (i.e. the higher is the test score, the less popular a student is) are more developed in racially mixed schools.[61] Munshi and Wilson (2008) combine data from the U.S. census and the

[61] Anthropologists have also observed that social groups seek to preserve their identity, an activity

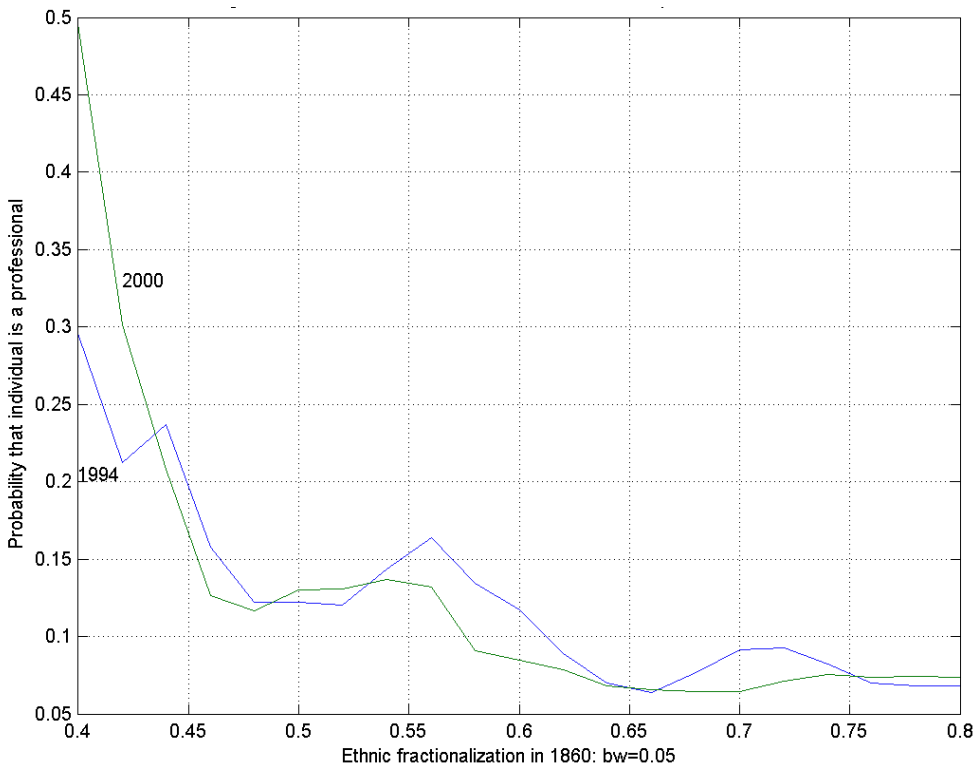

Figure 19: Relationship between ethnic fractionalization in 1860 and the probability that individuals have professional jobs. Source: Munshi and Wilson (2008).

National Longitudinal Survey of Youth 1979 (NLSY79) to identify a negative relationship across counties in the Midwest of the United States between ethnic fractionalization in 1860 and the probability that individuals have professional jobs or migrated out of the county by 2000; see Figure 19.

Furthermore, Munshi and Wilson (2008) also document a positive correlation between ethnic (and religious) fractionalization and better functioning religious and parochial institutions, suggesting an important role of churches in the transmission of ethnic traits.[62]

that accelerates when threats to internal cohesion intensify. Thus, groups may try to reinforce their identity by penalizing members for differentiating themselves from the group. The penalties are likely to increase whenever the threats to group cohesion intensify; for an early analysis of this issues, see Whyte (1943).

[62] Anthropologists have also observed that social groups seek to preserve their identity, an activity that accelerates when threats to internal cohesion intensify. Thus, groups may try to reinforce their identity by penalizing members for differentiating themselves from the group. The penalties are likely

3.4.7 Cultural distinction

Bisin, Patacchini, Verdier, and Zenou (2010) study instead identity formation, aiming at distinguishing *cultural conformity* from *cultural distinction*.[63] They exploit the Fourth National Survey of Ethnic Minorities (FNSEM) of the U.K. The dataset oversamples Caribbean, Indian, Pakistani, African-Asian, Bangladeshi, and Chinese and contains a direct survey question about respondents' identification with their own ethnic group and additional (indirect) information about different dimensions of identity (e.g. attitudes towards inter-marriage, importance of religion and other aspects of individual's ethnic preferences).

To better address the possible endogeneity of residential decisions Bisin, Patacchini, Verdier, and Zenou (2010) proceeds in steps, from a non-structural probit analysis of identity and homogamy in terms of ethnic composition to fully structural models of ethnic integration. The probit displays a negative relationship between ethnic identity and the share of the ethnic group in the neighborhood, for those neighborhoods in which the share is above 20%, a result consistent with cultural distinction, see Figure 20.[64]

The structural analysis of identity formation exploits the identity formation choice model (extended to jointly determine identity and homogamy in marriage) outlined in Section 2.2.5. The model produces a map between identity v^i and the psychological costs of interacting with the majority $c(q^i)$. A non-parametric estimate of $c(q^i)$ under the restrictions of the model is also consistent with ethnic identity being formed as a *cultural distinction* mechanism, and so is a structural estimate of the model parametrized to formally nest *distinction* and *conformity* and to allow individuals to choose the neighborhood where to resided depending on its ethnic composition.[65]

The predicted speed of in integration can be gauged upon from Figures 21 and 22,

to increase whenever the threats to group cohesion intensify; for an early analysis of this issues, see Whyte (1943).

[63] Other empirical studies on identity formation include Battu and Zenou (2009), Constant, Gataullina and Zimmermann (2009), Nekby and Rödin (2009), and Manning and Roy (2009). We do not discuss them in detail because they take a more descriptive approach.

[64] The analysis uses a self-reported measure of "importance of religion" as a proxy for ethnic identity. The use of the other proxies leads to similar results.

[65] Also, recent studies of the *Islamic Revival*, the surge in Islamic participation in the world since the 1970s, suggest interpretations which are consistent with cultural defense, inasmuch as the decline of social mobility and the impoverishment of the middle-class in Islamic countries, relatively to the economic success of West, have intensified the religious revival of Islam; see Carvalho (2009) and references therein.

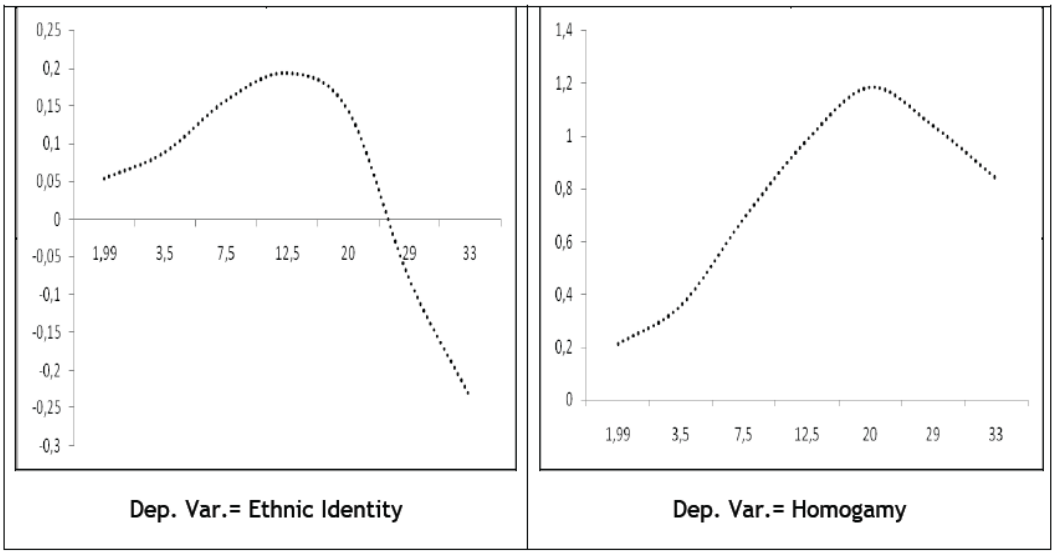

Figure 20: Non linear effect of neighborhood ethnic composition on identity and homogamy. Source: Bisin, Patacchini, Verdier, and Zenou (2009).

reporting predicted identity and homogamy, respectively, as a function of time spent in the U.K . The ethnic homogamy rate, for instance, is predicted to decline less than 10% between first and second immigration immigrants.

Finally, *cultural distinction* is also consistent with the literature on participation in social activities as a function of segregation and fractionalization, as in Alesina and La Ferrara (2000), Putnam (2007), Letki (2008), and Fumagalli and Fumagalli (2010).

4 Conclusions

This article has reviewed the main contributions of models of cultural transmission, from theoretical and empirical perspectives. The literature reviewed has developed a set of workhorse models to study the dynamics of cultural traits, values, and beliefs. These models have been extended in several dimensions of interest and have been put to data.

This literature has been successful in providing a better understanding of the cultural heterogeneity which characterizes the human condition as well as of the cultural resilience of ethnic and religious traits which has been repeatedly observed in human history. Furthermore, this literature has advanced our understanding of the patterns of cultural integration of immigrants and of the properties of various socialization mechanism.

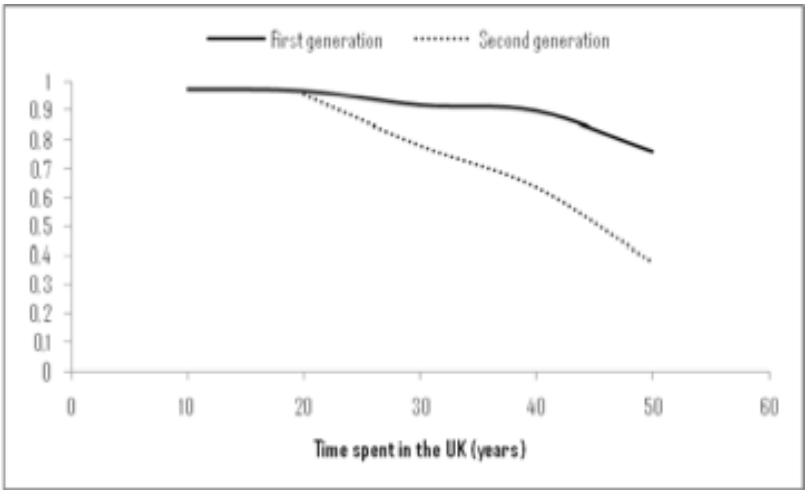

Figure 21: Predicted identity as a function of time in the U.K. Source: Bisin, Patacchini, Verdier, and Zenou (2009).

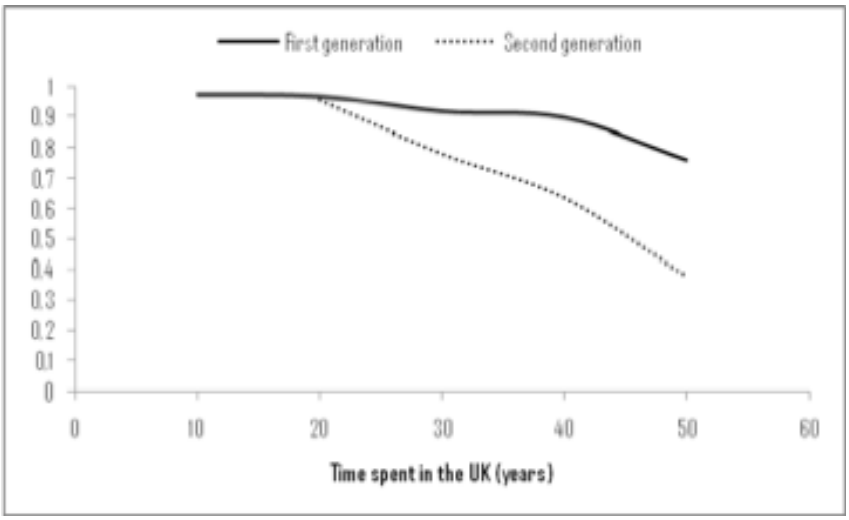

Figure 22: Predicted homogamy as a function of time in the U.K. Source: Bisin, Patacchini, Verdier, and Zenou (2009).

The interaction of cultural traits and institutions along human history and its effect on present socio-economic condition of populations is a fascinating topic which is now being explored, both theoretically and empirically along the lines and with the models surveyed in this paper.

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