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ECONOMIC MODELS OF CULTURAL TRANSMISSION

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ABSTRACT

In this chapter we survey recent advances in modeling cultural transmission in the economics literature. We first present the basic canonical model of the evolution of cultural traits in the social sciences. Both Economics and Evolutionary anthropology build on this canonical model but their approaches are conceptually very different. After elucidating these differences, we introduce several recent economic models of cultural transmission which address a rich set of novel and interesting questions in the literature. We present these models as extensions of the canonical framework, organized along theoretical dimensions that we categorize as pertaining to preferences and technology. We finally briefly discuss how cultural evolution represents a fundamental component - alongside institutional change - of recent theoretical work on the political economy of long-run growth. We conclude suggesting interesting areas for future research.

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1 Introduction

In this chapter we survey recent advances in the economic theory of cultural transmission, demonstrating that cultural explanations of socio-economic phenomena are not tautological "residual" explanations as long as theoretical and empirical restrictions are imposed and tested on what culture is and on how it evolves.

While it is well recognized that the social sciences do not rely on a well-agreed upon abstract definition of culture, the existing definitions - 164 of them were classified already in the 50's[1] - are actually very closely related when projected into an actionable formal space. For our purposes, we let culture represent:

> those components of behavioral traits, preferences, attitudes, and beliefs which depend upon the capacity for social learning and transmission across generations.

While the economic theory of cultural transmission draws on the influential work in evolutionary biology and anthropology from the 1980s - notably Cavalli-Forza and Feldman (1981) and Boyd and Richerson (1985) - it has gone much further by developing a coherent set of models which leverage economic theory to understand the dynamics of culture and its determinants. Importantly, economic models of cultural transmission successfully disentangle socio-economic and political characteristics that may affect (and interact with) cultural evolution mechanisms. Furthermore, this literature, by developing testable models with a wealth of empirical implications, has inspired numerous empirical studies exploring the role of culture in shaping socio-economic and political contexts, contributing e.g., to a better understanding of conditions under and which cultures persist over time and vary across geographical areas and to the identifications of the main mechanisms which favor such persistence.[2]

The basic structure of an economic model of cultural transmission may be construed as a map from preferences and technologies onto rates of cultural transmission - that is, onto a transmission mechanism for a set of cultural traits. Cultural transmission can be inter-generational, from parents and other parental figures to children, or it can be intra-generational, capturing various identity formation mechanisms by children. Cultural traits are represented by preferences, which in turn determine the children's actions in their

[1] See Alfred Kroeber and Clyde Kluckhohn's "Culture: A Critical Review of Concepts and Definitions," *The Journal of Philosophy* (1954)

[2] We concentrate on the theory of cultural transmission in this chapter. But see Bisin and Verdier (2010) for an early survey of empirical work and, recently, Bisin-Verdier (2023) and Nunn (2021).

lifetime. Most importantly, the parental transmission process is modeled as the result of parental choices, altruistically evaluating the childrens' actions and anticipating the socio-economic environment they (the children) will inhabit.

As a consequence, in economic models cultural transmission depend on socialization preferences, opportunity costs, resource constraints, information structures, policies, as well as social connectivity and group structures, spatial and ecological elements, and institutional dimensions that regulate economic, political and social interactions. In such set-up, these factors jointly shape the relative success for traits to diffuse and be transmitted more effectively across individuals. Importantly, these factors rely on forward-looking choice and expectation formation mechanisms. This is in contrast to cultural transmission models in evolutionary anthropology, centered on backward-looking social learning processes driven by past socio-economic success (and various proxies for it when success is not directly observable).

In Section 2 we pursue a novel detailed analysis of the distinct approaches to the study of cultural transmission and evolution in evolutionary anthropology and in economics, identifying the main conceptual differences and their implications.

In Section 3 we concentrate on the economic approach to cultural transmission. We demonstrate that the choice theoretic formulation of socialization in economics opens up these models to a rich set of extensions - which allow for a varied class of models, addressing a large set of new questions, well-defined enough that they can be tackled empirically. We find it useful to categorize these extensions as driven by either preferences or technology. On the preference side, we first introduce (a novel analysis of) complementarity and substitutability between consumption and socialization. We then survey contributions in the literature which focus on parental preferences for socialization which are endogenously depending on the socio-economic environment children will inhabit; on cultural leaders and collective transmission mechanisms. On the technology side, we survey the literature studying cultural transmission mechanisms that rely on the composition of parental effort as well as other parental choices, like fertility or marriage; that display various forms of complementarity between parental and societal transmission mechanisms; that allow for e.g., network effects and bias due to parental choices or identity formation choices on the part of the children.

In Section 4 we survey a recent literature which, departing from the relationship between cultural evolution and social interactions, focuses on the two-way interactions between cultural and institutional environments. The models in this literature generally have the distribution of cultural traits in the population affecting the institutional and political

structure of society and, on the other hand, the institutional and political structure of society affecting the distribution of cultural traits in the population. They offer a novel approach to growth and development. Unlike traditional studies that try to isolate the causal impact of each factor on contemporary outcomes, these models can study how historical shocks propagate through their joint dynamics, and analyze how these interactions may have magnified or mitigated effects on long-run socioeconomic outcomes. We discuss a series of interesting applications of this literature, to the study of the relationship between culture and various specific institutions - market, political, environmental institutions - and to the study of the cultural and institutional determinants of long-run growth.

We end the chapter - in Section 5 - with a brief discussion of several areas of research - within the theory of cultural transmission - which in our opinion merit further attention in the future.

We believe that the literature surveyed in this chapter serves as clear evidence of the substantial advances in the economic theory of cultural transmission. This theory has generated significant insights on how cultural diversity evolves and how it may persist. It can help provide better understanding of e.g., economic growth and development, political economy, and long-run historical phenomena.

2 The Canonical Model of Cultural Transmission

The purpose of this section is to review the structure and logic of cultural transmission models in the social sciences. With this aim we constrain ourselves to a simple abstract environment. We consider a population constituted by a continuum of agents. Agents are characterized by the cultural trait they are associated to. We assume for simplicity the trait to be binary, i, j.[3] Let $0 \leq q^i \leq 1$ denote the fraction of the population with trait i. Cultural traits are transmitted inter-generationally, from parents to children. Under the simple abstract specification we shall introduce next, the dynamics of the cultural distribution in the population - that is, the dynamics of q^i over generations - will satisfy the following *logistic* equation:

$$\dot{q}^i = q^i(1 - q^i)f^i. \tag{1}$$

[3]In Appendix A, we outline extensions of cultural transmission models with traits taking $n > 2$ discrete values or a continuum of values in an interval.

By analogy with evolutionary biology, This same equation - called *replicator dynamics* in evolutionary biology - drives the selection of genetic traits, where f^i is a measure of the relative fitness of trait i (Taylor and Jonker, 1978, Hofbauer and Sigmund, 1998, Weibull, 1995). By analogy, then, in the canonical cultural transmission model of Equation (1), f^i is the interpreted as the the *relative cultural fitness* of trait i. The conceptualization of f^i is what distinguishes genetic and cultural transmission - as well as different mocdels of cultural transmission - in this abstract context.

2.1 Transmission technology

The first mathematical models of intergenerational cultural transmission were pioneered by Cavalli-Sforza and Feldman (1981) in evolutionary biology. The simple abstract cultural transmission technology proposed in this paper has become canonical in the literature and provides a micro-foundation for the general logistic Equation (1) and for relative cultural fitness f^i.

Let population size be stationary - and normalized to 1 - by having each parent give birth a-sexually to one child. Cultural transmission operates via two distinct channels occurring in stages. The first channel - called *direct vertical* or *parental* transmission - has each parent with trait i socialize his/her child to trait i with probability d^i. With the residual probability $1-d^i$, the second channel - called *oblique* or *social* transmission - comes into operation. In the social transmission stage the child is matched randomly to a member of the parent's generation and is socialized to his/her trait.[4] Therefore, conditionally on reaching this stage (with probability $1-d^i$), the child is socialized to trait i with probability q^i (since matching is random). Notably, a child of a parent with trait i can be socialized to trait i either by parental transmission or by social transmission, while he/she can be socialized to trait $j \neq i$ only by social transmission.

Formally, letting P^{ij} denote the transition probability that a child from a parent with trait i is socialized to trait j, this cultural transmission technology is represented by the following system of equations:

$$P^{ii} = d^i + (1-d^i)q^i, \quad P^{ij} = (1-d^i)(1-q^i). \tag{2}$$

Using the Law of Large Numbers, this process of cultural socialization results in a dynamics of the distribution of trait i in the population,

[4] Transmission can also be *horizontal*, within the children's generation. We avoid horizontal transmission here for simplicity but we shall introduce it later in the survey.

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

which is a specification of the general logistic Equation (1), where the relative cultural fitness f^i is represented by the difference in parental transmission rates:

$$f^i = d^i - d^j. \tag{3}$$

2.2 Cultural fitness in the Social Sciences

The canonical technology of cultural transmission introduced in the previous section, from Cavalli Sforza and Feldman (1981), constitutes the initial building block for the study of the population dynamics of culture in the social sciences. Distinct theories of cultural transmission - in the simple context of the canonical model of cultural transmission represented by Equations (1 - 3) - can be synthetically identified along two lines, i) the definition of a cultural trait i, and ii) the determination of parental transmission d^i (and hence of relative cultural fitness f^i). In this section we abstractly distinguish two different class of such theories, developed respectively in evolutionary anthropology and in economics. We introduce the simplest barebone models in either case - the most direct projections of the canonical model of cultural transmission.

Evolutionary Anthropology. The earliest cultural transmission model in evolutionary anthropology is in Boyd and Richerson (1985), building on the analysis of Cavalli Sforza and Feldman. Generally, in this literature, cultural traits are represented by behavioral traits: to a trait i is associated directly an action/behavior x^i. Furthermore, fitness is interpreted literally as an indicator of reproductive success. Behavioral traits are transmitted intergenerationally via a process of social learning. Relative fitness is then generally biased towards the trait which - in previous periods - was more successful in the population - *direct bias* - and/or more associated to a proxy for relative success, like wealth or social prestige - *indirect bias*.

Formally, the transmission rate of trait i will then be frequency-dependent, that is, a function of the relative size of group i, q^i. More specifically, direct and indirect bias will (be modeled so as to) induce a characterization of social learning displaying some form of *conformity*, so that transmission rates will be as follows:

$$d^i = d(q^i), \text{ where } d(.) \text{ is increasing and (for regularity) } d^i(0) = 0. \tag{4}$$

Economics. The economic approach the theory of cultural transmission has been developed by Bisin and Verdier (2001). While building closely on Cavalli Sforza and Feldaman

as well as on Boyd and Richerson, their analysis develops along radically different conceptual lines from evolutionary anthropology. First of all, cultural traits are represented by preference traits: to a trait i is associated a utility function u^i, which in turn determines an action x^i as a choice of the agent. Secondly, cultural fitness is not interpreted literally, as reproductive success, but it generally encodes a cultural socialization mechanism built on the distinction between parental and social transmission in the canonical technology of Cavalli-Sforza and Feldman. Most importantly, the parental transmission process is modeled as the result of parental choices, which anticipate the possible occurrence of the social transmission stage. Relative cultural fitness therefore will not only be frequency-dependent, but it will also depend on parental preferences regarding the cultural socialization of children.

Formally, the transmission rate of trait i is modeled as the solution of a parental socialization choice problem. A parent with trait i obtains a payoff of V^{ij} if her child acquires trait j. Assume that $V^{ii} > V^{ij}$ whenever $i \neq j$, that is, parents have a preference to transmit their own cultural trait to their own children. A rational parent chooses the transmission rate d^i - facing a socialization effort cost $c(d^i)$ - to maximize the expected parental payoff from socialization, $P^{ii}V^{ii} + P^{ij}V^{ij}$, where P^{ii}, P^{ij} satisfy the transmission technology in Equation (2) at the chosen d^i. But $P^{ii}V^{ii} + P^{ij}V^{ij} = V^{ij} + P^{ii}\Delta V^i$, where $\Delta V^i = V^{ii} - V^{ij}$ encodes parental preferences over their child's cultural trait, the *cultural intolerance* of parents i. The socialization problem therefore reduces to

$$\begin{aligned} \max_{d^i} \quad & P^{ii}\Delta V^i - c(d^i) \\ s.t. \quad & P^{ii} = d^i + (1 - d^i)q^i \end{aligned} \tag{5}$$

where $c(d^i)$ is assumed increasing and convex for regularity. At the solution, the transmission rate is

$$d^i = d(q^i, \Delta V^i), \text{ where } d(.) \text{ is increasing in } \Delta V^i, \text{ decreasing in } q^i \text{ and } d^i(1) = 0.^5 \tag{6}$$

We can now compare the canonical models of cultural transmission in evolutionary anthropology and in economics along three important dimensions: i) the object of cultural transmission, i; ii) the determinants of relative fitness f^i; and iii) the population dynamics of the distribution of cultural traits q^i. With respect to the object of cultural transmission - that is, the implicit definition pf culture - the conceptual distinction between evolutionary anthropology and economics is quite stark. In evolutionary anthropology, since cultural

[5] Under (the often adopted simplification with) quadratic socialization costs, $d^i = (1 - q^i)\Delta V^i$.

traits are construed as agents' actions - they are to be interpreted as lifetime behavioral patterns of actions - independent of intra-generational changes in the environment - or as broad social norms of behavior.[6] In economics, cultural trait are instead defined as (parameters of) preferences and attitudes, in turn determining behavior which is well-adapted to changing environments. As a consequence, the objects of cultural transmission can be represented both by fundamental dimensions of human preferences (and hence behavior) as well as by historically determined characteristics of preferences. [7]

With respect to their transition mechanisms - that is, the determinants of the transmission rates d^i, d^j and hence of the relative cultural fitness f^i - both approaches produce formulations of cultural fitness which are frequency-dependent; but they result in orthogonally different implications: the transmission rate of cultural trait i is increasing in the frequency of the trait q^i in the evolutionary anthropology model and decreasing in the economic model; compare Equations (4) and (6).[8] Most importantly, in the economic model, the transmission rate of cultural trait i depends on parental preferences ΔV^i.[9] Parental preferences in turn generally depend on the socio-economic environment in which parents and children live and make choices. In particular, to evaluate their preferences ΔV^i and to choose upon them parents need to form expectations about the future socio-economic environment, its realization and equilibrium behavior. This dependence opens up cultural

[6]Examples of such patterns include cooperating (Boyd and Richerson, 1982, 1988; Henrich and Boyd, 2001), favoring kin altruistically (Fehr and Fischbacher, 2003; Lehmann and Feldman, 2008; McElreath et al., 2003), reciprocating favors (Boyd and Richerson, 1988), punishing altruistically (Guzmán et al., 2007).

[7]Economic cultural transmission of fundamental preferences include e.g., time-discounting, risk-aversion, attitude towards social status and towards cooperation (Bisin and Verdier, 1998, 2004, and 2010, for a survey; Zakharenko, 2016). Cultural transmission of historical preferences include, instead, ethnic and religious traits (Bisin and Verdier, 2000; Bisin et al., 2004b), or civic and social capital (Francois and Zabojnik, 2005; Bidner and Francois, 2009; Guiso et al., 2008; Tabellini, 2008; Okada, 2020; Acemoglu and Robinson, 2024; Bisin et al., 2024; Bisin and Verdier, 2024; and several of the papers collected in Bisin and Federico, 2021). Relatedly, an interesting literature in economics - referred to as *Indirect evolutionary approach* and introduced by Guth and Yaari (1992) and Guth (1995) - also aims at providing an evolutionary foundation for fundamental preferences by assuming that agents' choices are rational given preferences whose change is driven by an evolutionary process depending on the relative success of individuals endowed with these preferences (Kockesen et al., 2000; Ely and Yilankaya, 2001; Ok and Vega Redondo, 2001).

[8]This is not the case, obviously, in less canonical models in either approaches. The fundamental distinct "forces" we are identifying in this section are meant to characterize the core mechanisms of these models.

[9]Their foundation on rational or behavioral choice gives these models a solid bedrock on which e.g., to select assumptions about preferences and psychological attitudes - validated by the whole theoretical and empirical corpus of the economic discipline.

transmission and social learning to a rich set of socio-economic determinants - to forward-looking behavior in particular - with important theoretical (and interesting empirical) implications. In evolutionary anthropology, on the other hand, social learning is generally a backward-looking process and so is agents' behavior in socio-economic environments.[10]

The third important dimension of comparison between the canonical models of cultural transmission in evolutionary anthropology and in economics refers to the distinct implications of the two models with regard to the population dynamics of culture in the limit, that is, the stationary states of the distribution of culture and their stability properties. This is important because the "massive diversification of human cultures" contrasts with the fact that "humans are a species with low genetic diversity" (Boyd-Richerson, 2024, p.7/10); and because cultural resilience and fractionalization - e.g., in the context of ethnic and religious traits - motivates a large fraction of the theoretical and empirical literature on culture in the social sciences (Bisin and Verdier, 2010). In this respect, we study and compare the dynamics of Equation (1) in three different cases: i) when cultural fitness $f^i = d^i - d^j$ is exogenous; ii) when social learning induces conformity, due to direct or indirect bias, in the canonical model in evolutionary anthropology; iii) when parental socialization results from parental choice, in the economic model. Figure (1) represents graphically the dynamical equations in the three distinct cases.

The results of this comparison are striking: Within the confines of the canonical model, the differential implications of these models with respect to frequency-dependence of relative cultural fitness, implies that only parental socialization choice manifests a "force" leading to cultural heterogeneity by means of the resilience of cultural traits across generations. Formally,

i) With exogenous fitness, the population converges to cultural homogeneity with

$$q^i = 1 \text{ if } f^i > 0 \text{ and } q^i = 0 \text{ if } f^i < 0.$$

Trivially, population is constant if $f^i = 0$.

ii) With conformity in social learning, the population also converges monotonically to cultural homogeneity, where

$$q^i = 0 \text{ or } q^i = 1, \text{ depending on the initial condition.}$$

[10]Even when modeling social learning and social behavior as the result of agents' interactions - the game theoretic constructs adopted in the literature rely on backward-looking equilibrium concepts (Henrich, 2021; and Smaldino, 2023, survey this literature). The analysis of cooperative behavior, for instance, leaves aside the classic folk-theorem results in repeated games (Bisin, 2024, for a review of Smaldino, 2023).

A stationary state $0 < q^i < 1$ such that $f(q^i) = 0$ exists but is unstable.

iii) With parental socialization choice the population converges monotonically to cultural heterogeneity, that is, to a stationary state

$$0 < q^i < 1 \text{ such that } f^i(q^i) = 0.$$

The culturally homogeneous states $q^i = 0$ and $q^i = 1$ are also stationary states but they are unstable.[11]

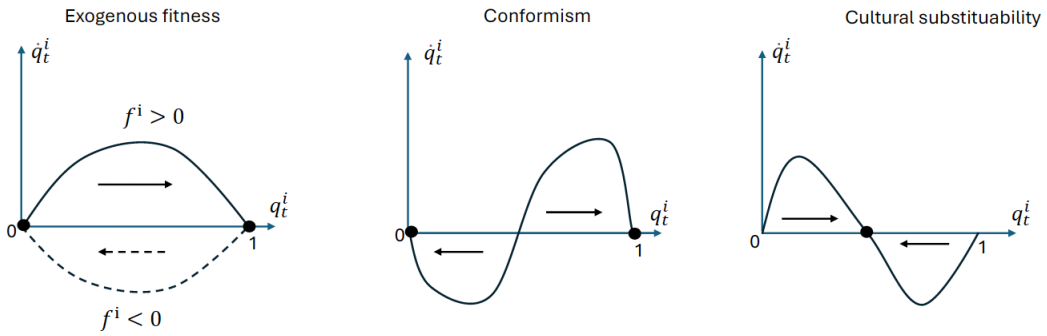

Figure 1

The dynamics in the economic model are a consequence of the property that d^i is decreasing in q^i - which Bisin and Verdier (2001) call *cultural substitution*. It implies that parents with the minoritarian trait socialize their children relatively more than parents with the majoritarian trait, to overcome the effect of social transmission, which favors majorities. On the other hand, it is the complementarity built into the evolutionary dynamics - via conformity in the social learning process - that induces cultural homogeneity. While of course the canonical cultural evolutionary model can be extended in several dimensions

[11] With quadratic costs, the stationary state is

$$0 < q^i = \frac{\Delta V^i}{\Delta V^i + \Delta V^j} < 1.$$

to obtain richer dynamics, the complementarity in social learning tends to reduce the explanatory power of the model with respect to cultural heterogeneity, at least at relatively short time scales - say at historical (as opposed to evolutionary) frequencies. Henrich (2021), for instance, suggests that "the variation (in cultural traits) we observe around the world and back into history represents different stable equilibria or cultural evolutionary trajectories toward different equilibria." But multiple equilibria of un-coupled population dynamics in evolutionary times are not natural determinants of e.g., the wide variation of ethnic and cultural traits at the historical frequencies at which socio-economic environments and institutional set-ups vary within and across interacting populations.

2.2.1 Genetic and cultural evolution

Our comparison of models of cultural evolution in evolutionary anthropology and economics in the previous section has taken as given the process controlling cultural dynamics: social learning and parental socialization, respectively. But evolutionary anthropologists also study gene-culture coevolution theory, modeling genes and cultural traits co-evolving and influencing each other over time measured at evolutionary time-scale. In our context, most relevant are the class of models pertaining to the *Dual inheritance theory* developed by Boyd and Richerson (1976, 1978, 1985) (and then, e.g., Richerson and Boyd, 2005; Henrich and McElreath, 2007; Boyd, et al., 2011), which study the joint dynamics of both cultural traits and (specific aspects of) the cultural evolution process - identified with social learning. This literature produces various interesting theoretical predictions regarding evolutionary adaptations of the social learning process, e.g., a general bias towards social conformity (Boyd and Richerson, 1985; Rogers, 1988; Perreault et al., 2012; Derex and Boyd, 2015); a bias in favor of prestige, or social status (Henrich and Gil White, 2001, and Jiménez and Mesoudi, 2019); and a bias in favor of observable costly displays (Henrich, 2009, 2016). Most importantly, this literature identifies the cumulative capacity of cultural evolution - via high-fidelity transmission - as a fundamental property of human culture (Boyd and Richerson, 1996; Tomasello, 1999; Boyd et al., 2011; Mesoudi, 2011; Muthukrishna et al., 2018; Mesoudi and Thornton, 2018; Richerson and Boyd, 2022).[12] Along these lines,

[12]The collection of papers in article in Fogarty et al. (2024) - including Boyd and Richerson (2024) - and Boyd and Richerson (2026)'s contribution to this Handbook provide surveys of these and other related results in the literature. Several other interesting papers along these lines also include Feldman and Laland (1996), Strimling et al. (2009), McElreath, and Strimling (2006), Richerson and Boyd (2005), Richerson et al. (2010), Chudek and Henrich (2011), Ghirlanda and Enquist (2007), Enquist et al. (2011), Derex M, Perreault C, Boyd R. (2018).

Bisin and Verdier (2001) and Giuliano and Nunn (2021) study how the characteristics of social learning mechanisms which are evolutionary selected - specifically, how persistent are transmitted traits within families across generations - depend on the stochastic processes driving the environment agents face.[13]

From the point of view of economists, what is striking in this literature in evolutionary anthropology is the lack of any attempt to identify theoretically conditions under which evolutionary adaptations would favor some form of rationality in the social learning process. Rational choice - even when restricted by various behavioral limitations rooted in psychological evidence - introduces both flexibility with respect to environmental change and forward-looking considerations which could provide an evolutionary advantage to human populations and hence be adaptively selected. Indeed, a small but fascinating literature in economics has developed which aims to endogenously derive elements of rational choice - including the assumption that cultural evolution operates on preferences rather than on actions - from social learning processes as selected by genetic evolution.[14] Robson (2001)'s aptly titled - *Why Would Nature Give Individuals Utility Functions?* - is the foundational paper in this literature. A wealth of results in this literature pertains generally to identifying condition under which time-discounting - whether exponential or quasi-hyperbolic (with present-bias) - and expected utility representations - whether on linear or concave utility functions (with risk-neutrality or risk-aversion) - are endogenously obtained as evolutionary adaptations; see Robson and Samuelson (2011, 2026), Robalino and Robson (2019, 2026, in this Handbook) and Bisin and Verdier (2026) for exhaustive surveys. Even with respect to the cumulative character of human culture, the role of strategic rationality and greater recall memory in particular has been shown to represent an evolutionarily adaptative foundation for it (the *Red queen effect*, in Robson, 2003)

One of the main manifestations of the lack of rational choice in the theory of cultural transmission in evolutionary anthropology is the absence of parental socialization choice. But evolution might select parental preferences for socialization whereby, other things

[13]See for instance Strimling et al. (2009); Enquist et al. (2011); Ghirlanda and Enquist (2007);, Derex M, Perreault C, Boyd R. (2018), .

[14]The ideological divide in the social sciences along the rational choice line might in part explain - but not justify - why only economists tend to consider rational forward-looking models in the study of cultural evolution. In this sense - admittedly with some liberty of interpretation - we read Morgan and Feldman's (2024) call for the theory of cultural evolution in anthropology and biology to recognize *open-endedness* as the defining feature of human culture, as a prominent suggestion that (the flexibility induced by) rational choice may help explain the "scope [...] of what can be acquired and transmitted in human culture" across varying socio-economic and environmental conditions.

equal, parents have a preference to transmit their own cultural trait to their children (Bisin and Verdier, 2001, 2026). In economic cultural transmission models, parental socialization choice allows for social learning mechanisms which are well-adapted to a moving socio-economic environment. As such, cultural transmission can be represented by relatively high-frequency processes - within and across ethnic and religious traits - driving e.g., family values and gender roles (Escriche, Olcina, and Sánchez, 2004; Hiller and Baudin, 2016; Alesina et al., 2015; attitudes towards work/leisure (Senik and Verdier, 2011; Saez-Marti and Zenou, 2012; Michaud, 2013); preferences for fertility (Baudin, 2010; Bar-Gill and Fershtman, 2016; Melki et al., 2024); preferences for autonomy (Hiller, 2011); preferences for lifestyle (Ponthiere, 2010).

3 Economic Models of Cultural Transmission

In this section we concentrate on the economic approach to cultural transmission. Our aim is to demonstrate that the choice theoretic formulation of socialization in economics opens up these models to a rich set of extensions - which allow for a varied class of models, addressing a rich set of novel questions, well-defined enough that they can be tackled empirically.[15] Socialization and cultural transmission are modeled as the outcome of different individuals' and institutions' choices: parents, children themselves e.g., via peer effects, role models, on one side; school, churches, nations, cultural leaders, on the other. Relative cultural fitness will therefore depend on parental preferences but also on children attitudes towards cultural identity, and on various institutional characteristic of society the present and future socio-economic conditions affecting these choices. Furthermore, being integrated in the specific present and future socio-economic conditions of a society, cultural transmission will generally rely on a varied set of direct and indirect mechanisms, as technologies for socialization and identify formation, including e.g., fertility, marriage, social segregation, identity formation and so on. Importantly, in these class of economic models, parental socialization preferences generally depend - via some form of altruism - on the socio-economic outcomes of their children. As a consequence, socialization and cultural transmission are forward-looking equilibrium processes in the economics literature, a substantial difference with respect to the processes studied in evolutionary anthropol-

[15] While outside of the scope of the present chapter, we note here that the economic theory of cultural transmission - after the early theoretical contribution following Bisin and Verdier (2001) - has developed into a substantial and vivid empirical field. Several chapters of this Handbook survey this literature.

ogy, which greatly expands the space of applications and the interest of the analysis.[16] Finally, focusing on cultural phenomena at higher time frequencies than evolutionary anthropology models, the economic approach to cultural transmission has a precise focus on the socio-economic determinants of cultural transmission and their selective implications for cultural dynamics, resulting from costly and purposeful socioeconomic actions by socializing agents. This perspective typically generates cultural transmission rates that are affected by important socio-economic factors such as prices, incomes, resources and more generally institutional contexts.

Along these dimensions, the theory of cultural transmission in economics has built on the canonical model along a series of very interesting dimensions. We categorize them in this paper as follows - see also Figure 2 - distinguishing extensions on preferences from those on technology.

Preferences. In the canonical economic cultural transmission model parental preferences for socialization and encoded by exogenous *cultural intolerances* ΔV^i and are assumed separable from preferences for consumption $u^i(x^i)$. More generally, in this section we shall study models where:

1. The separability between socialization and consumption choice is relaxed by assuming that socialization requires resources, both in terms of income and time.

2. Parental preferences for socialization are endogenous: cultural intelerance ΔV^i depends on the socio-economic environment children will inhabit.

3. Collective transmission mechanisms - like cultural leaders through various institutions - act to affect parental preferences for socialization.

Technology. In the canonical economic cultural transmission model the socialization technology is determined by the composition of a direct parental effort d^i and oblique transmission in the form of random matching. More generally, in this section we shall study models where:

4. Relative cultural fitness f^i is modeled as a socio-economic mechanism structured as the composition of parental effort as well as other parental choices, like fertility or marriage.

[16] This is not the case in the simple canonical model we introduced in this section, but it will be in most of the theoretical analyses of cultural transmission we shall present in the following sections. Forward looking models require some theoretical sophistication to handle the different formal representations of the dynamic equations.

5. Parental transmission has a more general form than implied by cultural substitution.

6. Oblique transmission has more general form than random matching, allowing e.g., for network effects and bias due to parental choices or identity formation choices on the part of the children.

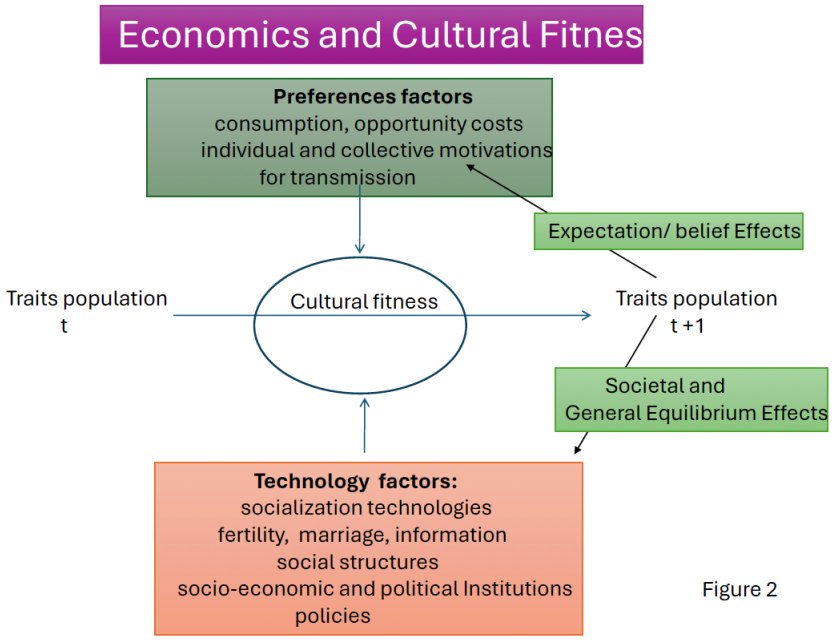

Figure 2

3.1 Parental Transmission and Consumption

In the canonical economic model of cultural transmission the consumption and the socialization problems of the agents are assumed separable. Relaxing this assumption allows us to characterize how the socialization choice of parents depends on their resources - like income and time - and on prices, including wages. By simply allowing for socialization costs to be derived implicitly from the agents' budget constraint, we present a version of this model which emphasizes how, in its basic form, cultural transmission i) fits rightly into the standard simple model of consumer's choice in microeconomics; and therefore ii) has comparative statics driven by basic income and substitution effect.

Formally, let parental transmission d^i represent the outcome of a production function with resources m^i and time l^i as factors in the socialization process of the child: $d^i = d(f(m^i, l^i))$, where the function $d(.)$ is an increasing function defined on the interval $[0, \infty[$

such that $d(0) = 0$, $d(\infty) = 1$ and $f(m^i, l^i)$ satisfies the usual properties of production function: increasing concave in each argument and homogeneous of degree 1.[17] Assume that parents of cultural type i are endowed with an exogenous endowment of the resource R and an amount of time $L = 1$ that they can share between producing resources at wage w and socializing their child.

Now, the choice problem of each agent is

$$\begin{aligned} \max_{x^i, m^i, l^i} \quad & u^i(x^i) + P^{ii}\Delta V^i \\ s.t. \quad & d^i = d(f(m^i, l^i)) \\ & x^i + m^i = R + w(1 - l^i) \end{aligned}$$

Solving this problem we obtain a transmission rate of the form

$$d^i(q^i, \Delta V^i; R, w),$$

that is, depending on total resources R and on the wage w - besides $q^i, \Delta V^i$ as in the canonical model. The relevant comparative statics correspond to those of the canonical model: $\frac{\partial d^i}{\partial \Delta V^i} > 0; \frac{\partial d^i}{\partial q^i} < 0$. An increase in ΔV^i leads to more effective parental socialization by increasing the marginal utility of socialization, other things equal; while a change in the state of the cultural population q^i also affects the marginal rate of substitution between x^i and d^i and its effect depends on cultural substitution. But, when embedding the socialization problem and the consumption problem, we have further interesting novel effects:

$$\frac{\partial d^i}{\partial R} > 0; \frac{\partial d^i}{\partial w} \gtrless 0.$$

In fact, an increase in R has a positive income effect.

Conversely, an increase in w leads to a change in the budget constraint that can be decomposed in an income and a substitution effect: as the wage increases, the opportunity cost of socialization increases but so do the total available resources, other things equal.

These comparative statics with respect to d^i map directly into comparative dynamics on the distribution of traits in the population - via Equation (1). In particular, the analysis can be naturally extended to the case where socio-economic fundamentals such as R and w are different across cultural groups. For instance, it is easy to see that the relative

[17] This specification ensures that d^i remains a probability between 0 and 1.

cultural fitness $d^i - d^j$ is an increasing (resp. decreasing function) function of R^i. If the difference between R^i and R^j is not too large, there will exist an interior steady state q^i increasing in R^i Thus the cultural trait group having access to more economic resources is more likely to prevail in the long run. Correspondingly, consider what happens when work productivities w^i and w^j are different. In that case the differential effect of these economic fundamentals on the cultural selection process will depend on the relative strength of the income and the substitution effects, the opportunity cost of vertical socialization may increase or decrease. It could in particular be the case that the trait associated to the group with higher productivity is less likely to be culturally selected if the substitution effects are stronger than the income effects for both groups.

Interestingly, this framework also allows to analyze the effect of economic heterogeneity within cultural trait groups. Consider an environment in which resources R are heterogenously distributed within groups. Let the cumulative distribution of R for group i be $F_i(R)$. Let i be the group with more equally distributed resources R, in that $F_j(.)$ is a mean preserving-spread of $F_i(.)$. We show that, ceteris paribus, the trait associated to a more equal distribution of resources is more likely to prevail in the long run cultural dynamics of the population.[18]

3.2 (Endogenous) Preferences for cultural transmission

In canonical cultural transmission models, parental socialization depends on the exogenous value of having a child with the same cultural trait, ΔV^i (the *paternalistic or cultural intolerance* motive of trait i). While this assumption is useful to illustrate the main elements of an abstract model of cultural transmission - how to formulate cultural fitness and how to derive the population dynamics - in general ΔV^i have to be modeled as endogenous, influenced by various environments. For example, in markets, individuals' utility may depend on economic variables like prices, incomes, or policy outcomes shaped by the prevailing distribution of cultural traits. Similarly, in strategic interactions, matching, political economy, and public choice contexts, an individual's payoffs are likely affected by the population's cultural trait distribution. In this section we allow for cultural intolerance to represent (indirect utilities) determined at a socio-economic equilibrium of interest. While the implications of the endogeneity of ΔV^i for socialization and population dynamics need to be derived case-by-case, a reduced form analysis is useful, to clarify what to look for in

[18]This result follows by Jensen's inequality form concavity of parental socialization d^i with respect to R; see Appendix A for details and proofs.

the applications.

Consider each individual (parent or child) choosing some action x to maximize $u^i(x, q^i)$. The action x can be interpreted e.g., as a lifetime pattern of choices. Assume parental preferences display a form of imperfect altruism - called *imperfect empathy* Bisin and Verdier (2001): parents evaluate their children actions with their own (the parents') preferences. In this case, parental socialization preferences for types i depend on

$$\Delta V^i(q^i) = u^i(x^i, q^i) - u^i(x^j, q^i).$$

The socio-economic interaction between agents determines, at equilibrium, the endogenous *cultural intolerance* $\Delta V^i(q^i)$, as a transformation of the agents' indirect utilities - depending on child's choices in the future, in the future socio-economic environment (prices, policies, social interactions, political economy.[19] The socialization problem then determines $d^i\big(q^i, \Delta V^i(q^i)\big)$ so that:

$$\frac{d}{dq_t^i}\, d^i\big(q^i, \Delta V^i(q^i)\big) = \underbrace{\frac{\partial d^i}{\partial q_t^i}}_{\text{direct effect}} + \underbrace{\frac{dd^i}{d\Delta V^i}\frac{d\Delta V^i}{dq_{t+1}^i}}_{\text{feedback effect}} \underbrace{\frac{dq_{t+1}^i}{\partial q_t^i}}_{\text{expectations effect}}$$

A negative direct effect follows from cultural substitution; while a positive (resp. negative) feedback effect corresponds to a strategic social complementarity (resp. substitution).

When paternalistic motivations are endogenous, the dynamic system for the evolution of cultural traits can be written as:

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

In this case, a sufficient set of conditions to obtain an heterogeneous cultural distribution in the limit, requires cultural substitution as well as an additional condition on $\Delta V^i(q^i)$ - called *strategic substitution* in Bisin and Verdier (2001):

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

In words, *strategic substitution* ensures that cultural minorities face relatively larger gains from socialization, independently of the socialization mechanism. It is then easy

[19]Note that in this context paternalism does not now 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 reflects parents' preferences for sharing their cultural traits with their children, these preferences are also influenced by the economic and social conditions parents anticipate for their children. Consequently, different conditions might lead parents to socialize their children to adopt traits different than their own (or to not socialize them).

to see that, when the social environment is characterized by strategic substitution and that moreover direct and oblique socialization mechanisms are cultural substitutes, then from any interior state $q \in (0,1)$, the cultural dynamics converge to cultural heterogeneity, that is, a $0 < q^i < 1$. case of strategic complementarity (i.e., $\frac{\partial}{\partial q_i}\Delta V^i(q^i)) > 0$), cultural minorities face smaller (even possibly negative) socialization gains. Depending on the strength of cultural substitution, therefore, in this case cultural heterogeneity might or might not be preserved.

In summary, i) cultural substitution and strategic substitution tend induce cultural heterogeneity as stable stationary state; while b) social strategic complementarity tend to induce cultural homogeneity - that is, corners - as stable stationary states. The way $\Delta V^i(q_i)$ might be frequency dependent and vary with q^i depends on the circumstances. In many social contexts, an increase in q^i can reduce social and economic discrimination against individuals with that trait. More individuals sharing trait i means more opportunities for interaction within that group, reducing reliance on others and the impact of socio-economic discrimination. As discrimination decreases, the perceived economic cost of transmitting the trait intergenerationally also drops, thereby increasing the parents' paternalistic motive $\Delta V^i(q^i)$ to pass on their trait. Conversely, an increase in the frequency of a cultural group q^i may also induce a lower paternalistic motive $\Delta V^i(q^i)$, when discrimination has an endogenous taste or identity component. For instance, a higher value of q^i may increase the frequency of intergroup contacts which might trigger negative reactions of other groups to reaffirm their differences, leading to more discrimination and social segmentation against group i. This reduces the paternalistic motive $\Delta V^i(q^i)$ to transmit the trait. This *strategic substitution* effect gives smaller minority groups higher incentives to preserve their traits, thus promoting cultural diversity.

3.2.1 Endogenous preferences in specific applications of interest

A large strand of the economic literature on cultural transmission has explored the transmission of various distinct cultural traits in contexts where parental socialization choices anticipate the socio-economic environment which the children will inhabit with the preferences they will be socialized to. The resulting models are specific applications of the general set-up exposed in the previous section. They are generally laid out as such: i) the specific socio-economic interactions of the children is modeled; ii) a reduced form for $\Delta V^i(q^i)$ is obtained; iii) the induced properties of the transmission rates d^i - and hence of fitness f^i are characterized; iv) the implications about the dynamics of cultural traits in the

population are derived. We now introduce some relatively new and interesting theoretical contributions along these lines.[20]

General patterns of strategic interaction and matching. Della Lena and Dindo (2022) study the implications for cultural intolerance $\Delta V^i(q^i)$ of general patterns of strategic interactions across the generation of children. In particular, they show that strategic complementarity (resp. substitability) in the structure of such interactions maps into strategic complementarity (resp. substitability) in cultural intolerance and hence in the cultural transmission process - leading the cultural dynamics to homogeneity (resp. heterogeneity.[21]

Wu (2017, 2021) study instead the implications for cultural intolerance $\Delta V^i(q^i)$ of different matching interactions across the generation of children. More precisely, in Wu (2017) political institutions regulate the hierarchical structure of matching interactions between a majority and a minority with distinct cultural traits. High hierarchical status is obtained differentially across institutional environments which differ by their degree of inclusiveness towards minorities and cultural transmission has stronger selective power under more inclusive political institutions. Wu (2021) instead studies a more decentralized setting where children interact in production, comparing the cultural transmission process under different rules governing surplus sharing in matching interactions. In particular, two types of matching mechanisms are compared: i) *bargaining in match* (BIM)) - which induces a stable matching a la Gale and Shapley (1962), depending on the outside option under no match; and ii) *binding agreement in the matching market* (BAMM)) - which

[20] A first wave of examples 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 discrimination; Francois (2002), Francois and Zabojnik (2005) and Estrella López (2003) for social capital; Bisin and Verdier (2005) for the transmission of work ethic and redistributive policies, Saez-Marti and Zenou (2012) and Senik and Verdier (2011) for work values and ethnic labor market discrimination; Bidner and Francois (2011),for the evolution of informal institutions; Hiller (20011) for preferences for autonomy and work organization; Hiller (2008) for pro-social preferences and corporate culture; Baudin (2010) for fertility; Ponthiere (2010) for lifestyles transmission and longevity; Melindi Ghidi (2009) for political ideology; Correani, Di Dio and Garofalo (2010) for tolerance; Michaud (2013) for work values and social/ unemployment insurance, Pichler (2008) and Panebianco (2009) for general analyses on endogenous cultural distance and oblique socialization.

[21] In more specific strategic contexts, Della Lena et al (2021) study parental transmission of guilt aversion in a society where agents' interactions are centered on a trust game (with or without incomplete information). Delli Gatti et al (2022) analyze parental incentives to transmit patience across different economic environments. Goto (2022) centers on the transmission of an egalitarian culture in an environment where high productivity is rewarded only under meritocratic institutions.

induces equilibrium matches a la Shapley and Shubik (1971) and Becker (1973). It turns out that cultural transmission tends to lead to cultural homogeneity under BIM - favoring the cultural group with the highest outside option - and to cultural heterogeneity under BAMM - which induces a sort of cultural substitution which increases the socialization effort of minorities as in Bisin and Verdier (2001).

Olivier et al. (2008) and Bisin and Verdier (2014) study instead competitive market interactions. Strategic substitution - and hence heterogeneity of preferences in the cultural transmission limit - obtains in the case of standard Walrasian price effects on the demand side. Indeed, the larger the predominance in the population of a trait i, associated to a preference for a specific class of commodities, the higher is total demand for this class of commodities, and hence the higher its relative market price at equilibrium. As a consequence, the relative parental preference for socialization of the children to this trait is lower, $\Delta V^i(q^i)$ is decreasing and strategic substitutability obtains. In Olivier et al. (2008), however, some of the commodities also generate group identity externality effects - a la Akerlof and Kranton (2000) - for those who identify to the group. In this case, the strategic substitution effects on ΔV^i arising from the Walrasian price effects are compensated by strategic complementarity effects due to the group externality associated to identity. Strategic complementarity typically also arises in market interactions involving social increasing returns, positive market size, or market matching thickness effects, fostering long-term cultural homogeneity. Maystre et al. (2014) provide an example where a specific differentiated commodity is traded in a monopolistically competitive environment. As the size of the cultural group with a preference bias for the commodity increases, so does the market size and entry of firms producing differentiated varieties. This makes it more attractive to acquire and transmit preferences for the commodity, resulting in strategic complementarity, that is, to an increasing $\Delta V^i(q^i)$.

Preferences for cooperative behavior in the Prisoner's Dilemma. The population dynamics of preferences for cooperative behavior, within the context of the economic theory of cultural transmission is studied by Bisin, Topa, and Verdier (2004). Consider preferences which induce a psychological gain when playing cooperatively in situations like e.g., the Prisoner's Dilemma.[22]. More precisely, the population is composed of two groups of agents, Non-Cooperators and Cooperators, who are distinguished by their preferences (their actions

[22]The evolutionary selection of cooperative behavior is central issue in the social sciences; cites. More related to the approach surveyed here - where it is preferences for cooperation rather than behavior which is selected - see e.g., Bowles and Gintis (2002) who study cultural evolutionary models of norms of cooperation, but in contexts with exogenous cultural transmission and standard replicator dynamics.

being Nash equilibrium actions given their preferences): the payoff of Non-Cooperators' are the Prisoner's Dilemma's; while the payoffs of Cooperators are the Prisoner's Dilemma's to which however they add $d > 0$ utils when cooperating. Cooperators are in fraction q^C of the population. In this context, it natural to distinguish environments with complete or incomplete information, that is environments where agents do or do not observe each others' preferences (adherence to the norms) before playing the Prisoner's Dilemma. Consider complete information first. Agents are randomly matched to play a Prisoner's Dilemma. In an environment where agents are matched randomly to play the Prisoner's Dilemma, the gains to transmit norms of pro-sociality tend to be higher when many individuals in the population share the norms.

Let $V^{NC}(q^C), V^C(q^C)$ denote the expected payoff of the non-cooperators and the co-operators. Bisin, Topa, and Verdier (2004) show that cultural transmission leads to a heterogeneous stationary state $q^c > 0$ when the payoffs of the game are such that Co-operators cooperate unconditionally (independently of whether they are matched with a Cooperator or not). On the other hand thew dynamics converge to the cultural homo-geneous stationary state $q^C = 1$ when Cooperators cooperate unconditionally (only with Cooperators). The first case occurs, e.g., when the psychological gain h is high enough. This is an important results in that it contrast with what is generally obtained in models of cultural transmission where the cultural trait is the action and the intensity of transmission is linked to fitness defined as the Prisoner's Dilemma payoff.[23] .

Relatedly, Tabellini (2008) examines norms that i) impose a psychological cost on indi-viduals who fail to cooperate in situations like the Prisoner's Dilemma and are such that ii) this cost decreases with the cultural distance of the opponent. The cultural traits in the population separate individuals with more or less "limited" morality, that is, with higher or lower steepness of the dependence of the cost with respect to distance. In equilibrium individuals cooperate only with culturally close opponents, the more so the more limited is their morality. Building on Bisin, Topa, and Verdier (2004), Tabellini (2009) embedds this structure into an economic model of cultural transmission. A higher anticipated fraction of individuals in the children's generation with relatively general - less limited - morality makes cooperation less costly and more beneficial in psychological terms. Consequently, the gains from socializing children to preferences of general morality are higher in societies where such preferences prevail and strategic complementarity obtains.

[23]Bisin, Topa, and Verdier (2004) also characterize conditions on the payoff of the game under which incomplete information hinders or favors the transmission of Cooperation, that is, under which q^C is higher or smaller in the limit.

Institutions and political economy In several interesting contexts, the gains from socialization to a trait i is affected by a collective choice/action in the children's generation, that in turn may depend on the size of the respective cultural groups. For instance, in Tabellini's (2008) study of local and general morality norms, gains from socialization depend on voting decisions about the structure of the legal enforcement system. Under majority rule, minority traits may suffer, leading to inefficient legal systems that hinder cultural transmission of norms of general morality. This in turn reinforces the political support for an inefficient legal system. Similarly, Bisin and Verdier (2000) explore cultural transmission of preferences for a public good determined by voting, revealing a two-way causality between culture and political decision-making. Parents' gains from socialization hinge on expectations of political aggregation, while voting outcomes depend on the present trait distribution, influenced by past socialization. Under perfect foresight, initial conditions shape preference and political outcome dynamics, leading to either homogeneous long-run preferences or multiple equilibrium paths for balanced initial distributions.

Along the same vein, Bisin and Verdier (2005) examine the interaction between the transmission of work ethic and support for redistributive policies. The paper higlights how welfare state policies may weaken incentives to pass on work ethic norms, leading to sustained political support for redistribution, but ultimately causing its own decline as work ethic norms fade. Along the perfect foresight path of preferences evolution in the society, redistribution fosters cultural homogenization towards a preference structure that is initially strongly majoritarian in society. However, if the initial distribution of work ethic preferences is sufficiently balanced, cultural and political dynamics can generate multiple paths, depending on the type of expectations individuals are coordinated on. These different trajectories have long-term consequences for cultural values and policy outcomes. Crucially, steady-state politico-cultural equilibria are shaped by self-fulfilling expectations, highlighting the role of ideologies as programmatic coordination expectation devices that help to select a particular path of cultural values and political power structure in society.

3.3 Collective transmission mechanisms

In the canonical economic model of cultural transmission, traits are transmitted individually from parent to child. Recent economic literature has expanded the cultural transmission process to consider collective mechanisms like schools, churches, parties, and community institutions. We refer to these collective mechanisms as *cultural leaders*.

Leaders have their motivations regarding specific cultural traits, influencing their promotion or discouragement within society. They can manipulate individuals' paternalistic motives, impacting cultural dynamics. Moreover, through centralized actions, leaders can internalize group-related effects of cultural transmission, incentivizing collective action and taking a forward-looking perspective on cultural evolution and the dynamic externalities associated with the diffusion of cultural attributes. Lastly, cultural leaders may compete across or within communities to maintain their positions, shaping the supply side of cultural transmission alongside decentralized parental and oblique motives. From a conceptual perspective, the process of cultural transmission is therefore not only determined by decentralized parental and social transmission motives but also by the competitive context in which cultural leaders and organizations design incentives and motivations for cultural transmission.

Following Verdier and Zenou (2018), consider a leader of the cultural group i, who can - possibly at a cost - affect or manipulate the paternalistic motives ΔV^i of parents. For instance, the cultural leader can provide the members of group i with a public good G^i which increases the paternalistic motive of parents of type i to transmit their trait, so that $V^{ii} = V^{ii}(G^i)$. Assume that the cultural leader is intrinsically motivated by proselytism, i.e., to maximize the number of people socialized to their cultural trait. Assume also that the leader only cares about the steady states of the cultural dynamics. Then, with a linear cost of providing the public good cG^i and quadratic costs of parental socialization, a proselytizing leader of group i solves the following problem:

$$\max_{G^i} \frac{\Delta V^i(G^i)}{\Delta V^i(G^i) + \Delta V^j(G^j)} - cG^i,$$

given G^j. If both groups have a cultural leader, the equilibrium is the Nash equilibrium of the game.

Relatedly, Hauk and Mueller (2015) extend this analysis by considering both cultural leaders intrinsically motivated by proselytism, or alternatively by rents associated to the overall level of socialization effort exerted in their group. With quadratic socialization costs, a rent-seeking leader maximizes

$$q^i d^i = q^i(1 - q^i)\Delta V^i = \left(\frac{\Delta V^i}{\Delta V^i + \Delta V^j}\right)^2 \Delta V^j.$$

In either case, the cultural leader is allowed to affect the paternalistic values of members of his/her group i, V^{ii}, V^{ij}, as well as the perceptions members of group j hold regarding group i, V^{ji}. Clearly, the cultural leader has an incentive to raise the perception of cultural differences ΔV^i, the *cultural intolerance*, of in-group members. This can be achieved

through the provision of cultural values, that is, raising V^{ii}; or through claims of "cultural superiority" making the alternative trait appear inferior, that is, lowering V^{ij}. Furthermore, suppose the cultural leader has some influence on the intolerance of the members of the out-group towards the in-group, ΔV^j, for instance through manipulation of V^{ji}. Then a proselytizing leader from group i, would have an incentive to increase V^{ji}, to reduce in turn ΔV^j. Interestingly, this is not necessarily the case for a rent-seeking leader, who might find it optimal to manipulate the cultural perception of the out-group towards the in-group so as to increase ΔV^j by lowering V^{ji} - going for *cultural alienation,* in the terminology of Hauk and Mueller (2015). This results from *cultural substitution*. As ΔV^j rises, out-group members intensify socialization efforts to maintain their traits, reducing the in-group's population and q^i. In response, the in-group enhances its own socialization (d^i). This may offset the shrinking in-group size, potentially increasing the leader's rents (proportional to $q^i d^i$). Thus, leaders may prefer a smaller, highly active in-group, the source of their rents. Consequently, leaders may amplify cultural intolerances, which may not benefit the population or even their own group members.[24]

The transitional dynamics effect of forward-looking cultural leaders is studied by Verdier and Zenou (2018) and Almagro and Andrés-Cerezo (2020). In both these studies leaders provide community public goods that affect positively the paternalistic motive of their members to transmit their trait to their children. In Verdier and Zenou (2018), when the provision of G^i is allowed to be time-varying, the cultural leader is perfectly forward-looking and his utility is a discounted sum of instantaneous utilities linear in q^i, the solution has a bang-bang property. The optimal cultural trajectory has the property that it approaches as rapidly as possible some interior point q^i and stays there forever. The characterization of q^i (and the associated time-varying control function $G^i(t)$) clearly depends on the initial state q_0^i of the population. When q_0^i is small, the cultural leader might find it too costly to promote more socialization than in-group parents already do, so the system remains at q_0^i. Conversely, when q_0^i is large, parental socialization may be intense enough that the leader doesn't need to stimulate further cultural transmission. It's only when q_0^i takes intermediate values that it may be optimal for the leader to push cultural dynamics towards a higher steady state. Interestingly, short-term parameter shifts have different effects on

[24]Prummer and Siedlarek (2017) study cultural leaders who care about the economic wellbeing of their cultural group members and influencing the beliefs and attitudes of community members, by establishing rules and social norms. Carvalho (2016) studies organizations - cultural clubs - dealing with various externalities associated to cultural transmission by (i) imposing rules of participation in cultural activities and (ii) excluding non-members from social interactions. Carvalho et al (2024) analyze group level socialization efforts interacting with an education system transmitting a mainstream cultural trait.

socialization activity compared to long-term effects, leading to potential over- or under-shooting. These transitional dynamics hold significant policy implications for minority cultural community associations. Extending the framework to strategic forward-looking leaders in either of the cultural groups, equally patient leaders set the same level of public goods, neutralizing therefore their cultural influence. When however time discount rates are different, the more patient leader dominates, while the less patient remains inactive. As differences in time discount factors may reflect variations in institutional stability, this suggests that leaders from stable organizations shape cultural diffusion at the expense of less stable outgroups.[25]

Almagro and Andrés-Cerezo (2020) explore a similar problem in the context of nation-building, studying how a forward looking leader, i.e., a central state, may promote the diffusion of a cultural trait like national identity on its territory. The key control variable in this context is the share of a fixed resource that is allocated to the provision of a public good specifically attached to the national identity trait. Differently from Verdier and Zenou (2018), the zero-sum character of the conflict over resources pushes the cultural dynamic toward homogeneous steady states and extreme levels of allocations of the public good.

Forward looking leaders are also the focus of Carvalho and Sacks (2022), who study the conditions under which such a leader would be willing and able to radicalize a cultural group/community, transitioning it from an inclusive and liberal state to an exclusive and strict club. Two mechanisms are critical to radicalization: *prestige-biased* cultural transmission and *niche construction*.[26] Prestige bias occurs when active community members with higher visibility and prestige exert disproportionate influence on cultural transmission. Niche construction involves a leader inducing blanket discrimination against community members, shielding the club from external pressures. In both cases, leaders start with a small extreme club, radicalizing the community over time through cultural transmission and niche construction. However, competition between clubs prevents these dynamic radicalization strategies.

Finally a series of papers centers on public education and media in their role in collectively transmitting cultural values within a community. In this vein, Gradstein and Justman (2002, 2005) analyze how education can promote a common culture, emphasizing the importance of school curricula convergence to prevent excessive polarization. Similarly, Dixit (2009) explores how norms of pro-sociality, transmitted through majority-

[25] See also Verdier and Zenou (2015) for a simpler model of competition between cultural leaders.

[26] See Henrich and Gil-White (2001) and Odling-Smee et al. (2003) for the study of prestige bias and niche construction in models of cultural evolution.

funded schools, can impact a country's economic success. Taking a more information-based mechanism approach of cultural transmission, Dessí (2005) investigates collective socialization through intergenerational transmission of collective memory, highlighting how younger generations' investment decisions are influenced by beliefs inherited from older generations. Carvalho et al (2022) models an education system which transmits a mainstream cultural trait, while the minority group may culturally react at the individual level or as a coordinated group. Hauk and Immordino (2013) study cultural dynamics in an environment where the media industry plays a role in socialization and provides coverage to cultural traits.

3.4 Relative cultural fitness as a socio-economic mechanism

In the canonical economic cultural transmission model direct vertical transmission is modeled as a parental effort choice to socialize children. More generally, however, socialization is the outcome of a combined series of parental choices. in this section we shall study models where parental socialization results directly from parental effort and fertility or marriage.

3.4.1 Fertility

In this section we introduce endogenous fertility choices and investigate how they interact with cultural socialization. Consider for instance, the canonical model of cultural transmission,and extend it to allow for some parental choice of reproductive pattern. Specifically let $n_i \geq 0$ denote the number of children chosen by parents with trait i, at cost $\mu \cdot n_i$ (where μ is the cost of raising one child). Parents of type i choose d^i, n^i to maximize

$$n^i(P^{ii}V^{ii} + P^{ij}V^{ij}) - n^i c(d^i) - \mu \cdot n^i \tag{7}$$

with P^{ii}, P^{ij} as in (2). Relative cultural fertility encodes both parental socialization and fertility:

$$f^i = \frac{d^i\nu^i - d^j\nu^j}{\nu^i q^i + (1-\nu^i)(1-q^i)}.$$

The dynamics of the distribution of traits in the population is then determined by

$$\dot{q}^i = q^i(1-q^i)\frac{d^i\nu^i - d^j\nu^j}{\nu^i q^i + (1-\nu^i)(1-q^i)},$$

where $\nu^i = \frac{n^i}{n^i+n^j}$.

As noted by Bisin and Verdier (2001), the choice of reproduction patterns tends to introduce a cultural complementarity force in the cultural transmission process, in that $n^i(q^i)$ is increasing in q^i. Indeed, parents endowed with a more frequent trait have a higher chance, everything else being equal, to get their children sharing their trait through society's socialization. Such an outcome is perceived by paternalistic parents as increasing the "quality" of children, motivating higher fertility rates and consequently more effective cultural transmission of their trait in the population. When more generally fertility interacts with direct socialization, 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. In such a case, 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.[27]

In summary, under some regularity conditions: i) there exists an interior locally stationary state; ii) either the interior stationary state is globally stable or it is locally stable and then there exist intervals in initial q^i which are basins of attraction for each of the corner stationary states. Essentially, cultural substitutions tends to induce dynamics converging towards the interior, while the quality/quantity trade-off in fertility tends to induce dynamics converging to the corner stationary states (majority children - with high socialization rates at little cost - have higher quality).

More recently, Bar-Gill and Fershtman (2016) provide an extension of the Bisin Verdier model with endogenous fertility to the case where paternalistic preferences for transmitting one's own trait are not separable across children: the nature of the cultural trait adopted by one child affects the paternalistic motives to transmit one's own trait to another child. In this context, the analysis highlights two opposite situations: one in which the emphasis is on having at least one child remaining loyal to the parents' cultural trait (described as a "survivalist type"). In the other, the emphasis is on having all the children maintaining the group's cultural trait (described as a "zealot type"). Individuals' fertility decision and their direct socialization effort therefore crucially depend on their degree of zealousness. Interestingly in such a case, integration cultural policies aimed at promoting the cultural conversion of minority groups to the trait of the majority may be ineffective, and even result in more resilient and larger minority groups. Indeed, whenever individuals are of

[27] Bar-El et al. (2013) provide numerical simulations of a version of this fertility model to investigate the evolution of secularization in a society. In their framework, the presence of both cultural complementarity and cultural substitution effects eventually leads to multiple steady state levels of secularization in the population.

the "survivalist" type, an integration policy may induce higher fertility rates as individuals may switch from a one child strategy with a high (and costly) direct socialization level to a two children strategy with much lower direct socialization levels. This change may result in a larger minority size whenever the effect of higher fertility is stronger than the effect of lower direct socialization.

3.4.2 Marriage

Earlier models in Bisin and Verdier (2000) and Bisin et al (2004) study the marriage mechanism as a component of cultural transmission, where the preferences in marriage are endogenous, and reflect the indirect preferences of the expected outcomes of the marriage match. Specifically, they assume that the only relevant characteristic of marriage matches consist in whether they are homogamous or heterogamous, in that homogamous marriages are valued because they are more effective socialization mechanism. In the extreme case, for illustration purposes, only homogamous marriages have the option to directly transmit their trait to their children at a rate d^i. In this case, the probability that a child in a homogamous marriage of type i is socialized to trait i is $P^{ii,hom} = d^i + (1-d^i)q^i$; while the probability that a child in an heterogamous marriage is socialized to trait i is $P^{i,het} = q^i$. Letting the probability of homogamous marriage of such type i be π^{ii}, the population dynamics take the form:

$$\dot{q}^i = q^i(1-q^i)\left(d^i\pi^{ii} - d^j\pi^{jj}\right). \tag{8}$$

We discuss next two different models for the determination of π^{ii}, π^{jj}.

Restricted pool. Consider a marriage mechanism where each individual can affect, at a cost, the probability to be married homogamously by entering a restricted pool in which marriages, if they occur, are homogamous.[28]

The probability of marrying homogamously is:

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

where $\alpha^i \in [0,1]$ is the probability of being married homogamously in the restricted pool entered at a cost (convex in α^i); and A^i, A^j are the fractions of agents from group i, j in the restricted pool. The ex ante probability that a parent of group i has a child of type i is

[28] Churches, ethnic clubs, and various other cultural institutions may serve for instance this purpose.

$$P^i(\alpha^i, q^i) = \pi^i(\alpha^i, A^i, A^j, q^i)P^{ii,hom} + (1 - \pi^i(\alpha^i, A^i, A^j, q^i))P^{i,het}$$

Socialization entails the choice of d^i, α^i given $A^i,\ A^j$:

$$\max_{d^i,\alpha^i} P^{ii}(\alpha^i, q^i)V^{ii} + \Big(1 - P^{ii}(\alpha^i, q^i)\Big)V^{ij}.$$

At equilibrium $A^i = \alpha^i,\ A^j = \alpha^j$.

Under convexity and regularity assumptions, Bisin and Verdier (2000) show the existence of a unique symmetric Nash equilibrium of this marriage game, where all individuals of type i choose the same marital segregation effort. At equilibrium, cultural substitution is satisfied, that is ($d^i\pi^{ii}$ is decreasing in q^i), and the population dynamics (8) induce a stationary distribution which is culturally heterogeneous.[29]

Frictionless matching. Bisin and Tura (2019) extend this class of models, where the preferences in marriage represent the indirect preferences of the expected outcomes of the marriage match, by i) allowing for the cultural transmission of heterogamous household; and by ii) allowing for fertility and divorce choices in the marriage match.

Agents are characterized by binary gender and dichotomous cultural type i. A household where the male has type h and the female j is hj. A household type composed of a single male with type h is $h0$ and the one composed of a single female with type j is $0j$. Matching is frictionless with transferable utility (TU) across spouses. Expected utility is constructed rationally anticipating future choices as a household (fertility, divorce, socialization, ...). It also accounts for idiosyncratic component - observed before marriage - capturing residual idiosyncratic returns from marriage. Homogamy has a socialization advantage (as above): $P^{ii,hom} \geq P^{i,het}$ for the same effort d^i and for any q^i.

Given expected marital utility U_t for all different potential type of matches $t \in T$ (including those composed of single individuals), μ_t is the fraction of marriages of type $t \in T$ and m_h and f_j are males and females with trait h and j, respectively. Under

[29] Hiller et al (2022) studies marriage markets with either homophilic or heterophilic preferences. When marriage preferences are homophilic and parental transmission is more efficient - indeed perfect - in homogamous families, cultural heterogeneity prevails as a stationary state. However, the presence of a small mass of heterophilic individuals is enough to break that result and to lead to cultural homogeneity in the long-run.

separability and appropriate distributional assumptions, the optimal stable assignment μ_t solves:[30]

$$\begin{aligned} &\max_{(\mu_t \geq 0)_{t \in T}} \quad \sum_{t \in T} \mu_t U_t - \varepsilon(\mu) \\ &s.t. \\ &\sum_j \mu_{hj} + \mu_{h.} = m_h \quad \forall h \in C, \\ &\sum_h \mu_{hj} + \mu_{.j} = f_j \quad \forall j \in C \end{aligned} \tag{9}$$

The cultural dynamics are characterized computationally in a structurally estimated model, giving rise to long run distributions by trait which converge to homogeneity - whereby immigrants assimilate to the trait of natives - and interesting comparative dynamics results about the speed of assimilation.[31]

Gender effects. In the canonical model of cultural transmission socialization is the choice of one parent, that is, of two parents treated as a unitary household. Even in the marriage models in this section it is the cultural composition of the household - whether it's homogamous or heterogamous - that determines socialization at the first order.

Several papers study instead environments where parental socialization is mediated by the gender. In Bisin and Tura (2024) maternal and paternal socialization are endogenously different through an equilibrium effect. It is assumed in fact that upon divorce it is only mothers that socialize their children. Through an anticipation effect of a divorce shock, therefore, the parents face distinct socialization problems. For either of the parents, however, socialization is gender neutral.[32] In Wu and Zhang (2021) and Wu (2021), instead, parental socialization is mediated by the gender of the child. Interesting results are obtained leveraging the interaction between gender-specific parental transmission rates and degrees of assortativeness in the marriage market. Finally, while in Wu and Zhang (2021) gender-specific transmission rates are exogenous, Hiller and Baudin (2016) and Baudin and

[30] $\varepsilon(\mu)$ is the generalized entropy of the matching, which captures the dispersion of individual preferences with respect to the aggregate preferences, conditional on spouses' attributes; Chiappori-Salanié-Weiss (2017), Galichon-Salanié (2022).

[31] See also Guirkinger et al. (2024) analyzing the intergenerational conflict on marriage decisions in migrants' families with a bargaining game between parents, brides and grooms, in the context of the transmission of cultural values to future grandchildren. Similarly, Farahzadi (2024) investigates the issue of "migration by marriage", using a matching model involving the choice of marrying a partner from the country of origin, because of a preference for cultural endogamy.

[32] In Bezin et al. (2022) maternal and paternal socialization operate differently: socialization depends on the presence of the father in the household, as children from broken families are more influenced by peers.

Hiller (2019) consider an environment where parents may endogenously socialize their sons and daughters differently, studying the evolution of cultural traits within male and female populations distinctly. On the other hand, they restrict the marriage market to random matching.[33]

3.5 Parental Transmission: Complementarities and Information

A series of recent papers has studied more general models of parental transmission, incorporating interesting forms of interaction between direct parental transmission and the cultural composition of society as well as informational limits and constraints in the parental socialization problem.

3.5.1 Cultural Complementarity

In the canonical economic model of cultural transmission, d^i has the cultural substitution property, that is d^i is decreasing in q^i. Considering more general socialization technologies $P^{ii}(q^i)$ than in (2), it can be shown that cultural substitution follows when $\frac{\partial^2 P^{ii}}{\partial d^i \partial q^i} < 0$. Intuitively, the property of *cultural substitution,* indicates that role models inside the family (direct vertical transmission) act as *cultural substitutes* to role models outside the family (oblique or horizontal transmission). In such a case, parents have less incentives to socialize their children the more widely dominant are their values in the population. Formally, with *cultural substitution* , the cultural fitness of trait i is a continuous, strictly decreasing function of q^i and, moreover, $f(d^i) = 0$ when $q^i = 1$. In this case, it is easy to see that the cultural dynamics are away from the boundaries $q = 0$ and $q = 1$. Conversely, when $\frac{\partial^2 P^{ii}}{\partial d^i \partial q^i} > 0$ vertical and oblique transmission are complements, a case Bisin and Verdier (2001) call *cultural complementarity.* In this case, the population dynamics of culture leads to homogeneity - either $q^i = 1$ or $q^i = 0$ depending on the initial condition. As an illustration of cultural transmission mechanisms in which complementarities arise consider

[33]Bezin et al. (2021) is another example illustrating how family composition, influenced by economic factors, impacts cultural evolution. Specifically, they examine an environment where traits like honesty depend on the father's presence. Children from broken families are more influenced by peers, increasing their likelihood of engaging in crime. Imprisoning criminal fathers leads to more single-parent families, which are less effective at transmitting honesty than two-parent families. The study shows that intense crime repression can backfire by increasing the likelihood that criminals' sons also become criminals. This model aligns with sociological disorganization theories of crime, and explains the emergence and persistence of urban ghettos, where high crime rates and broken families are prevalent, further perpetuating criminal behavior through negative community influences.

the following cultural transmission technology where direct and oblique transmission are not sequentially separated: Any child is first exposed simultaneously to the parent's trait and to the trait of a role model from the population with which he or 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 or her trait. In this case, indeed,

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

and $\frac{\partial^2 P^{ii}}{\partial d^i \partial q^i} > 0$.

3.5.2 Parental Information

In the canonical cultural transmission model parental information plays no role. Recently however, more detailed technologies for cultural transmission have been studied which leverage parental information to produce important insights.

Learning and persuasion. Adriani et al. (2018) consider parental socialization as an explicit process of information transmission.[34] Children do not have full information about their own preferences - that is, about the payoffs associated to their actions. They then observe an action taken by the parents, form beliefs about the desirability of that action, and choose their own optimal action. Parents have better information about the payoff of each action and have a paternalistic attitude toward their children. In this context, parental choices convey information to children, thus generating an information externality. Moreover, as informed parents are aware that their own choices set relevant examples to their children, they may use this signal strategically. In the context of the paper, parents might exert for instance self-restraint to avoid setting a negative example to the next generation. Embedding this information mechanism into a dynamic model of cultural transmission, Adriani et al. (2018) investigate the implications of the signaling distortion for the long run distribution of traits in the population. Interestingly, in this

[34] A small emerging economic literature tackles the issue of parenting styles. For instance, Lizzeri and Siniscalchi (2008) investigate the trade-off between sheltering the child from mistakes and encouraging learning from experience. Similarly, Doepke and Zilibotti (2008,2014, 2017) analyze the trade-off between direct parental intervention (authoritarian parenting) and respecting the child's autonomy (authoritative parenting). More recently, Seror (2022) presents a model where parent-child interactions create a complementarity in the formation of cognitive and non-cognitive skills. As the child learns from the parent, he forms cognitive skills.

model some form of cultural heterogeneity may persist even in the absence of cultural substitution.[35]

Incomplete information. In the benchmark cultural transmission model, parents have perfect information in terms of how they perceive their interactions with their children and with society. Della Lena and Panebianco (2021) extend this framework to an environment where parents have incomplete information regarding the effects of their socialization practices, via their interactions with children and with society. Specifically, consider an environment where parents may not have full information on the distribution of the cultural traits in the population.[36] While the population dynamics of culture is unchanged with respect to the canonical model in (1), cultural fitness now depends on the parents' conjectures about population shares, denoted $\hat{q}^i$. The analysis highlights how incomplete information in the technology of transmission affects both parental socialization efforts and long-run population dynamics. In particular, it shows how cultural heterogeneity might not be sustained in the limit even under conditions of cultural substitution. The rationale for this result relates directly to the structure of perceptions bias from the minority and the majority groups about the actual distribution of the population. Consider for instance the steady state with $q^i = 0$. In the neighborhood of this point, agents of type i - the minority group - can only have non-negative biases, whereby $\hat{q}^i - q^i \geq 0$. Because of this, under cultural substitution, agents with trait i choose an average effort that is lower than the average optimal effort under complete information. This reduces the probability that, in the next period, the trait of type i is transmitted, and it negatively affects the dynamics of q^i. Similarly, agents of type j - the majority group - cannot overestimate their population share, generally inducing a higher effort than with complete information. This also negatively affects the dynamics of the minority trait i. When the negative average bias of the majority group is large enough, its average socialization effort is strong enough to dominate the average socialization effort of the minority group. As a consequence, the minority trait i cannot survive for small values of q^i and the steady state $q^i = 0$ is stable and long-run cultural homogeneity prevails.

[35] Adriani and Sonderegger (2018) also consider an extension of this framework to analyze how the desire to conform to peer pressure or to a social norm interacts with parents' signaling distortion, and affects cultural transmission .

[36] Della Lena and Panebianco (2021) also study an environment where the incomprete information regards the effectiveness of their own parental socialization technology.

3.6 Social Transmission: Networks, Identity, Segregation

A series of recent papers has studied novel mechanisms of social transmission, extending the random matching mechanism exploited in the canonical model. In this section we first study models where social transmission is the result of the children's interaction with a culturally biased subset of society. The bias can be exogenous - for instance a predetermined network of parental relationships - or endogenous. In this last case it could be the result of parental socialization choice - e.g., segregating the space of interactions of their children in the social transmission stage - or the results of the children's themselves *identity* choices.

3.6.1 Network effects

In the canonical model of cultural transmission, oblique transmission occurs via random matching. Finite networks and social structures through which individuals are connected have however been emphasized in several recent contributions to the literature; see Vaughan (2013), Büchel et al (2014), Panebianco (2014), Verdier and Zenou (2017)). In order to ensure long run cultural convergence, these models impose enough structure on the interacting social network matrix $\mathbf{\Gamma}$. Panebianco and Verdier (2017) consider the case of complex random social networks, merging therefore insights from the epidemiological literature on large scale networks (Pastor-Satorras and Vespignani, 2003) and the cultural transmission literature. Specifically, consider a society of agents located on a large random network, with links formed according to a standard degree-based sampling process, and a degree distribution $(\xi(k))_k$ among neighboring nodes. The socialization rate of parents of type i, dk^i, depends on their network connectivity, i.e., on the degree k in the network. Let q_k^i denote the share of individuals of type i in the subset of agents with degree k; and let $\tilde{q}^i$ be the expected fraction of neighbors' of cultural type i in the network, $\tilde{q}^i = \sum_{k=0}^{\infty} \xi(k) q_k$. In the mean-field approximation, the dynamics of q_k^i are the natural extension of those in (1):

$$\dot{q}_k^i = \left[-q_k^i(1-d_k^i)(1-\tilde{q}^i) + (1-q_k^i)(1-d_k^j)\tilde{q}^i\right] \tag{10}$$

where $-(1-d_k^i)(1-\tilde{q}^i)q_k^i$ represents how many children of i parents with degree k become of type j; and $(1-q_k^i)(1-d_k^j)\tilde{q}^i$ represents how many children of j parents with degree k become of type i. Under quadratic degree dependent socialization costs, the socialization rates are obtained as $d_k^i = c_k(1-\tilde{q}^i)\Delta V^i$, and satisfy the *cultural substitution* property. The dynamics therefore converge to a set of cultural heterogeneous steady states $(q_k^i)_k$,

characterized by the fixed point conditions:

$$q_k^i = \frac{(1-d_k^j)\tilde{q}^i}{(1-d_k^i)(1-\tilde{q}^i)+(1-d_k^j)\tilde{q}^i},\ where\ \tilde{q}^i = \sum_{k=0}^{\infty}\xi(k)\frac{(1-d_k^j)\tilde{q}^i}{(1-d_k^i)(1-\tilde{q}^i)+(1-d_k^j)\tilde{q}^i}.$$

3.6.2 Segregation and isolation

Sociologists and social psychologists have widely acknowledged the fact that people have significant contacts with others like themselves, and that social interactions are characterized by homophily (that is the fact that contact between similar people occurs at a higher rate than among dissimilar people) (McPherson et al. 2001). From a cultural transmission perspective, this feature implies that socialization at large with society is unlikely to be fully random. In particular, the matching process through which children get socialized may be partly controlled by their parents (or other role models) through their choice of schools, neighborhood where to live, associations or clubs where to go, and so on. As well, children themselves may also choose peer connections in a non random way, reinforcing or mitigating the bias that parents produced in the first place.

In the benchmark model, oblique transmission occurred through random matching with society at large. One may however extend this framework to include the possibility that the cultural composition of society children get exposed to is at least partly under the control of parents. Abstracting from specific details of the contact process, the transmission probabilities could be generally written as,

$$P^{ii} = d^i + (1-d^i)Q^i \tag{11}$$

$$P^{ij} = (1-d^i)(1-Q^i), \tag{12}$$

where the composition of the social environment of the child, Q^i, is itself a function of the population shares q^i and a costly parental intervention, say s^i. In such a case, the effective "technology" of parental socialization is multidimensional, involving various margins of transmission: time effort, and social or spatial segregation decisions.

A simple example may take the following form :

$$Q^i = Q^i(s^i, q^i) = s^i + (1-s^i)q^i$$

with $s^i \in [0,1]$ the oblique bias chosen by the parent. Typically when $s^i = 0$, there is random matching for oblique transmission and $Q^i(0,q^i) = q^i$. There is a positive bias to match towards a model similar to parent i when $s^i > 0$. Indeed when $s^i = 1$, oblique transmission is completely biased towards the cultural variant of the parent and the child

is only exposed to that specific type. After substitution, the dynamics of change across generations become:

$$\dot{q}^i = q^i(1-q^i)\left[\varphi^i - \varphi^j\right]$$

with $\varphi^i = d^i + (1-d^i)s^i$ reflecting the "effective rate of cultural transmission of type i. This is the sum of the socialization direct parental bias d^i plus the oblique socialization bias $(1-d^i)s^i$. Again the difference between these "effective" transmission rates across the two cultural variants is what creates a cultural selective force in the population.

The cost the socialization of a parent of type i can be now denoted as $C(d^i, s^i)$. The optimal direct socialization rates d^i and degree of oblique transmission bias s^i are then the solution of the following problem:

$$\max_{(d^i,s^i)} -C(d^i,s^i) + \left[P^{ii}(d^i,s^i)V^{ii} + P^{ij}(d^i,s^i)V^{ij}\right]$$

Assuming that socialization costs satisfy some standard regularity assumptions, it can be shown that when vertical transmission and biased oblique transmission reinforce each other in the socialization process - that is, when the two dimensions appear as complements in the socialization technology and $\frac{\partial^2 C^i}{\partial d^i \partial s^i} < 0$) - then cultural substitution prevails, namely the optimal socialization choices $d^i\left(q^i, \Delta V^i\right)$ and $s^i\left(q^i, \Delta V^i\right)$ are decreasing in the frequency of the parent trait q^i. As a result the "effective" rate of cultural transmission of type i, φ^i, is also decreasing in the frequency q^i. The long run state of the population dynamics is culturally heterogeneous.

Several other models of endogenous biased oblique transmission models are analyzed for instance in Bisin-Verdier (2001) and Saez-Marti and Sjogren (2008). The marriage segmentation model analyzed in Bisin and Verdier (2000) is also an example of segregation strategies that affect cultural transmission. More recent examples consider explicitly a social network structure and analyze how the topology of social connections matters for the cultural dynamics (Büchel et al., 2014, Panebianco 2014, Patacchini and Zenou (2016), Panebianco and Verdier 2017, Verdier and Zenou 2017).

3.6.3 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 pro-active motivations in choosing their own preferences and cultural traits, and forming their *identity* in the jargon of social psychology. In this respect, the economic model of cultural transmission can easily be extended to incorporate insights from the economics of

identity formation (Akerlof and Kranton 2000).[37] Typically, the formation of social identity (race, gender, religious or political) can be analyzed through two somewhat opposite lenses. A first perspective argues that group identity is driven by a motive for inclusiveness and *cultural conformity*, and therefore that identity is reduced by assimilation and contact across cultures.[38] The alternative view suggests that cultural minorities are motivated in keeping their own distinctive heritage to generate a sense of positive *distinctiveness* or *cultural distinction*[39] from individuals who are part of that group.[40] When identity formation is characterized by cultural distinction, social interactions across groups might induce the formation of oppositional or radical identities on the part of specific groups.

Several economic models of cultural transmission account for children taking conscious actions towards their own cultural *identity formation*. In these models, the technology of cultural socialization is predicated on the interactions between vertical socialization processes (e.g parental effects) and horizontal socialization (e.g., peer pressure effects). In this respect, parents attempt in various ways to mitigate or control the peer pressure their children are exposed to. For instance they may prevent interactions with other kids, provide counter-balancing values, or be more closely engaged with their children. Such parental internalization of peer pressure effects contributes to the long run dynamics of culture.

As a first step along those lines, Bisin et al. (2011) present a framework where individuals, after being socialized by their families to a particular trait, choose the intensity of their identification with that trait. High intensity is seen as a *cultural distinction* process. Parents invest in socializing their children to their ethnic trait, anticipating the children's identity formation.

Socialization technology allows for parents to bias the social set of contacts the child is exposed to when not directly socialized.

The probability of drawing a contact of type i in the oblique transmission component

[37] See for instance, Darity et al (2006) for an exogenous replicator dynamics mechanism of identity formation.

[38] *Assimilation theories*, in political science and sociology (Gordon, 1964; Moghaddam and Solliday 1991), *contact theory* in social psychology (Allport, 1953) are the prominent theories of this line of thought.

[39] *Cultural distinction*, as defined here, is a property of individual preferences. It is related but distinct from *cultural substitution*, which is a property of socialization mechanisms.

[40] These ideas have been expressed by the theories of *multiculturalism* (Glazer and Moynihan, 1970). At a broader level, this view is also related to the *social identity theory* in social psychology (Tajfel, 1979; Tajfel et al, 1979; and Abrams and Hogg, 1988).

of cultural transmission is

$$Q^i(s^i, q^i)$$

with $s^i \in [0,1]$ and $Q^i(s^i, q^i)$ as before. Identity formation requires that oblique transmission involves the choice of the child, so that the probability that the child adopts trait i is $T^i(s^i, q^i)$.

We can consider two distinct child adoption rules:

> By conformity: drawing an (odd) number N of contacts and picking the type of the majority, so that the (Binomial) probability the child is of type i is:
>
> $$T^i(s^i, q^i) = \binom{N}{\frac{N+1}{2}} \Big(Q^i(s^i, q^i)\Big)^{\frac{N+1}{2}} \Big(1 - Q^i(s^i, q^i)\Big)^{N-\frac{N+1}{2}}$$
>
> By extreme conformity ("It takes a village," when the village is a minority): picking the type i only if all the contacts are i:
>
> $$T^i(s^i, q^i) = \Big(Q^i(s^i, q^i)\Big)^N$$

The parental socialization problem is

$$\max_{(\tau^i, s^i) \in [0,1]^2} \; -c(\tau^i) - C(s^i) + P^{ii}(\tau^i, s^i, q^i)V^{ii} + (1 - P^{ii}(\tau^i, s^i, q^i))V^{ii}$$

where $P^{ii}(\tau^i, s^i, q^i) = \tau^i + (1 - \tau^i)T^i(s^i, q^i)$. Under regularity assumptions, cultural substitution is maintained.

Another interesting recent contribution along the same lines is Giavazzi et al (2019). In this paper, as in Bisin et al. (2011), parents first choose the family socialization rates and then children choose their own cultural identity.[41] Agents in the children generation match randomly and obtain a payoff for the match. Let V denote the value of a match between agents in the children generation with the same cultural trait. Let θ^M (resp. θ^m) denote the fraction of the value of the match lost when a child keeps (resp. switches from) the parental identity and meets with an individual of the other group. While parents derive utility from transmitting their own cultural trait, they also care about the value of that

[41] See also Lazear (1999) and Konya (2005). Relatedly, Michaeli and Wu (2022) - building on Cheung and Wu (2018) cultural transmission model of a continuum of traits - explore the roles of peer pressure and show that strong paternalistic parents, ignoring peer pressure's social costs on their children, adopt more extreme socialization to counteract their children's conformity away from the parent's preference.

trait for their own child in society and they anticipate the child's own choice problem, knowing the distribution of the switching costs he/she will face but not the realization.

Specializing the model to one where the cultural choice is only on the part of the minority group - say group i - where switching identity may be interpreted as assimilating - the socialization rate d^i is increasing in ΔV^i, decreasing in the cost of the effort and, most interestingly, decreasing in θ^M and increasing in θ^m. Altruistic parents in fact internalize the cost their socialization choice imposes on their children and reduce their socialization effort d^i the larger is θ^M and decrease it the smaller is θ^m.

Two types of equilibria may emerge in this model: one where all dynamical paths converge to assimilation of the minority, and another where the minority group does not assimilate. The occurrence of complete assimilation depends upon a set of parameters such as the payoffs and switching costs from assimilating, the degree of cultural intolerance of parents, the technology of parental socialization, and finally on how much parents account for their child's utility payoff, that is, their altruism.[42]

4 The joint evolution of culture and institutions

The literature we survey in the previous sections is centered on models of the dynamics of the distribution of cultural traits in the population. These models have highlighted the relationship between cultural evolution and social interactions. In several instances, these models capture the role that social and political institutions play in these dynamics.

A recent line of research explicitly focuses on the two-way interactions between cultural and institutional environments: the distribution of cultural traits in the population affects the institutional and political structure of society and, on the other hand, the institutional and political structure of society affects the distribution of cultural traits in the population. These models are typically formally represented by a system of (two) dynamic equations: one describing cultural evolution and the second describing institutional change. They offer a novel approach to growth and development. Unlike traditional studies that try to isolate the causal impact of each factor on contemporary outcomes, these models can discuss how historical shocks propagate through their joint dynamics, and analyze how these interactions may have magnified or mitigated effects on long-run socioeconomic

[42]Furthermore, Giavazzi et al. (2019) obtain interesting results about the speed of convergence as a function of the parameters of the environment, identifying the characteristics of traits which are likely to spread quickly across generations.

outcomes. Moreover, they often generate non-linear transitory trajectories with a host of interesting implications such as non-ergodicity, path dependence, and hysteresis effects—challenging the neo-classical view of development as fully determined by initial conditions and monotonic accumulation processes.

In a simple two political groups society set-up, let β^i denote a structural parameter characterizing the institutional structure of society, e.g., capturing the relative political power of group i. Parental preferences for socialization - depending on the cultural and institutional environment their children inhabit - take the form $\Delta V^i(q^i, \beta^i)$. Cultural evolution is then modelled as an application of the economics cultural transmission we have introduced in the previous sections: it follows Equation 1, with a the relative cultural fitness term represented by

$$\left[d^i(q^i, \Delta V^i(q^i, \beta^i)) - d^j(1-q^i, \Delta V^j(1-q^i, 1-\beta^i)\right].$$

Institutional change characterizes instead the evolution of the structural parameter β^i, in a game that determines policies and outcomes in society.[43] In a political economy perspective, β^i summarizes the power structure across, e.g., two political groups. Institutional change then may take different forms, from incremental changes in the institutional bargaining structure,to open conflicts and abrupt changes in the political system.[44] In general though, the forces of motion of β^i will reflect the fact that the institutional system imperfectly and indirectly internalizes various externalities and commitment issues which plague social choice problems.

Bisin and Verdier (2024) provide a simple abstract set-up that illustrates the core structure of the institutional bloc of these models. Each period t, a societal policy game is played between private individuals and a hierarchical public policy authority (the state) controlling socio-economic policies. Individuals in each group i are characterized by an objective function $U^i(a^i, p, A)$ that depends on private actions a^i, a policy vector p, and some measure of socio-economic outcomes A, capturing the aggregate society-wide outcomes of the interactions between private agents and public authorities. These aggregate outcomes naturally depend on the vector $a = [a^1, a^2]$ of actions by individuals of the two groups, the public policy vector p, and the cultural distribution q^i in society: $A = A(a, p, q^i)$.

Policies are the outcome of a (collective) decision problem, in accordance with the distribution of political power between the groups encoded and represented by institutions.

[43] See Acemoglu et al (2006), and Acemoglu et al (2021) for surveys.

[44] Acemoglu and Robinson (2000, 2006) typically consider discrete phenomena like democratization, revolutions and coup regime changes.

Institutions can then be abstractly defined and parametrized by the (Pareto) weight $\beta^i = 1 - \beta^j$ in the decision making problem regarding to the policy vector p. Specifically, we could have the objective of the public policy authority identified by a social welfare function

$$W = \beta^i U^i(a^i, p, A) + (1 - \beta^i) U^j(a^j, p, A). \tag{13}$$

Given institutions β^i, a set of policies $p = p\left(\beta^i, q^i\right)$ and actions $a = a\left(\beta^i, q^i\right)$, characterize the equilibrium of the societal policy game between individuals and the public authority. Importantly, the equilibrium outcomes $p = p\left(\beta^i, q^i\right)$ and $a = a\left(\beta^i, q^i\right)$ also depend on the distribution of cultural traits q^i prevailing in the population.

It should be noted that the policy game is in general characterized by several economic and political externalities that are not fully accounted for by private and public decisions. Externalities typically arise because of socio-economic or political imperfections associated with the existence of various frictions going from asymmetric/incomplete information, matching problems, limited rationality and cognitive biases, strategic behaviors associated with market power, private opportunism and lack of political commitment. The equilibrium outcomes $a(\beta^i, q^i)$ and $p(\beta^i, q^i)$ of the societal policy game do not fully internalize their impacts on aggregate social outcomes $A(a, p, q^i)$, and as a result inefficient policies and social allocations are implemented.

The core element is then the mechanism driving institutional change. A society characterized by a power structure β_t^i at any point in time t, might have an incentive to change the distribution of political power in the future, to internalize the externalities responsible for the inefficiencies at equilibrium.

For instance, Bisin and Verdier (2024) considers institutions as general mechanisms operating on the distribution of political power to internalize externalities due to some form of lack of commitment on the part of the public policy decision maker. This is consistent with earlier political economy work on institutional change such as Acemoglu and Robinson (2000, 2006). Allowing for smooth changes $\beta^i \in [0, 1]$[45], institutional change takes a relatively simple form:

$$\beta_{t+1}^i \in \arg\max \beta_t^i U^1(\beta_{t+1}^i, q_{t+1}^i) + (1 - \beta_t^i) U^2(\beta_{t+1}^i, q_{t+1}^i)$$

where $U^i(\beta_{t+1}, q_{t+1}^i) = U^i(a^i(\beta_{t+1}^i, q_{t+1}^i), p(\beta_{t+1}^i, q_{t+1}^i), A(\beta_{t+1}^i, q_{t+1}^i))$ is the utility for members of group $i \in \{1, 2\}$ evaluated at future equilibrium choices with institution β_{t+1}^i.[46]

[45] This captures incremental institutional changes (Mahoney and Thelen (2010)) rather than more extreme phenomena like democratization or revolutions and coup regime changes as in Acemoglu and Robinson (2000, 2006).

[46] For convenience we denote $A(\beta_{t+1}^i) = A\left(p(\beta_{t+1}^i), a(\beta_{t+1}^i), q_{t+1}^i\right)$

Institutional change takes the form of delegation of power from the current institutional structure (as reflected by the power weight β_t^i) to a new institutional setup (as reflected by a power weight β_{t+1}^i). The direction of institutional change relates to the general principle that the political group most likely to internalize the externality is the group receiving more residual decision rights along the institutional dynamics.[47] Power weights therefore change continuously, according to an endogenous dynamic law, $\dot{\beta}^i = \phi(\beta^i, q^i)$ (in the continuous time approximation).[48]

The second part of the framework concerns the cultural transmission block. while various cultural selection mechanisms may be considered,[49] in the Bisin-Verdier set-up, the important feature is the fact that paternalistic motivations for cultural transmission now depend on the equilibrium outcome of the societal policy game $\Delta V^i = \Delta V^i(a, p)$. Under cultural substitution, parental socialization is generally stronger for cultural minorities and, ceteris paribus, for the group which is relatively favored at the equilibrium outcome (a, p) of the policy game.

[47] The stationary state of such process is not generally efficient, see for instance Acemoglu, Egorov, Sonin (2010), Bisin and Verdier (2024).

[48] Acemoglu and Robinson (2001, 2006) were the first to formally study institutional change, focusing on power delegation by elites to avoid social conflict rather than to internalize externalities. In this case the dynamics of β is effectively discrete and hence it cannot be represented by a dynamic law. Besley and Persson (2009, 2011a, b) also explore related aspects of institutional change.

[49] For instance Besley (2017) Besley and Persson (2019, 2020a, 2020b)) use the indirect evolutionary approach of cultural change from Güth and Yaari (1992), while Bidner and Francois (2011), Bisin and Verdier (2024), or Bezin (2019) use economic cultural transmission models,

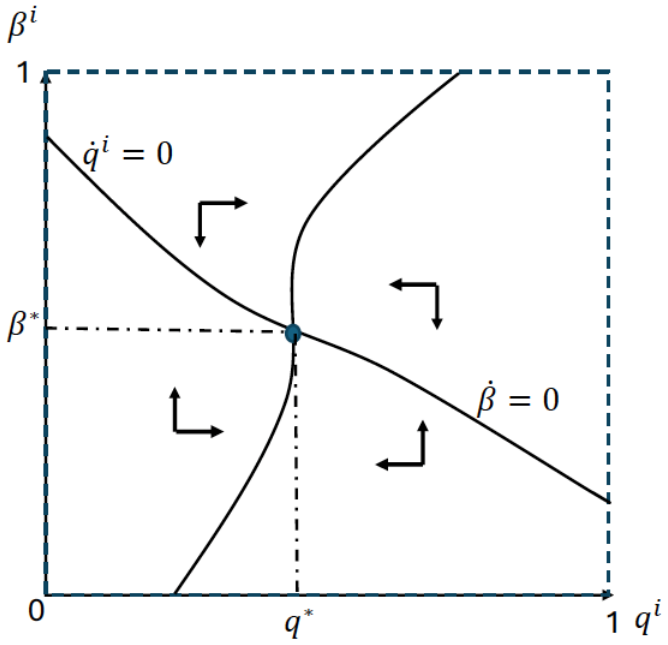

Figure 3

These considerations determine the cultural dynamic of the profile of society q_t over time. Given that (a, p) are themselves function of the institutional weights β_t^i, the diffusion of cultural traits across generations are consequently also influenced by the status of the institutional system, β_t^i. This mechanism induce a cultural dynamic $\dot{q}^i = q^i(1-q^i)G(\beta^i, q^i)$ (in the continuous time approximation).

The politico-economic and cultural structures of society are then characterized by the joint dynamics of institutions and culture (β^i, q^i) as described in Figure (3). This system eventually reaches a long run steady state (β^*, q^*).

A major theme across the literature is to highlight whether the joint dynamics between culture and institutions reinforce or hinder each other, depending on whether culture and institutions are dynamic complements or substitutes. Typically, a key complementarity between institutions and the dynamics of preferences would occur when having more of a certain cultural trait in the population is likely to induce an institutional equilibrium with an outcome more that benefits more individuals endowed with such trait. In turn,

the induced payoff outcomes is likely to facilitate the cultural diffusion of the trait in the population.[50]

4.1 Culture and various specific institutions

We turn to briefly discuss several papers in the literature that highlight the idea of a bi-directional relationship between culture and institutions in more specific contexts.

4.1.1 Culture and market institutions

An interesting line of research consider the relationship between culture, growth and market institutions. Earlier on, Doepke and Zilibotti (2008) already pointed at the role played by the development of an entrepreneurial culture in the industrialization process, and emphasized the relative importance of bourgeois cultural values compared to aristocratic cultural values as the roots of Britain's industrialization process. Along this line and using the Bisin and Verdier (2001) approach, Bidner and Francois (2011) considered the interaction between honesty norms and institutions encouraging trading, while other papers investigated the connections between cultural values and labor market institutions (Aghion et al., 2011, Michau, 2013 and Alesina et al., 2015). Hiller (2011) analyzed the reciprocal interplay between the cultural evolution of workers' autonomy and the industrialization process. More recently, Chakraborty et al. (2016) and Klasing (2014) consider the interaction between an entrepreneurship culture, measured by agents' risk attitudes, and the process of economic development, while Gorodnichenko and Roland (2017) investigate the existence of mutual reinforcement between the culture of individualism, growth and protection against the risk of expropriation.

Eruchimovitch et al. (2024) also explores the coevolution between individualism/collectivism and market-supporting institutions. In this setup, individuals join one of two types of social organizations: "market" or "clan", depending on the relative productivity in the market, the strength of individualistic inclinations, and the quality of market-supporting institutions. Statically, market size depends on individualism and institutional quality. When the quality of market institutions and the prevalence of the individualistic trait become

[50] A stylized model illustrating such a situation is Salazar and Szentes (2021) which considers a population game in which selfish agents and unconditional cooperators play the Prisoner's Dilemma repeatedly against random opponents, and there is institutional capital promoting cooperation among players. Both the type distribution and capital evolve according to a myopic best-response dynamics. The system exhibits complementarity between cultural types and institutional capital with eventually multiple equilibria which can be Pareto-ranked

endogenous, the model exhibits two stable long run equilibria: one with high individualism, strong institutions, and a thriving market organization, and the other one with collectivism, no institutions, and a weak market.

4.1.2 Culture and political institutions

A set of papers focus more specifically on the connections between culture and political institutions. For instance, Besley (2017) shows how the interplay between the dynamics of preferences for aspirations and the politics of income redistribution creates a feedback loop, which allows for the possibility of an aspirational poverty trap in which countries are locked into a low aspirations culture which inhibits development. Similarly, Besley (2019) discusses the idea of government as a reciprocal social contract between the state and its citizens: the citizens pay taxes and the state provides public goods. A strong civic culture, evolving in the society according to the relative payoffs of civic-minded and materialist citizens, manifests itself as high tax revenues sustained by high levels of voluntary tax compliance and provision of public goods. In the same vein, the complementarity between political institutions and culture is also investigated in Ticchi et al. (2013), and Besley and Persson (2019,) to study the coevolution between democratic values and democratic institutions. Finally, Besley and Persson (2021) discuss the dynamics of identity politics and the two-way relationship between politics and nationalism. They consider a context where voters have multidimensional cleavages and policies: redistribution along a rich/poor dimension and immigration control along a nationalist/cosmopolitan identity dimension that evolves overtime. The model exhibits political hysteresis, with large enough shocks to class polarization and immigration salience having long-run consequences on nationalism and immigration policy.

Taking a different angle, Alesina et al (2021) explore national identity formation through "nation-building," where policies like mass education or indoctrination shape the divergence of preferences among citizens. Their analysis, though lacking explicit dynamics of cultural homogenization, compares the incentives for homogenization in dictatorships versus democracies, considering government type and borders as endogenous. A key finding is that the threat of democratization strongly incentivizes preference homogenization, consistent with historical episodes in the nineteenth century and correlations from 1925-2014 data.

4.1.3 Culture and political-economic institutions

Touré (2021) examines how culture interacts with market and political institutions. Specifically, as in Bisin and Verdier (2017, 2024), political power is divided between workers and elites, with elites further split into entrepreneurs (who have a strong work ethic) and nonentrepreneurs. Culture evolves based on the relative utility of these traits. Public goods, such as infrastructure, that promote industrialization, are determined by through a political process reflecting the balance of power between the different social classes. It suffers from suboptimal provision due to commitment issues. Importantly, these elements are embodied in a general equilibrium model of market interactions with a final good competitively produced using both labor and intermediate inputs in a complementary way. In this context, workers prefer the highest level of public investment, as it boosts labor productivity. Entrepreneurs support an intermediate level, benefiting from labor's complementarity with their intermediate goods, while nonentrepreneurs favor the lowest level, as they gain little from industrialization. Following the logic of Bisin and Verdier (2017, 2024), institutional change corrects the suboptimal provision of public infrastructure by shifting power toward workers, especially when policy externalities are large. A politically powerful elite limits the scope of public investment, weakening productivity, and consequently the diffusion of the entrepreneurial trait is weak. Conversely, when entrepreneurship is rare, intermediate goods production remains low, reducing the marginal impact of the public policy. As the policy externality to be corrected is small, this makes an institutional shift toward workers less likely.

Together these elements generate a coevolution between culture and political and economic institutions with strong complementarities. An economy where entrepreneurial culture is not widespread and/or workers have little power is trapped in a regime without industrialization and in which institutions and culture do not evolve. Conversely, an economy with enough entrepreneurial culture and/or workers empowerment is likely to takeoff, and along its trajectory, industrialization will follow jointly with an ever expanding diffusion of the entrepreneurial culture and increasing workers' empowerment. The author discusses historical evidence suggestive of this mechanism in the case of British history.

4.1.4 Culture and environmental institutions

Key complementarities have also been identified in the diffusion of environmental culture, and its interactions with markets and political institutions. In this respect, Bezin (2015) which considers an overlapping generations model of environmental externalities and cap-

ital accumulation where private contributions to environmental quality are motivated by a desire to socialize others into environmental attitudes. Along the equilibrium path of capital-accumulation some, but not all, green agents contribute to the environment and effectively transmit a green culture intergenerationally.[51] Furthermore, Bezin (2019) considers the coevolution between a green consumer culture and sustainable technological change. Importantly, the set-up has now three state variables: culture, technology and the environment. Green preferences evolve according to the Bisin and Verdier (2001) model of cultural transmission, while innovation is endogenously directed towards green or brown sectors depending on culture through market size effects. Finally, pollution accumulates depending on the production level of the brown sectors. Because of dynamic complementarities beween technological change and cultural evolution, the model exhibits path dependency, an important feature of sustainable innovation processes. Also, when taxes on dirty production are decided by majority voting of the mature generation, a politically sustainable environmental tax exists only when the cost of socialization to green preferences is low enough. This highligths the key role for non-monetary interventions ("green" education) to foster the political sustainability of economic instruments (tax and subsidies).

Relatedly, Besley and Persson (2019, 2020b, 2021) also highlight the complementarity between value adaptation and policy choice in environmental policy. Their model features two types of citizens: materialists and environmentalists. Political outcomes are determined by a two-party competition model with probabilistic voting, where the policy reflects the average swing voter's interests, leading to a Pigouvian-like outcome. As environmental values evolve based on relative payoffs, policy choices drive society toward either environmentalism or materialism. The complementarity between expected policy and preference evolution stems from political externalities in majoritarian policymaking, which prevents optimal long-term welfare outcomes. As the political system does not internalize value dynamics induced by policies, institutional changes may be needed that delegate decision rights on environmental policies to political structures favoring environmentalist preferences, aligning therefore with Bisin and Verdier's (2017, 2024) perspective.

[51] In the same vein, Schumacher (2015) analyzes a dynamic model with Leontieff preferences such that environmental quality and consumption are perfect complements, and investing in the formation of an environmental culture is costly. An environmental culture emerges only after the society has reached a critical level of economic development.

4.2 Cultural and institutional determinants of long-run growth

Dynamic complementarities between culture and institutions facilitate the emergence of different long-run social organizational forms and divergent institutional and cultural trajectories. Some papers explicitly emphasize this dimension to model critical historical junctures in specific comparative historical contexts.

Greif and Tabellini (2017) compare social organizations such as clans and corporations that sustain cooperation through different enforcement methods. Clans rely on kin-based loyalty and reciprocal obligations, while corporations (e.g., cities or guilds) depend on generalized moral obligations and impersonal enforcement. Individuals with different cultural traits (personalized or generalized morality) choose to affiliate with either clans or corporations. The population's cultural trait distribution determines the equilibrium size of these organizations, as different traits provide advantages to each. This structure in turn affects the evolution of cultural traits, leading to multiple steady states based on initial conditions. The model is used to compare the organizational dynamics in China and Europe over the last millennium.

The same logic is applied by Bisin et al. (2024) to examine the role of religious legitimacy in political economy. Legitimacy enables secular elites to affirm their authority and lower the transaction costs of implementing policies. However, clerics' ability to supply legitimacy depends on how well religious values are disseminated in society. This dissemination is facilitated by institutions granting more political power to clerics. Drawing on Bisin and Verdier's (2017, 2024) institutional change mechanism, if the legitimacy effect is strong enough, institutional change shifts power towards clerics, internalizing the social externalities of religious activities.[52] Clerics then exercise this power by providing religious activities in larger quantities, in turn propagating cultural values within the population that justify the ruling and extractive capacity of the political elite. Culture and institutions are then complementary. As in Greif and Tabellini (2017), these effects give rise to multiple stationary states with joint diverging dynamic trajectories, converging towards a *religious state* or alternatively, a *secular state.*The model formally compares the historical institutional and cultural trajectories of the Christian West and the Muslim East at the end of medieval times.

[52]See Benabou, Ticchi and Vindigni (2015) and Seror (2018) for a discussion of these externalities.

4.2.1 Substituability between culture and institutions

While complementarity between culture and institution is a feature of most models of their dynamics, dynamic substitutability also plays a role in this literature. Early on in this literature, Tabellini (2008) notes that legal systems based on localized external enforcement are likely to undermine the transmission of cooperative cultural values. Similarly, Aghion et al. (2010) highlight the fact that trust and entry regulation can be substitutes, as low-trust economies demand entry regulation to prevent entrepreneurs with limited civic from imposing negative externalities on the market. Along the same vein, Carlin et al. (2009) consider the functioning of financial markets and suggest that trust and regulation are substitutes or complements depending on the extent of social capital in the society.More recently, Bisin and Verdier (2024) provide an example of dynamics between civic culture, corruption and political empowerment of the civil society that suggest that the relationship between culture and institutional structures can be complements or substitutes depending on technological fundamentals of the social environment.

Migliaccio and Verdier (2018) provide an example where the degree of complementarity/substitutability between culture and institutions is time varying. Specifically, they analyze how cooperative cultural traits spread spatially and lead to social segregation institutions shaped by political processes at the level of local communities. In their set-up, local cultural transmission is influenced by parental efforts and a random spatial noise. Assortative matching allows cooperators to partially segregate, but its degree is endogenous and costly. Using reaction-diffusion equations on a continuum space, the analysis shows how cooperation spreads via a *traveling wave*, enabling localized clusters to expand and influence broader spatial populations.[53] The equilibrium assortativity level evolves non-monotonically during spatial diffusion. In places where cooperators and segmentation are absent, an assortative matching mechanism emerges and spreads. However, as cooperators grow locally in number, it eventually fades away. Culture and institutions initially complement each other, but later become substitutes, shaping the diffusion dynamics of cooperative behavior.

Asano (2018) also exhibits an example where the relationship between cultural and institutional dynamics can be time varying. He examines the coevolution of trust and

[53]Technically, this approach differs from agent-based simulations models analyzing cooperation in discrete spatial environments such as lattice or networks frameworks. Considering spatial diffusion on a continuum space, allows the application of mathematical techniques and results from partial differential reaction-diffusion equations theory, with the derivation of analytical results on the spatial evolution of cooperation and assortative matching institutions.

legal institutions in competitive credit markets. Entrepreneurs can be civic (productive) or uncivic (cheating), with their true intentions been private information, and enforcement quality shaping their incentives. Strong enforcement benefits civic entrepreneurs by reducing cross-subsidization of uncivic ones but harms uncivic entrepreneurs. Voting dynamics determine enforcement: high-trust economies (with many civic entrepreneurs) support strong enforcement, while low-trust economies prefer weak enforcement. Civic values evolve according to a transmission process a la Bisin and Verdier (2001). This influences long-term institutional quality, potentially leading to an underdevelopment trap with weak enforcement and distrust. Interestingly, long-term complementarity between trust and enforcement contrasts with short-term substitutability. Indeed, during transitions where uncivic entrepreneurs are pivotal political agents, higher trust improves the long run establishment of civic entrepreneurs who support enforcement, but it also leads in the short run, uncivic ones to vote for weaker enforcement to exploit the benefits of cheating.

5 Future avenues for research

As testified by the literature reviewed above, substantial advances has been made in the economic theory of cultural transmission. This has generated significant insights on how cultural diversity evolves and how it may persist. Furthermore, cultural transmission processes have been embedded into models aimed at better understanding e.g., economic growth and development, political economy, long-run historical phenomena, and environmental sustainability issues. In this last section, we conclude by briefly discussing three areas that, in our opinion, merit further attention in future research.

5.1 Cumulative culture and the transmission of cultural systems

Most economic theories of cultural transmission focus on the evolution of individual cultural traits. However, culture typically consists of packages of traits, suggesting an "extensive margin" alongside the "intensive margin" of trait frequency in the population. This conceptualization of culture aligns well with the notion of *cumulative culture* in evolutionary anthropology and biology, which we discuss in Section 2. Whe3n culture is cumulative, information accumulates over time to create complex artifacts and knowledge beyond the capability of a single generation. Research in this area explores how the amount and complexity of culture evolve dynamically, often examining constraints on cumulative cultural

evolution, and identifying its determinants.[54]

Cultural systems of multiple traits have been studied with the help of graph-theory and agent-based models (Buskell et al., 2019; Jansson et al., 2021), but they lack explicit socio-economic context modeling.[55] Recently, Acemoglu and Robinson (2024) propose a hierarchical cultural framework with various attributes, building upon the insights from cultural sociology which sees culture as a "toolkit" of attributes that individuals use to shape and justify their actions (Swidler, 1986; Alexander, 2003; DiMaggio and Markus, 2010). They discuss how the fluidity of the cultural system depends on the nature of the attributes, their connectivity, and specific social and political contexts. They do not however explore population-level cultural transmission or diffusion, which remains a significant challenge.

Population dynamics of cultural systems can bring new and interesting insights on the dynamics of culture and its interactions with socio-economic contexts. It may identify conditions for the emergence of cultural clusterings, self-organisation, and path dependency. It may also illustrate how connections between traits contribute modulating rates of cultural change, in turn providing a better understanding of slow-moving cultural change (Roland 2004) as opposed to fast-moving fads and fashions.[56]

5.2 The economic geography of cultural transmission.

Cultural specificities persist and differ significantly across space, e.g., neighborhoods or cities. At the same time, cultural traits also tend to spatially diffuse, whether directly through cultural contacts of the population carrying the trait, or indirectly through trade and exchange of goods implicitly embodying cultural information. Few economic models of cultural transmission focus explicitly on these spatial and geographic dimensions.

As already mentioned, Migliaccio and Verdier (2018) is an example applying the theory of reaction-diffusion models to analyze the spatial transmission and diffusion of a cooperative cultural trait. In this set-up, the spatial dispersal of the trait evolves according to

[54]For instance, Henrich (2004) and Aoki and Kobayashi (2012) analyze how larger populations directly facilitate cumulative cultural evolution through biased cultural transmission models. Derex and Boyd (2016), and Derex et al. (2018) show that population structure critically affects cumulative culture, Smolla and Akçai (2023) consider the co-evolution of cumulative culture and social networks.

[55]See as well Enquist et al. (2011) for a general formal framework to study stepwise modification, differentiation or combination of elements in cultural systems.

[56]In the terminology of Acemoglu and Robinson (2024), cultural sets may be expanding or contracting at low frequency, while cultural attributes may be wired and rewired at higher frequency; enriching the span of plausible responses to changes in the socio-economic environment, at different time scales.

a simple random walk process. This leaves aside any relevant economic aspect related to geographic mobility or location decisions. Specifically, an important insight from economic geography and urban economics has been to identify the source of agglomeration and diffusion forces which affect the spatial distribution of socio-economic activities and their associated amenities and opportunity costs. In economic models of cultural transmission, such elements are likely to impact cultural socialization strategies and the dynamics of the spatial distribution of cultural traits. These features have started to be illustrated in Bezin and Moizeau (2017), and Bezin,Verdier and Zenou (2022) in the context of education and crime, respectively. They provide examples of models of neighborhood formation and cultural transmission, showing how the tension between culture preservation and socioeconomic integration drives the pattern of segregation in the city.[57]

More generally, a promising area for future research might be to construct spatial models that incorporate explicitly the two dimensions of agglomeration/dispersion forces related to the location of socio-economic activities, and the transmission of cultural traits that are functional (or not) to these activities. Such approach is expected to generate an economic geography theory of the emergence/persistence of cultural clusters and their association to specific markets and spatial infrastructures. Given the feedback effects and externalities that exist in spatial economic contexts, this can also be useful to derive interesting policy implications.

5.3 Equilibrium models of culture, institutions, and growth

As we noted in Section 4, a recent literature has successfully embedded cultural transmission and institutional change to study the dynamics of several important long-run historical phenomena. With regards to specific comparative historical contexts of differential growth, Greif and Tabellini (2017) and Bisin et al. (2020), are the main examples of this approach. More generally, however, after the large literature on endogenous growth theory,[58] studies of the determinants of long-run growth and development in economics have i) widened in focus, to account for various relevant socio-economic activities characterizing economic development - like the formation of democratic and autocratic institutions, voting participation, public health, gender and racial equality, ethnic fractionalization; ii) are searching

[57] In the context of international labor mobility, Rapoport, Sardoschau, and Silve (2020) also present a theoretical model of migration-based cultural change that investigates how migration affects cultural proximity between home and host countries.

[58] See e.g., Aghion and Howitt (2008) and Acemoglu (2009) for book-length treatments of the subject.

for explanatory factors of long-run growth in persistent cultural and institutional factors.[59]

In this context, theoretical models that center on institutional change and on the interaction of culture and institutions are a first step towards a novel theory of long-run growth and development. So far, these models lack however a fully integrated analysis of culture, institutions, and the various relevant socio-economic activities that contribute to economic development. Theoretical contributions along these lines are challenging, due to the high degree of heterogeneity and dimensionality of the dynamical system to be studied. However, these technical aspects have been at the center of the macroeconomic literature with heterogenous agents (Krusell and Smith 2006, Achdou et al. 2022) and dynamic political macoeconomic models (Hassler et al. 2003). Adapting the tools developed in this literature to study general equilibrium models of growth with cultural and institutional change could provide interesting qualitative insights, aligned with historical narratives. It will also generate quantitative implications clarifying the total and relative influence of culture and institutions on development, beyond the standard focus of first-order causal effects which are at the core of the wealth of recent *persistent studies*.[60]

[59]Inspiration for these analyses are found, e.g., in the early work of Douglas North (North and Thomas, 1973) and Avner Greif (Greif, 1989, 1993). But this literature in its current form has its origin in Acemoglu et. al (2001) and the subsequent work of Daron Acemoglu, James Robinson and coauthors; see Bisin and Federico (2021) for detailed analyses and discussions of this approach.

[60]See Bisin and Moro (2021), Voth (2021), and several other contributions in Bisin and Federico (2021) for overviews of the literature on persistent studies.

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Appendix: Extensions

In these appendix we indicate several extensions of interest.

A: Within cultural group heterogeneity and cultural socialization

We consider the effect of economic heterogeneity within cultural trait groups on the cultural dynamics. For this assume now that all the socioeconomic parameters $u^i(.)$ and ΔV^i are the same across members of the two cultural groups, but the resource R is heterogenously distributed within group i according to a cumulative distribution $F_i(.)$.

First, denote for convenience the minimum economic cost $C(w,d)$ for a parent to reach a given level of socialization rate $d = f(d(m_i, l_i))$ where $f(.)$ an increasing concave function such that $f(0) = 0$ and $f(\infty) = 1$, and $d(m_i, l_i)$ a standard production function concave in each argument and with constant returns to scale:

$$\begin{aligned} C(w,d) &= \min_{m_i, l_i} m_i + w l_i \\ f(d(m_i, l_i)) &= d \end{aligned} \tag{14}$$

Standard properties of the socialization production function provides that $C(w,d)$ can be rewritten as $C(w,d) = c(w)\varphi(d)$ with $c(w)$ an increasing concave function of the productivity w and $\varphi(d) = f^{-1}(d)$ an increasing convex function of d such that $\varphi(0) = 0$ and $\varphi(1) = +\infty$. Using the budget constraint, the socialization problem of a typical parent of type i can then be stated as

$$\max_{d^i} u^i(R + w - c(w)\varphi(d^i)) + P^{ii}(d^i, q^i)V^{ii} + P^{ij}(d^i, q^i)V^{ij}$$

Then the socialization rate of that parent with trait i and resource R is given by $d^i(R, q^i) = d^*(R, w, q^i, \Delta V)$ solution of the equation

$$c(w)\varphi'(d^*) \cdot u'(R + w - c(w)\varphi(d^*)) = (1 - q^i)\Delta V$$

It is easy to see that the dynamic evolution of the cultural population therefore is then given by :

$$\dot{q}_t^i = q_t^i(1 - q_t^i)\left[\int d^i\left(R, q_t^i\right) dF_i(R) - \int d^j\left(R, q_t^j\right))dF_j(R)\right]$$

Consider then the fact that the resource R is more unequally distributed across individuals with trait j than across individuals with trait j, in the sense that the distribution $F_i(.)$ is a mean preserving-spread of the distribution $F_j(.)$. By Jensen's inequality, it is

easy to see that the effect of such distributional difference on the dynamics of culture will depend on whether the individual vertical socialization rate $d^i\left(R, q_t^i\right)$ is a convex or a concave function of R. When it is convex, then the trait where the resource is more unequally distributed has a relatively higher cultural fitness than the other trait. The converse holds when the vertical socialization rate $d^i\left(R, q_t^i\right)$ is concave in R. In particular, at a second order approximation of the concave utility function $u(.)$ and the concave socialization rate function $d^i\left(R, q_t^i\right)$,

We can easily prove the following result:

Result : *Assume that the functions $u(.)$ and $\varphi\left(.\right)$ are such that $u''' \geq 0$ and $2\varphi''^2 < \varphi'\varphi'''$. Then the socialization rate $d^i\left(R, q_t^i\right)$ is concave in R, and, ceteris paribus, the trait associated to a more equal distribution of resources R is more likely to prevail in the long run cultural dynamics of the population.*

Indeed from the FOC, on gets that $d^*(R, w, q^i, \Delta V)$ is satisfying :

$$c(w)\varphi'(d^*) \cdot u'(R + w - c(w)\varphi(d^*)) = (1 - q^i)\Delta V$$

and thus differentiation provides (with obvious notations):

$$\frac{\partial d^*}{\partial R} = \frac{-u''\varphi'}{\varphi'' \cdot u' - c\left[\varphi'\right]^2 \cdot u''} > 0$$

Observe as well that

$$1 - c\varphi' \frac{\partial d^*}{\partial R} = \frac{\varphi'' \cdot u'}{\varphi'' \cdot u' - c\left[\varphi'\right]^2 \cdot u''} > 0$$

differentiating another time provides that the sign of $\frac{\partial^2 d^*}{\partial R^2}$ is the same as the sign of

$$A = \begin{array}{c} \left[-u'''\varphi'\left(1 - c\varphi' \frac{\partial d^*}{\partial R}\right) - u''\varphi'' \frac{\partial d^*}{\partial R}\right]\left[\varphi'' \cdot u' - c\left[\varphi'\right]^2 \cdot u''\right] \\ +u''\varphi' \left[\begin{array}{c} \varphi''' \frac{\partial d^*}{\partial R} \cdot u' + \varphi'' \cdot u''\left(1 - c\varphi' \frac{\partial d^*}{\partial R}\right) \\ -2c\varphi''\varphi' \frac{\partial d^*}{\partial R} \cdot u'' - c\left[\varphi'\right]^2 \cdot u'''\left(1 - c\varphi' \frac{\partial d^*}{\partial R}\right) \end{array}\right] \end{array}$$

Note that A can be decomposed into two terms:

$$\begin{aligned} B = & -u'''\varphi'\left(1 - c\varphi' \frac{\partial d^*}{\partial R}\right)\left[\varphi'' \cdot u' - c\left[\varphi'\right]^2 \cdot u''\right] \\ & - u''\varphi' c\left[\varphi'\right]^2 \cdot u'''\left(1 - c\varphi' \frac{\partial d^*}{\partial R}\right) \end{aligned}$$

and

$$C = -u''\varphi''\frac{\partial d^*}{\partial R}\left[\varphi'' \cdot u' - c\left[\varphi'\right]^2 \cdot u''\right] + u''\varphi'\left[\varphi'''\frac{\partial d^*}{\partial R} \cdot u' + \varphi'' \cdot u''\left(1 - 3c\varphi'\frac{\partial d^*}{\partial R}\right)\right]$$

the sign of B is negative when $u''' \geq 0$ (recalling that $1 - c\varphi'\frac{\partial d^*}{\partial R} > 0$ and $\varphi'' > 0$) as B rewrites as:

$$B = u'''\left(1 - c\varphi'\frac{\partial d^*}{\partial R}\right)\left[-\varphi'\varphi'' \cdot u'\right] < 0$$

The sign of C is the same as the sign of

$$D = \frac{\partial d^*}{\partial R}\left(\varphi''^2 - \varphi'\varphi'''\right) \cdot u' + \frac{\partial d^*}{\partial R}2c\varphi'^2\varphi''u'' - \varphi'\varphi'' \cdot u''$$

Substituting the value of $\frac{\partial d^*}{\partial R}$ and rearranging terms after tedious but straightforward calculations provides that

$$D = \frac{-\varphi'\left(\varphi''^2 - \varphi'\varphi'''\right) \cdot u'u''}{\varphi'' \cdot u' - c\left[\varphi'\right]^2 \cdot u''} - \varphi'\varphi'' \cdot u''\left[\frac{\varphi'' \cdot u' + cu''\varphi'^2}{\varphi'' \cdot u' - c\left[\varphi'\right]^2 \cdot u''}\right]$$

Thus $D < 0$ when

$$\left[-\varphi'\left(\varphi''^2 - \varphi'\varphi'''\right) \cdot u'u''\right] - \varphi'\varphi'' \cdot u''\left[\varphi'' \cdot u' + cu''\varphi'^2\right] < 0$$

or

$$(-u'')\left[(2\varphi''^2 - \varphi'\varphi''')\varphi'u' + \varphi''cu''\varphi'^3\right] < 0$$

Thus when $2\varphi''^2 - \varphi'\varphi''' < 0$, we have $D < 0$.

Collecting these results we see that $2\varphi''^2 < \varphi'\varphi'''$ and $u''' \geq 0$ are sufficient conditions for $\frac{\partial^2 d^*}{\partial R^2} < 0$ are .QED

B: The domain of cultural traits

A first line of research has been to expand the domain of the cultural traits transmitted across generations, allowing in particular for multiple (more than 2) discrete traits and for a continuum of traits. This extension is important as it naturally introduces a topology over cultural traits.

Multiple (discrete) traits

An important contribution along these lines has been the extension of the cultural transmission model in Bisin and Verdier (2001) (from now on BV), pursued by Bisin et al (2009) and Montgomery (2010), to a domain of $n > 2$ discrete trait values. Consider for instance the direct extension of the dynamics in Equation 1 to n cultural traits:

$$\dot{q}^i = q^i \left[d^i - \sum_j q^j d^j \right], \text{ for all } i = 1, \dots n. \tag{15}$$

Clearly, when the transmission rates d^i's are exogenous, the dynamic converges from every interior state to a homogeneous distribution centered on trait $i \in \arg\max_i \{d^i\}_{i=1}^n$. Allowing for endogenous parental socialization à la BV, we obtain instead the following dynamics:

$$\dot{q}^i = q^i \left[C'^{-1}(\sum_j q^j \Delta V^{ij}) - \sum_j q^j C'^{-1}(\sum_k q^k \Delta V^{jk}) \right], \text{ for all } i = 1, \dots n. \tag{16}$$

When the cost function $C(d)$ takes a simple quadratic form $C(d) = c\frac{d^2}{2}$, equation (16) rewrites as

$$\dot{q}^i = q^i \left[\sum_j q^j \frac{\Delta V^{ij}}{c} - \sum_j \sum_k q^j q^k \frac{\Delta V^{jk}}{c} \right], \text{ for all } i = 1, \dots n.$$

which represents the replicator dynamics of a $n \times n$ random matching evolutionary game with matrix payoffs $\mathbf{\Delta V} = (\Delta V^{ij}/c)_{ij \in [1,n]^2}$, once $\Delta V^{ij}/c$ is interpreted as the payoff from playing strategy i against j. [61]

There is therefore a formal connection between cultural transmission and other evolutionary game theory processes. This allows the application of a large body of results about the replicator dynamics to study cultural evolution. Specifically, suppose for instance that $\Delta V^{ij} = \Delta V^i$ for all $j \neq i$ (and $\Delta V^{ii} = 0$); that is, suppose that each group's *cultural paternalism* does not depend on the identity of the other group. Then the evolutionary game structure associated to the cultural transmission model is a *strictly stable* game. There is a unique distribution of traits, $q^i = \frac{1}{n}$, which is globally asymptotically stable and every trajectory of the replicator dynamics in the interior of the n-dimensional simplex converges to this state. Importantly, this implies, again, persistent cultural diversity in the limit.[62]

[61] These replicator dynamics can arise from natural selection, imitation, and reinforcement learning (see Young (1998), Sandholm (2010)).

[62] A recent interesting application of this general multiple-trait transmission model is Wu and Zhang (2022), which specializes the *cultural paternalism* structure to analyze conditions for the emergence of polarization of ideologies, exploiting the implied topology of traits.

Continuous traits

A well established tradition in evolutionary biology and anthropology considers continuous traits models of cultural transmission. These models postulate a dynamic of cultural traits which is driven by exogenous linear mixing (Cavalli-Sforza and Feldman (1973), Otto et al (1994).

Formally, consider a finite population of N dynasties. Each representative individual of dynasty i at time t is characterized by the intensity of a cultural trait $H_t^i \in (0, \infty)$ that he/she holds during his/her lifetime. Transmission from one generation to the next results from vertical and oblique transmission. Specifically, let $d^i \in (0, 1)$ represent vertical socialization by parents of type i and let oblique transmission be represented as a weighted average of various role models in society, $G_t^i = \sum_{j=1}^{j=N} \phi^{ij} H_t^j$; where $\Phi = [\phi^{ij}]_{i,j}$ is a row stochastic matrix reflecting the social connectivity of oblique influence across the different dynasties. Cultural dynamics then is postulated to follow the process

$$\dot{H^i} = (1 - d^i)(G^i - H^i). \tag{17}$$

Let $H = (H^j)_{i=1,N}$, denote the population N-dimensional vector of the cultural trait, I the identity matrix of dimension N, and T a diagonal matrix of dimension N where the i^{th} diagonal element is τ^i. The cultural dynamics can then be written in matrix form:

$$\dot{H} = (Z - I) \cdot H, \quad Z = T + (I - T)\Phi.$$

The matrix Z is a row stochastic matrix reflecting the force of the cultural inheritance blending process resulting from the interaction between vertical and oblique transmission. When the vertical influence weights τ_i are exogenous, and the matrix Z is irreducible and noncyclic, the evolutionary process induce homogeneity of the trait, leading to a "melting-pot" equilibrium, in which the value of the cultural trait is the same across the population.[63]

With a proper probabilistic structure of cultural transmission, however, cultural diversity may still be obtained in the limit, once again as a consequence of *cultural substitution*. Indeed, this is the main result obtained by Cheung and Wu (2018), in an elegant extension of BV along these lines. Specifically, consider a population of unit mass, where each agent in the population has a trait from set $H = [0, 1]$. The population state is a probability distribution q over H. Denote by $\Delta V^{zy} := V^{zz} - V^{zy}$ the *cultural paternalistic motive* of a z-parent towards trait $y \in H$, with $\Delta V^{zy} \geq 0, = 0$ only if $y = z$. A population state over

[63] On the other hand, Brueckner and Smirnov (2007, 2008) show that cyclicity of the matrix Z preserves the possibility of long term heterogeneity.

H is described by its probability distribution μ. Denoting by $d^z(\mu)$ the socialization rate exerted by a z-parent at population state μ, the cultural evolutionary dynamic is characterized by a differential equation for all (integrable) subset of traits $J \subseteq H$ of the following form:

$$\dot{\mu}(J) = \underbrace{\int_{y\in J}\int_{z\in H\setminus J}(1-d^z(\mu))\mu(dz)\mu(dy)}_{\text{inflows}} - \underbrace{\int_{y\in J}\int_{z\in H\setminus J}(1-d^y(\mu))\mu(dy)\mu(dz)}_{\text{outflows}}. \tag{18}$$

Intuitively, $\dot{\mu}(J)$ in the mass of agents with traits in set J is equal to the "inflow" of children whose parents' traits are not in set J, minus the "outflow" of children whose parents' traits are in set J. In this context, *cultural substitutability* is defined by the socialization rate $d^z(\mu)$ being an increasing function of the average intolerance of group z at population state μ, $\Delta V^z(q) = \int_{y\in H}\Delta V^{zy}q(dy)$. As in Bisin and Verdier (2001) *cultural substitution* is satisfied by this cultural transmission process $\mu$and the cultural dynamics with continuous traits satisfy the following:

$$\dot{\mu}(J) = \int_{y\in J}\Delta V^y(\mu)\mu(dy) - q\left(J\right)\int_{z\in H}\Delta V^z(\mu)\mu(dz). \tag{19}$$

As Montgomery (2010) for discrete traits, Cheung and Wu (2018) note a formal connection with evolutionary game dynamics: the cultural dynamics of continuous traits in Equation (19) is equivalent to a continuous strategy type replicator dynamics (Oechssler and Riedel (2001)). Using sophisticated measure theory tools for such dynamic systems, they show that cultural substitutability is again essential for the preservation of long run cultural heterogeneity. Furthermore, when an agent's cultural paternalistic motive towards another agent ΔV^{zy} is an increasing convex function of their cultural distance $|z-y|$, Cheung and Wu (2018) show that only the most extremely polarized state distribution with mass points at the extreme traits $z=0$ and $z=1$ is a stable limit point of the cultural dynamics, replicating the results for discrete traits transmission found in Wu and Zhang (2022).

C: Dynastic forward looking cultural transmission

An implicit assumption of most economic model of cultural transmission is the fact that parents, when socializing their children, do not take into account how children themselves will raise their grandchildren. While there may be cognitive reasons for the existence of such myopia, parents might also take a more "dynastic" perspective of the transmission

of their cultural traits across generations. One key aspect that arises in such a context, is the fact that parents need to take into account that their children will solve a similar problem as themselves, problem which replicates itself at each generational level. This creates a proper dynamic game between all generations. Spiro (2020) presents a simple linear-quadratic framework analyzing such decisions of multigenerational transmission of culture.

The basic model consists of a dynasty with an infinite sequence of overlapping generations indexed by $i \in \mathbb{N}$. Each generation consists of one individual referred to i, who is "the parent" of individual $i+1$ referred to as "the child". Each i in the dynasty is associated with a type $t_i \in \mathbb{R}$ and takes an action $s^i \in \mathbb{R}$. The game is sequential so that i takes her action before $i+1$, who in turn takes her action before $i+2$, and so on. The socialization problem of parent i is the following:

$$\min_{s^i} L(s^i, t^i) = \min_{s^i} \left[\frac{\left(t^i - s^i\right)^2}{2} + \sum_{h=1}^{h=\infty} \beta^h \frac{\left(t^i - \widetilde{s}^{i+h}\right)^2}{2} \right] \tag{20}$$

under the constraints :

$$t^{i+h} = \alpha \widetilde{s}^{i+h-1} + (1-\alpha)\overline{s}^{i+h-1} \tag{21}$$

$$\widetilde{s}^{i+h} = \arg\min_{s^{i+h}} L(s^{i+h}, t^{i+h}) \tag{22}$$

Equation (20) states that parent i gets a disutility loss when taking an action s^i that differs from her bliss point type t^i, and when also all future generations' optimal actions $\widetilde{s}^{i+h}$ differs from his type. The parent discount at a rate $\beta \in]0,1[$ this utility loss the further away the generation. (21) states that the type of an individual t^{i+h} is determined by a weighted average of her parent's action $\widetilde{s}^{i+h-1}$ (the vertical transmission channel) and some other action in society $\overline{s}_{i+j-1}$ (the oblique transmission channel). $\alpha \in]0,1[$ captures the relative importance of the vertical channel. In the simplest version of the model, $\overline{s}_{i+j-1}$ is assumed to be constant in all generations and normalized to zero. Finally, the last equation (22) reflects the fact that each subsequent generation $i+h$ solves the same problem as the parent, taking her own preferences type t^{i+h} into account.

Taking into account this chain of intergenerational transmission of preferences when trying to affect future generations, the first-order condition for the parent writes as:

$$-\left(t^i - s^i\right) - \sum_{h=1}^{h=\infty} \beta^h \left(t^i - \widetilde{s}^{i+h}\right) \frac{d\widetilde{s}^{i+h}}{ds^i} = 0 \tag{23}$$

where the transmission to future generations is captured by the derivatives $\frac{d\widetilde{s}^{i+h}}{ds^i}$. Given the quadratic nature of the objective function, it is natural to focus on linear Markov Perfect

Equilibria of the form $s^{i*}(t^i) = C \cdot t^i$ for all $i \geq 0$ with C is a constant to be determined. Assuming this form of intergenerational strategy, the equilibrium value C^* is characterized by a fixed point equation derived from (21) and (23).[64]

Solving this equation, it can be seen that $C^* > 1$, namely agents behave more extremely than their own type, and that the more extreme a type is the more she extremizes (ie. $s^{i*}(t^i) - t^i$ is increasing in t^i). Still, there is dynastic integration as $t^{i+1} = \alpha C^* t^i < t^i$. Intuitively, forward looking parents anticipate that over their dynasty, their own trait will converge towards the external trait $\overline{s} = 0$. To fight against this process, they "overshoot", the trait they transfer to their child. Still, this is not enough to prevent convergence, and the best they can do is to reduce the speed of convergence towards $\overline{s} = 0$.[65]

[64] (21) implies $s^{i+h} = (C\alpha)^h s^i$. Substitution in ((23)) and manipulations yields that C^* is the solution of

$$C^* = \frac{1 - \beta (C^* \alpha)^2}{1 - \beta (C^* \alpha)}$$

[65] The model can be extended to the case with two groups influencing each other, that is where the child's type of a given group is influenced both by her own parent's behavior (with weight α), but also by the behavior of the parent in the other group (with weight $1 - \alpha$).