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Cultural Transmission, Marriage and the Evolution of Ethnic and Religious Traits

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Abstract

This paper presents an economic analysis of the evolution of religious and ethnic characteristics in a model of intergenerational transmission of cultural traits which occurs through family socialization and marital segregation decisions.

The model implies that the frequency of intragroup marriage (homogamy), as well as the socialization rates of religious and ethnic groups, depends on the group's share of the population; minority groups search more intensely for homogamous mates, and spend more resources to socialize their offspring.

We study the implications of the model regarding the effect of the social matching technology, divorce rates and the degree of cultural tolerance between groups on the evolution of cultural traits.

Existing empirical evidence bearing directly and indirectly on the implications of the model is discussed.

Keywords: Cultural Transmission, Marriage
JEL: I2, Z1, D9

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1 Introduction

History contains several examples of the striking persistence of ethnic and religious traits. Basques, Catalans, Corsicans, Irish Catholics, in Europe, and Quebecois in Canada, have all remained strongly attached to their languages and cultural traits even through the formation of political states which did not recognize their ethnic and religious diversity. Jews of the diaspora have maintained a tenacious religious and ethnic identity resisting many attempts at acculturation and even extermination. Many small ethnic and religious enclaves are highly resilient. For example, small communities of Orthodox Christian Albanians living in the south of Italy since they emigrated there in the 15th century, maintained their language and religious faith. Similarly, small white communities in the French Caribbean islands, 'Blancs Matignons', preserve themselves from racial mixing, and have done so since the 18th century. Long-lived divisions along cultural and tribal lines are still commonplace in modern Africa (McEvedy, 1996).

These and the many other examples of the persistence of cultural traits in history should obviously not be interpreted as evidence that cultural traits are necessarily maintained against all odds. The rapid assimilation of Jews in Italy is a clear counter-example (Della Pergola, 1972). But the persistence of cultural traits and the difficulty of acculturating minorities does often take sociologists and anthropologists who study cultural evolution by surprise. For instance, most sociological work on American Jews in the 50s and 60s predicted the 'extinction' of Jewish Orthodoxy, thereby failing to identify the roots of the demographic 'Renaissance' that Orthodox Jewish culture in the U.S. has been experiencing since the 70s (Mayer, 1979, Ch. 1). More generally, Claude Levi Strauss (1997) has recently observed that the risks of cultural assimilation have been much over-stated in the anthropological and sociological debate of the 50s, because cultures have demonstrated a 'very resilient strong core'. [1]

The persistence of the evolution of ethnic and religious traits is mirrored in high and persistent intragroup marriage (homogamy) rates, even for small ethnic and religious groups. For instance, ethnic intermarriage was virtually unknown to immigrants in the U.S. at the turn of the century. Pagnini-Morgan (1990), for instance estimate that Italian and Polish immigrants around the beginning of the century in the U.S. were more than $2;000$ times more likely to marry in their ethnic group than to inter-marry. They also note low levels of inter-marriage persisting in second and third generation immigrants. Religious homogamy is also very well documented for most religious groups (e.g., Sander,

[1] We can even read the political debate on assimilation in the United States as a reaction to the persistence of cultural traits despite the efforts of the assimilation and Americanization movement born in the beginning of the century to include immigrants, and offer of full participation. Facing growing resistance to assimilation (religiously and even linguistically segregated parochial schools, for instance, spread in this period; see Tyack, 1974), by the 20s the movement turned into an increasingly hostile demand for immigrants' acculturation to the English language and American culture (see Davis, 1920, for a selection of early readings on assimilation). The heated debate over multi-cultural education has continued and has recently taken a radical turn; see Glazer (1997).

1993, for Catholics, and Johnson, 1980, Schoen-Weinick, 1993, for other denominations). In Section 2 we report in some detail on two ethnographic examples of populations which adopt extreme strategies of marriage segregation to preserve speci…c cultural traits and to socialize children: aristocrats in France and Orthodox Jews in New York.

The historical examples and evidence of cultural persistence and homogamy raise important questions regarding cultural traits, particularly ethnic and religious traits, their determinants in the short run and their long run distribution in the population.

This paper studies the evolution and persistence of cultural traits as dynamic properties of cultural transmission and socialization mechanisms. In particular, we concentrate on segregation by marriage along ethnic and religious lines as a mechanism to favor socialization at the family level.[2]

The model of socialization we develop and study is motivated by various stylized facts which emerge from the sociological literature (see the next section). We model cultural transmission as a mechanism which interacts socialization inside the family and socialization outside the family in society at large via imitation and learning from peers and role models. In the model, altruism motivates parents' e¤orts to socialize their children, and to transmit their own cultural traits. (Socialization e¤ort consists, for instance, in the choice of neighborhood, school, or church attendance.) Families in which parents have a homogeneous cultural trait are advantaged in the socialization process for this trait, with respect to heterogamous families. Since each parent wishes to transfer his own trait to his children, the choice of a mate in the marriage market is functional to the desire to socialize the eventual children arising from such a union. While then perfect assortative matching (complete homogamy) would arise optimally in the absence of search costs, we model the marriage process as characterized by search frictions. More speci…cally, we assume that both males and females can search for a mate in some restricted pool where admission is costly, but where everybody who is admitted has the same cultural trait (hence all marriages in the pool are homogamous).

We derive implications of such cultural transmission mechanisms in terms of di¤erential behavior of cultural minorities and majorities with respect to their e¤ort to marry homogamously and to socialize children to their own trait. We also study the dynamics of the distribution of cultural traits in the population implied by such transmission mechanisms, and the determinants of the long run stable distribution of traits, with the objective of understanding the observed persistence of minority cultural traits. Some of the results and the intuition behind them are summarized below.

[2] Cultural transmission, but with random mating and exogenous propensities for socialization, is studied in biology; see e.g., Cavalli Sforza-Feldman (1981). The role of marriage as an institution of transmission of cultural values has been stressed in anthropology, for instance by Boas (1928) and Levi Strauss (1949). Economists have mostly concentrated instead on the agents' choice of their own preferences and values, as e.g., Becker (1996), Becker-Mulligan (1997), and, speci…cally for religious preferences, Iannaccone (1990, 1998). For genetic rathen than cultural transmission models, see e.g., Kockesen-Ok-Sethi (1997). We refer to Bowles (1998) for a survey and complete references.

Minorities, other things equal, have more highly segregated marriage markets, and exercise more effort in directly socializing their children. They have, in fact, a stronger incentive to segregate, to be homogamous and to socialize their children. Since the population at large is mostly populated by majority types, a member of a minority cultural group is likely to marry heterogamously if he does not structure his life so as to meet mostly mates with the same traits (e.g., by going to the appropriate church, living in the right neighborhood, etc.). Moreover, a minority type in an heterogamous marriage will have difficulty transmitting his own traits, since the spouse will favor a different set of traits, and peers and role models will be taken from a population mostly of the majority types.

Patterns of marital segregations and socialization across cultural groups also have effects on the evolution of cultural traits in society. We show that the cultural transmission mechanisms we study generate dynamics in the distribution of cultural traits which tend to multicultural populations and away from complete assimilation of minorities. Cultural minorities tend to react in equilibrium to the prospect of cultural assimilation with marriage segregation, homogamous marriages, and with more intense strategies for the direct socialization of children. Though majorities have higher homogamy and socialization rates overall, it is the socialization effort (which is higher for minorities) to determine the transitional dynamics of the distribution of traits when one trait is close to extinction. As a consequence, the fraction of the population of agents with minority traits tends to increase, minority traits appear quite persistent, and long-run multicultural populations are stable.

In other words, linear extrapolations of inter-marriage rates, socialization practices, and demographic dynamics, tend to underestimate the persistence of cultural traits, because minorities react to their assimilation. The resilience of many ethnic and religious neighborhoods in American cities, the increasing demand for multicultural education in American society, as well as in many Western European countries, and the history of many cultural communities such as American Orthodox Jews can however be explained by the complex interaction of marriage segregation, direct cultural socialization of families, and children's exposure to the cultural traits of the majority of the population at large.

Our model of cultural transmission also allows us to study the dynamic effects on the composition of the population with respect to ethnic and religious traits of various institutional arrangements within marriage. In particular we study the long-run effects in the dynamics due to structural changes i) in the availability of inter-cultural relationships (due for instance to urbanization or information technologies), ii) in the freedom to choose ones' mate, and iii) in the organization of the family (divorce rates, single parent families, female labor market participation).

We show that if the distribution of the population with respect to the cultural traits is such that a majority and a minority trait are identifiable, then a higher availability of intercultural relationships causes agents to react with higher efforts at marriage segregation and socialization of children. A negative direct effect via random matching and a positive indirect effect due to the increase in the effort to marry homogamously and socialize counter each other in affecting homogamy rates. The direct effect on homogamy rates tends to be stronger, and hence, homogamy decreases with easier intercultural relationships. As the homogamy rates decrease, the probability of homogamous marriages decreases for both groups but less rapidly for the majority group than for the minority group. As a consequence, easier inter-cultural relationships increase, in the long-run, the fraction of the population with the majority trait.

Greater freedom to choose ones' mate, arguably a relatively recent historical trend in many cultural populations, has similar effects. By increasing the costs of marriage segregation, segregation effort and homogamy rates are decreased. Greater freedom of mating choice increases, in the long-run, the fraction of the population with the majority trait.

We also show that a higher probability of divorce reduces at the margin the value of homogamous marriage, thereby decreasing homogamy rates in equilibrium. The probability of divorce reduces the resources spent to segregate in marriage and hence brings more heterogamy in the short run. As in the case of easier intercultural relationships, the probability of homogamous marriages decreases for both groups but less rapidly for the majority group than for the minority group. Higher probabilities of divorce tend to increase, in the long-run, the fraction of the population with the majority trait.

Similarly, changes in levels of tolerance between cultural groups affect homogamy rates and the persistence of cultural minorities. In particular, an increase in cultural tolerance between two groups induces less marital segregation and less family socialization in the short-run tending to bias cultural evolution, in the long-run, towards the trait of the majority group in society. (Greater tolerance on the part of the majority with respect to intermarriage with minority populations generates a form of acculturation of the minority.)[3]

The paper is organized as follows. First, in Section 2.1, we introduce various stylized facts on cultural transmission and socialization which motivate our modelling. In Section 2.2 we analyze the implications of the basic model of marriage and cultural transmission, provide some extensions, and perform some comparative statics. Section 2.3. introduces some empirical evidence on homogamy, socialization practices, and segregation and divorce, offering support for the implications of our model with respect to the transmission of ethnic and religious traits. Finally, Section 3 studies the dynamics of the distribution of traits in the population and derives several comparative dynamic implications.

[3] The greater tolerance of intermarriage with Jews after World War II in the U.S. might be the cause of the trend toward acculturation of Jews, as noted by several contributors in the current debate on the 'Jewish identity' in the U.S.; see Dershowitz (1997).

2 Marriage and socialization

Various stylized facts on marriages as cultural transmission mechanisms can be collected from an analysis of the empirical literature in sociology and social psychology.

1. Cultural traits are usually adopted in the early formative years of children's psychology. Family, peers and role models play a crucial role in the adoption of cultural traits. This has been extensively documented for religious and ethnic traits, for instance, by Clark-Worthington (1987), Cornwall (1988), DeVaus (1983), Erickson (1992), Hayes-Pittelkow (1993).[4]

2. Families care about their children's cultural traits and consciously exercise effort in an attempt to socialize children. Also, homogamous families (i.e., families in which parents have homogeneous cultural traits) predominantly favor the transmission of their own traits. Psychological studies of heterogamous couples consistently report their concern about the possible cultural attitudes of children when deciding to form a family (see Rosenblatt et al., 1995, for racial traits, and Mayer, 1985, Smith, 1996, for ethnic and religious traits). Gussin Paley (1995) provides a vivid ethnographic documentation of school choice of middle-class African-American parents in Chicago's South Side. The main issue in the choice consists in trading off the low academic quality of the predominantly black public schools and the exposure to 'white culture' in integrated schools. O'Brien-Fugita (1991) document the perceived importance for Japanese families of the development of Japanese schools after World War II in the U.S. (often contrary to the preferences of their children). Similar attitudes are documented for many ethnic groups (e.g., Mayer, 1985, for Jews, and Tyack, 1974, for Germans, and, more recently, Glazer, 1997, for African-Americans).

3. The effectiveness of family socialization depends strongly on parental agreement on the trait to be transmitted. Children of mixed religious marriages have weaker religious commitments than those of religiously homogamous marriages (Hoge-Petrillo, 1978), and Ozorak, 1989). Also, children of mixed religious marriages are less likely to conform to any parental religious ideologies, and to practices such as church attendance, or prescribed fertility behavior (Heaton, 1986, Hoge-Petrillo-Smith, 1982, and Ozorak, 1989).

These facts motivate our model of socialization. In particular, we model cultural transmission as a mechanism which interacts socialization inside the family with socialization outside the family, in society at large. (Socialization inside the family is also called 'direct vertical' socialization, while socialization by society, which occurs via imitation and learning from peers and role models, is also called 'oblique' socialization.)[5]

[4] The transmission of traits which are formed later in the psychological developement of children, though, is often dominated by the role of peers; see e.g., East-Felice-Morgan (1993) for evidence on the transmission of attitudes toward sexual behavior.

[5] This terminology is taken from Cavalli Sforza-Feldman (1981).

We model direct vertical socialization through parents having altruistic attitudes towards their children. Altruism motivates parents to exert effort to socialize their children, and to transmit their own cultural traits. An important assumption we make in this respect is that parents wish to transmit their own trait, and do not just internalize their children's preferences or some measure of their success. Indirect evidence for such 'paternalistic altruism' comes, as already noted, from studies of parental school choice decisions. Also, an analysis of norms regarding inter-religious marriages reveals that parents of most major denominations (from Catholics to Baptists and Jews; but also for instance Seventh-Day Adventists and Lutherans) at least tend to warn children not to inter-marry, justifying their position with a concern about the religious education of grand-children (Smith, 1996)[6]. Some evidence in support of 'paternalistic altruism' can also be derived from socio-economic surveys. For instance, in response to NORC's General Social Survey's question, Which three of the qualities listed would you say are the most desirable for a child to have ?', 'obedience' is cited on average across the sample more than, (in order) 'self-control', 'success', 'studiousness', 'cleanliness', and less only than 'honesty'.[7] [8]

This assumption of parents' paternalistic attitudes is consistent with our modelling of cultural traits as 'pure' traits, with no direct economic effect. For instance, we implicitly assume that agents' economic opportunities, e.g., their expected present discounted income or their human capital accumulation costs, are independent of their trait. This is, of course, an abstraction meant to disentangle the cultural transmission mechanism from other economic considerations. Ethnic and religious traits, more than other cultural traits and attitudes, seem to approximate satisfactorily 'pure' traits.[9]

We finally assume that families in which parents have a homogeneous cultural trait are advantaged in the socialization process for this trait, with respect to heterogamous families. Since each parent wishes to transfer his own trait to his children, the choice of a mate in the marriage market is functional to the desire to socialize the eventual children from such a union. While assortative matching would arise then at equilibrium in the absence of search costs (see Becker, 1973, 1974), we model the marriage process

[6] For example, the 1983 Code of Canon law for the Catholic Church says: " Without the express permission of the competent authority, marriage is forbidden between two baptized persons, one of whom was baptized in the Catholic Church...and the other of whom is a member of a Church... which is not in full communion with the Catholic Church " (801). Moreover, the permission cannot be granted unless the following condition is fulfilled: " the Catholic party declares that he or she is prepared to remove dangers of falling away from the faith and makes a sincere promise to do all in his or her power to have all children baptized and brought up in the Catholic Church".

[7] A similar pattern of answers is reported to a similar question in the National Survey of Families and Households.

[8] For a natural selection explanation of paternalistic forms of altruism, see Bisin-Verdier (1998).

[9] However, some evidence on the effect of religious and ethnic traits on economic opportunities is found in Warren (1970) and Sowell (1994). A first analysis of these effects of traits can be found in Bisin-Verdier (1996).

as characterized by search frictions. More specifically, we assume that while both males and females can search for a mate in some restricted pool where everyone admitted has the same cultural trait (hence all marriages in the pool are homogamous), admission to the pool is costly. (We think of direct admission costs, but also of the costs in terms of other unmodelled desirable characteristics of the match, which derive from constraining oneself to search in a restricted pool.)

Many different institutions do function at least partially as marriage pools restricted along cultural traits. For instance Kwon (1997) documents the centrality of the Korean Ethnic Church in Houston as a mechanism for cultural identity and as a network of contacts among first and second immigration Korean immigrants. A similar picture regarding local catholic churches is drawn by Matovina (1995) for the Spanish-speaking population in San Antonio, Texas, between 1821 to 1860. To better illustrate our analysis of the marriage process as a mechanism for transmission of cultural traits, and in particular to isolate the institutions which may function as restricted marriage pools, we consider two examples of populations with rather extreme socialization practices: aristocrats in France and Orthodox Jews in New York.

The Bottin Mondain and the Rallye. Various ethnographic studies of aristocrats have revealed the importance of their attachment to specific cultural values and their concern for the inter-generational transmission of their symbolic and cultural capital such as family names, negative attitudes towards work and money, and the importance of land property (Grange (1996), Mension-Rigau (1993), Pincon-Pincon Charlot (1989), de Saint Martin (1993)).

But how are these values transmitted ? In France the most relevant institutions with this purpose are the Bottin Mondain, the main aristocracy's listing book, and the Rallye, a chain of dancing parties (Grange, 1996).

Families can be listed in the Bottin only if invited by families already listed. Most information published in the Bottin Mundain is family and dynastic oriented, and professional indications are kept to a strict minimum. [10] The Rallye, which organizes a gathering of between 100 and 500 young people each month, consists instead of a group of young single women, whose families are listed in the Bottin Mondain. The family of each woman, when subscribing to the Rallye, commits to host a party for all the participants of the Rallye.

Along with the Bottin Mondain, the Rallye is therefore an institution intended to stimulate homogamous aristocratic mating. It involves substantial resources spent by the different families (parties are generally organized in sumptuous palaces), and well reflects our vision of a restricted pool in which resources are spent to increase the probability of being married homogamously with respect to the relevant cultural trait.

From a survey of 3014 nuclear families in the Bottin Mondain during the period 1903-

[10] Dates of birth are not mentioned except for minor children, which is useful if the book is to be used as a marriage pool.

1987, Arrondel-Grange (1993) estimate the probability of homogamous marriage for a child of a family in the Bottin Mondain. They find a significant rate of homogamy well above that implied by random matching. The average probability of being married with someone of the Bottin Mondain for a daughter of a couple listed in the Bottin is 44% (in the period 1950-1969) and 39% (in the period 1970-1983). For young males the average estimated probability in either periods is 39%. When the two parents share important aristocratic attributes (e.g., old aristocracy, a family castle, or membership in an aristocratic club), this probability is over 65% for young females, and over 80% for young males.

The Shadchan. Orthodox Jews live in mostly segregated neighborhoods and adhere to very extreme norms to preserve their religious and cultural traits (see the ethnographic studies of Heilman, 1995, and Mayer, 1979). In a religious community whose various proscriptions limit casual encounter between the sexes, many marriages are arranged. The ethnographic study of Orthodox Jews in Boro Park, an Orthodox Jewish neighborhood in Brooklyn, New York, conducted by Mayer (1979) in the 70s, surveys match-makers (shadchans). This study reveals that not only do shadchans serve as go-betweens ('telephone numbers' distributors'), but most importantly they also inform both parties of each other's adherence to religious norms, prescriptions and proscriptions (e.g., about the dress code of the woman, the tenure at the rabbinical seminary of the man, etc.). Essentially, the role of the shadchan in guaranteeing the preservation of religious and cultural traits in marriage is preserved, even if its historical role in protecting and matching families' assets has lost much of its importance and is not any more an integral part of the traditional marriage system.

As important as match-making is (as a restricted marriage pool) in Orthodox Jewish communities, 'love-marriages' are slowly replacing arranged ones. Nonetheless, for instance in Boro Park, many institutions, from kosher pizza parlors and cafeterias of the hundreds of the Yeshivas (religious schools) in the neighborhood, to Orthodox summer camps, and Young Men's & Women's Hebrew Association's co-ed activities, operate to substitute the shadchan in facilitating mating by religious and cultural traits (see again Mayer, 1979).

The institutions of arranged marriages, segregated living arrangements, segregated education in religious school, and the creation of restricted marriage pools like summer camps, has been exceptionally effective in promoting homogamy for Orthodox Jews. According to the National Jews Population Survey, the intermarriage rate in 1990 for Orthodox Jews was only 3%, as opposed to 37% for Conservative Jews and 53% for Reform Jews.

The pattern of homogamy and segregation observed for French aristocrats and Orthodox Jews, while extreme, is certainly not unique. Baker (1979), for instance, documents similar rates of homogamy for a community of Upper Silesian farmers living in segregated neighborhoods around an ethnic catholic parish in Texas, from 1850 to 1920. Homogamy rates in this community are still very high, at around 50%.

2.1 The Analysis

Suppose there are two possible types, $\{a, b\}$, of cultural traits in the population. In particular, different traits might capture some aspect of ethnic traits or religious beliefs.

In each period there are two stationary, equally sized populations of adult males and females. Agents live two periods. Young agents are born without well defined cultural traits, which they acquire (in a way described below) before becoming adult. In his adult life, a male gets matched with an adult female (in a way to be described below) to form a household. In order to maintain the size of each population stationary, we assume that each family union has two children, a male and a female.

Parents are altruistic towards their children and want to socialize them to their own specific cultural model. Let V^{ij} denote the utility a type i parent derives from a type j child ($i \in \{a, b\}$). We assume then $V^{ii} > V^{ij}$ (and $V^{jj} > V^{ji}$).[11]

The socialization process is modelled as follows. The fraction of individuals with trait i in the population is denoted q^i. All 'naive' children, without defined preferences or cultural traits, living in a family in which both parents have the same trait, are first exposed to their family trait, say i. 'Direct vertical' socialization to trait i occurs with probability τ^i. We impose the extreme assumption that only families in which both parents have the same trait can vertically socialize their children. Children in families with a 'mixed' trait pick the trait of a role model chosen at random in the population (i.e., they pick trait i with probability q^i and trait j with probability $q^j = 1 - q^i$). Similarly if a child from a family with, say, trait i is not directly socialized, which occurs with probability $1 - \tau^i$, he picks the trait of a role model chosen randomly in the population. Finally, socialization is costly. Socialization costs increase with the probability of successful direct socialization by parents, and are denoted $H(\beta\tau^i)$, for $i \in \{a, b\}$ (β is just a parameter which we shall use in the comparative statics exercises). The marriage choice, then, has a crucial effect on the socialization technology available, and agents, choosing the best mate to socialize children, aspire for homogamy in marriage.

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[11] Suppose agents choose when adult some abstract action x in some set X. Children with preferences of type j, $u^j(x)$, then will, in general, make a different choice than parents of type i would, and viceversa. Altruistic parents will necessarily prefer children with their own type of preferences when evaluating their children's choices with their own (the parents') utility function. Formally:

$$V^{ij} = u^i(x^j); \quad \text{where } x^j = \operatorname{argmax}_{x \in X} \; u^j(x)$$

and hence typically $V^{ii} > V^{ij}$ (symmetrically for trait j). It is important to notice, though, that if the choice set X depends on the preference type, and for instance is larger for agents of type i (e.g. because type i agents are favored in the labour markets), then parents of type j might want to socialize their children to the opposite type i. By assuming that $V^{ii} > V^{ij}$, as already mentioned, we effectively restrict the relevance of our analysis to 'pure' cultural traits which have no effect on the objective economic success of the agents.

We model marriage choice in what follows (we set the notation for the general agent $i \in \{a, b\}$).

Matching of adult individuals is organized via a marriage game. The probability of entering an homogamous marriage is endogenously chosen by each agent. More precisely, we assume there are two restricted marriage matching pools (one for each cultural trait) where individuals with the same trait can possibly match in marriage. With probability α^i an agent of type i enters the restricted pool and is married homogamously. With probability $1 - \alpha^i$ an agent of type i does not get married in the restricted pool. He then enters a common pool made of all individuals who have not been matched in marriage in their own restricted pools. In this common pool individuals match randomly. If A^i is the fraction of individuals of type i who are matched in their restricted pool (in equilibrium, by symmetry, all individuals with the same trait behave identically and hence $\alpha^i = A^i$) the probability an individual of type i in the common unrestricted marriage pool is matched in marriage with an individual of the same type is then $\frac{(1-A^i)q^i}{(1-A^i)q^i + (1-A^j)(1-q^i)}$; and hence the probability of homogamous marriage of an individual of type i is given by:

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

We assume that individuals of type i can affect the probability of being matched in their restricted pool by choosing α^i at a cost $C(\delta\alpha^i)$, where δ is just a parameter which we will use in the comparative statics exercises. The typical problem of a male of type i will be to choose the probability of matching in the restricted marriage pool knowing that, if he is matched in an homogamous household, he has access to a technology to socialize his children. An agent with trait i chooses $\alpha^i \in [0;1]$, for given A^i, A^j, q^i, to maximize

$$\pi^i(\alpha^i; A^i; A^j; q^i)W^i(q^i) + [1 - \pi^i(\alpha^i; A^i; A^j; q^i)][q^i V^{ii} + (1 - q^i)V^{ij}] - C(\delta\alpha^i) \qquad (2)$$

where $q^i V^{ii} + (1 - q^i)V^{ij}$ represents the expected utility of a type i parent in an heterogamous marriage (in which the socialization of the children is determined by random matching only); while $W^i(q^i)$ represents the corresponding expected utility in an homogamous marriage. Since homogamous marriages are endowed with a direct socialization technology, $W^i(q^i_t)$ depends on the parents' choice of socialization effort, τ^i, as well as on matching probability q^i:

$$W^i(q^i_t) = \max_{\tau^i} [\tau^i + (1 - \tau^i)q^i]V^{ii} + (1 - \tau^i)(1 - q^i)V^{ij}] - H(\beta\tau^i) \qquad (3)$$

Note that agents i and j interact non-trivially in the marriage game: agent's i maximization problem depends (via $\pi^i(:)$) on A^j, the fraction of agents of type j in the restricted pool. In fact the more agents of type j in the restricted pool, the less of them in the residual population, and the more favorable for agents of type i the strategy of not entering their own restricted pool (and being matched in the common residual pool).

A symmetric Nash equilibrium of the marriage game is then represented by mappings $\alpha^i(q^i)$ which are fixed points of the best replies of agents $i \in \{a, b\}$ derived from the maximization of equation (2). The probability of homogamous marriage for agents of type i is then in equilibrium just function of q^i, and is denoted $\pi^i(q^i)$.

Proposition 1 *Under convexity and regularity assumptions on costs $C(\delta\alpha^i)$ and $H(\beta\tau^i)$ (explicitely stated in the appendix),*

- *There exist a unique symmetric Nash equilibrium of the marriage game, denoted $[\alpha(q^i)] = [\alpha^i(q^i)]_{i \in \{a,b\}}$; moreover, $\alpha(q^i)$ is a continuous mapping.*
- *The solution of the socialization effort choice of homogamous families, i.e. of the maximization in equation (3), denoted $[\tau^i(q^i)]_{i \in \{a,b\}}$, is a continuous mapping.*

2.2 Implications

In this section we study several implication of the marriage and socialization model for a given distribution of traits in the population, q^i. The implied dynamics of the distribution of traits is studied in the next section.

Proposition 2 *The equilibrium probability of matching in the restricted pool, $\alpha^i(q^i)$, and the equilibrium socialization effort of homogamous families, $\tau^i(q^i)$, are decreasing in q^i, for $i \in \{a, b\}$.*

The probability of matching in the restricted pool and the choice of socialization effort of homogamous families are higher for minorities, other things equal.[12] Minorities have a stronger incentive to segregate, to be homogamous, and to socialize children. In fact, an individual in a cultural minority has a large probability of making an heterogamous marriage if he does not enter the restricted pool, since the common unrestricted pool would be mostly populated by majority types. Moreover, a minority type in an heterogamous marriage will not have access to the technology of socialization and his children will be socialized to the external cultural environment, that is, with large probability, the majority trait. This motivates agents with minority traits to homogamy. Once homogamous, families with a minority trait still have large incentives to directly socialize their children because if direct socialization is unsuccessful, once again, children will be socialized to the external cultural environment, i.e. most probably to the majority trait.

[12] It is important to stress that this cross-sectional interpretation of Proposition 2 requires cultural traits not too much different in terms of tolerance to each other, i.e. in terms of $V^{ii} - V^{ij} = \Delta V^i$; $i \in \{a, b\}$. Moreover, the identification of cultural minorities and majorities is only possible if the dynamics of the distribution of cultural traits is not at its stationary state, since otherwise the population will tend to be evenly distributed across cultural traits; see Section 3. The cross-sectional interpretation is central to our analysis because most of the empirical evidence available on marriage and socialization is in fact cross-sectional; see Section 2.3.

It is also easily shown that for any given distribution of traits, q^i, both $\alpha^i(q^i)$ and $\tau^i(q^i)$ are decreasing in socialization costs, β, and increasing in the gain from socialization, $V^{ii} - V^{ij} = \Delta V^i$. Also, α^i is decreasing in (while τ^i is unaffected by) marriage segregation costs, parametrized by δ. A positive change in the cost of direct socialization, not surprisingly, negatively affects direct socialization effort, but it also negatively affects entry to the restricted marriage pool since the benefits of the restricted pool consist in the option to use the direct socialization technology, which is now more costly. In the same way, higher gains from socialization positively affect both direct socialization effort and entry into the restricted marriage pool, while higher marriage segregation costs δ negatively affect marriage segregation, without having any effect on family socialization, which is possible only for homogamous families.

The equilibrium homogamy rate of the type i population at equilibrium is given by:

$$\pi^i(\alpha^i; \alpha^i; \alpha^j; q^i) = \pi^i(q^i) = \alpha^i(q^i) + (1 - \alpha^i(q^i)) \frac{[1 - \alpha^i(q^i)]q^i}{[1 - \alpha^i(q^i)]q^i + [1 - \alpha^j(1 - q^i)](1 - q^i)} \tag{4}$$

How do homogamy rates depend on the composition of the population? Homogamy rates of minority populations reflect the trade-off of stronger marriage segregation strategies ($\alpha^i(q^i)$ is decreasing in q^i by Proposition 2) with the adverse effect due to their higher intercultural matching in the common pool, where matching is random and hence reflects relative population sizes. As a consequence, the dependence of π^i on q^i is not monotonic. It can be shown that, if population i is intolerant enough (i.e. for high enough ΔV^i), its homogamy rate first decreases and then increases in q^i. Minority populations hence will tend to have homogamy rates inversely related to their share in the whole population.

Socialization rates, as measured by the probability of an homogamous family with trait i of having a child of the same trait, $P^{ii} = \tau^i(q^i) + (1 - \tau^i(q^i))q^i$, also do not depend monotonically on q^i. It is easy to show that, as with the homogamy rate, the socialization rate of group i first decreases and then increases in q^i, if ΔV^i is large enough.

2.2.1 Extensions

The marriage model just introduced can be extended in various directions with the objective of deriving richer empirical implications. We summarily report here on some extensions we pursued. (The complete analysis is reported in an Appendix available from the authors upon request.)

Suppose a fraction of the population, the same across gender and cultural type, cannot (or does not want to) have children. We assume, for simplicity, that such agents form a marriage pool by themselves. Since the only advantage of homogamy in our set-up lies in the technology of children's socialization, they have in fact no interest in homogamy along the cultural trait dimension. In such a model, the differential homogamy of families with children with respect to families without children is measured by as

$$\Delta HM^i(q^i) = HM^i(q^i) - [q^i]^2$$

where $[q^i]^2$ is the probability of homogamy for an agent with trait i if he cannot have children, calculated from pure random matching.

It can be shown that such homogamy differential, $\Delta HM^i(q^i)$, is positive in equilibrium.

Suppose marriage in the common pool is biased in favor of homogamous matching. For instance, the bias could arise from segregated neighborhoods in the population, or from the existence of institutions which function as restricted marriage pools and whose entry is free. We write the probability of an individual of type i being matched in marriage with an individual of the same type (the homogamy rate of type i) as

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

where the second term on the right-hand-side of (5) represents the fraction of type i individuals homogamously matched in the common residual marriage pool, given that there is a biased matching process parametrized by $\gamma \in [0;1]$. When $\gamma = 0$; there is random matching in the common pool. When $\gamma = 1$; individuals match with probability 1 to someone of the same type in the common pool: there is perfect assortative matching for each community independent of the existence of restricted pools (i.e. $\pi^i(\alpha^i; A^i; A^j; q^i; 1) = 1$ for any α^i).

For this extension of the marriage model, comparative statics exercises show that α^i is decreasing in γ. An increase in segregation of the population outside of the restricted pool, (i.e., a positive change in γ), reduces the incentives for agents to enter the restricted pool. The effect on homogamy rates is, on the other hand, ambiguous, because the chgange in γ has also a direct effect on homogamy rates (homogamous marriages by random matching are now easier). Under some weak conditions (detailed in the Appendix), it can be shown that the direct effect on homogamy rates is stronger, and hence that a positive change in γ has a positive effect on equilibrium homogamy rates.[13]

The last extension we consider involves adding an exogenous probability of divorce. Suppose each family has a probability c of separating. We assume separation occurs after children are born, but before they are socialized to the cultural traits. If separation occurs, we assume that one of the parents is chosen randomly to form a single parent family. We also assume that socialization is more costly for single parent families (see

[13] Obviously γ has no effect on τ^i and π^i. It can also be shown that ΔHM^i decreases with γ.

A similar analysis, with qualitatively similar comparative statics results, can be carried over for distortions which favor the parents' trait in the oblique phase of socialization.

Thomson-McLanahan-Curtin, 1992, for some evidence on this point). Note that single parent families, as opposed to heterogamous families, have a technology to socialize children; no ambiguity on which trait to transmit arises in this case.

In this case the typical problem of an individual of type i is becomes to maximize

$$\pi^i(\alpha^i; A^i; A^j; q^i)[(1-\delta)W_m^i(q^i) + \delta W_s^i(q^i)] +$$
$$[1-\pi^i(\alpha^i; A^i; A^j; q^i)][(1-\delta)W_h^i(q^i) + \delta W_s^i(q^i)] - C(\delta\alpha^i)$$

where $W_m^i(q^i)$, $W_s^i(q^i)$, and $W_h^i(q^i)$ denote, respectively, the gains from socializing children inside an homogamous marriage, a single parent family, and an heterogamous marriage. Given our assumptions about the socialization technologies of the different family types, the gains from socialization are given by:

$$W_m^i(q^i) = \max_{\tau^i}[\tau^i + (1-\tau^i)q^i]V^{ii} + (1-\tau^i)(1-q^i)V^{ij}] - H_m(\beta\tau^i) \tag{6}$$

$$W_s^i(q^i) = \max_{\tau^i}[\tau^i + (1-\tau^i)q^i]V^{ii} + (1-\tau^i)(1-q^i)V^{ij}] - H_s(\beta\tau^i) \tag{7}$$

$$W_h(q^i) = [q^iV^{ii} + (1-q^i)V^{ij}]$$

with $H_m(\beta\tau^i)$ and $H_s(\beta\tau^i)$ being the socialization cost functions of homogamous couples and single parent family. We assume $H_m(\beta\tau^i) < H_s(\beta\tau^i)$, for all $\tau^i \in (0;1)$.

The solution to the socialization problems provides socialization efforts for homogamous parents, $\tau_m^i(q^i)$, and single parent families, $\tau_s^i(q^i)$, with the property that $\tau_m^i(q^i) > \tau_s^i(q^i)$; homogamous families have a better direct socialization technology than single parent families, and hence in equilibrium they actually do socialize their children more intensely. Comparative statics exercises show that higher divorce rates in equilibrium imply lower segregation rates in restricted marriage pools, lower homogamy rates, and lower differentials in homogamy with respect to agents who cannot have children. When looking for a mate, agents anticipate that the marriage might fail. The value of the homogamy in marriage is then reduced, because, if the marriage ends, children will be socialized with a relatively inefficient technology. Agents' incentives to enter the restricted marriage pool, i.e., to look for an homogamous mate, are lower the higher the probability of divorce, δ.

2.3 Evidence

This section collects some of the existing empirical evidence, mostly drawn from the sociological literature, on the implications of the model regarding homogamy and socialization with respect to ethnic and religious traits.

2.3.1 Homogamy

High rates of homogamy along cultural dimensions and positive differentials in homogamy with respect to families which cannot have children are certainly a fact, at least along the religious and the ethnic dimensions. The homogamy of new immigrants in the U.S. at the turn of the century was 'almost castelike', and quite persistent over successive generations. High rates of homogamy by ethnic group are more generally documented by Peach (1980). The examples of French aristocrats, Orthodox Jews, and Upper Silesian farmers reported in Section 2 also support these observations. Religious homogamy is also pervasive (see Sander, 1993, for Catholics, and Johnson, 1980, Schoen-Weinick, 1993, for other denominations).[14] Homogamy rates well above those implied by random matching, of course, might well have many explanations other than the desire to preserve one or several cultural traits in children. Measures of psychological costs of religious intermarriage are quite low, both in terms of costs borne by spouses (e.g., marital instability; see Lehrer-Chiswick, 1993, Heaton, 1994) and by children (e.g., anomie, lack of self-esteem; see Aellen-Lambert, 1969, Johnson-Nagoshi, 1986, Stephan-Stephan, 1991), thereby supporting the argument that the socialization of children is an important determinant of the observed religious homogamy.

The marriage model we have developed more specifically implies that homogamy rates should be higher for families which expect to have children. In particular, homogamy rates should be higher in marriage unions than in cohabitations, since fertility expectations of cohabiters are not statistically different from those of single individuals, as documented by Rindfuss-VandenHeuvel (1990). Consistently, 51% of marriages in the National Survey of Families and Households (1987-88) are religiously homogamous, compared to only 37% of cohabitations (Schoen-Weinick, 1993). Relatedly, Lehrer (1996) reports higher intended fertility for religiously homogamous couples.

Our model of cultural transmission has its most important class of implications for the behavior of minorities. Minorities, other things equal, should exercise more effort in marriage segregation. While effort in marriage segregation is difficult to measure directly, populations with minority traits, such as Orthodox Jews or Amish, seem to segregate more intensely and to develop institutions for segregated marriages. Even for a population with less extreme homogamy patterns, Japanese-Americans, O'Brien-Fugita (1991) report that cultural and ethnic institutions and clubs (which we would interpret as restricted marriage pools) are most prevalent in areas where Japanese-American are minorities.

Formal evidence on homogamy rates for religious traits has been reported and studied by Johnson (1980). Using data from the pooled 1973-76 NORC General Social Survey, the 1960 Growth of Families Survey, and other sources, Johnson (1980) constructs marriage tables for six religious groups.[15] He then estimates a log-linear model of marriage

[14] Indirect evidence for the perceived importance of religious homogamy in marriage decisions comes from the study of conversions: both Warren (1970) and Greeley (1979) found that most religious identification changes were attributable to the conversions of spouses to estabilish homogamy in religiously heterogamous marriages.

[15] The main denominations in each of the six groups are: Baptists, Methodists, Presbyterians, Lutherans, Catholics, and Others.

frequencies for each religious group to …t the marriage tables, identifying two main explanatory factors in the analysis of assortative marriage: the religious composition of the population, and the 'intrinsic endogamy' of each religious group, where 'intrinsic endogamy' is a measure of the group's e¤ort in marriage segregation, i.e., a measure of ®^{i} in our notation. Both the estimates of the model relative to the national and the regional level (i.e., relative to the national or the regional composition of the population by religious group), show that the intrinsic homogamy coe¢cients are generally higher for the groups which comprise a smaller proportion of the population, as our results imply. At the national level, for instance, the smallest group, 'Others' (the residual group), has the highest intrinsic homogamy, while the largest groups, Baptists and Catholics, have the lowest. At the regional level, also, the smallest intrinsic homogamy for Catholics is in the North-East, where Catholics comprise more than 45% of the population, while the largest (more than three times as large) is in the South, where Catholics constitute only 10% of the population.

2.3.2 Socialization and socialization e¤ort

Socialization to trait i in the model depends positively on socialization e¤ort, ¿^{i}, and on the share of the population with trait i, q^i. Moreover, since we assumed heterogamous families are not endowed with a socialization technology, homogamy should proxy for socialization e¤ort, ¿^{i}. Consistently with these implications of our analysis, there is evidence that successful socialization occurs more frequently in homogamous families (Hayes-Pittelkow, 1993, Heaton, 1986, Hoge-Petrillo, 1978, Hoge-Petrillo-Smith, 1982, Ozorak, 1989). Also, Mayer (1985) constructed a survey of mixed Jewish-Christian marriages in 1983, comparing several measures of socialization success of conversionary marriages (in which the Christian spouse converted to Judaism at marriage) to the same measures for heterogamous marriages. He estimates that children of conversionary marriages are more than three times as likely to identify themselves as Jews than children of heterogamous marriages.

More importantly, in their study of religious belief in Australia, Hayes-Pittelkow (1993) …nd that the e¤ect of homogamy on socialization vanishes when a measure of socialization e¤ort (e.g., 'parental discussion of religious beliefs') is introduced in the regression. This is consistent with our model's implication that homogamy a¤ects socialization only as a proxy for higher socialization e¤ort.

In term of direct socialization e¤ort, our model implies that homogamous families exercise more e¤ort on children socialization (because they have a better technology to this e¤ect), and families with minority cultural traits exercise higher socialization e¤orts, coeteris paribus. The presence of higher socialization e¤ort for homogamous families with children is suggested by the analysis of the survey panel constructed by Thornton-Axinn-Hill (1992) on Detroit families between 1962 and 1980. Married families in the panel engage more in religious activities (proxying for religious socialization), after conditioning for religiosity at the moment in which the family is formed, than families in cohabitation (as already noted, cohabitations are much less fertile and much more heterogamous that marriages).

Direct evidence for the socialization behavior of minorities is rather scarce. Barber (1994), however, does document that black and Hispanic families more aggressively socialize their children: they both have higher standards for behavior and are better able to enforce those standard.

Other interesting evidence on socialization effort can be obtained by analyzing neighborhood segregation by ethnic and religious group, insofar as neighborhood segregation is endogenously determined partly by the desire to socialize offspring. Ethnic neighborhoods have been a dominant aspect of American society since its early history, especially since the mass migrations to the U.S. in the last century. As early as 1703, for instance New York streets were identified as either Dutch or British (Homberger, 1994). Also, extreme residential segregation by ethnicity of turn of the century immigrants is well documented, e.g., by Duncan-Lieberson (1959), Peach (1980). While adjustment cost explanations are also consistent with high segregation levels along ethnic lines of first generation migrants, such explanations can hardly be extended, in our opinion, to significant levels of ethnic segregation of neighborhoods which persist after the second and third generations. In this respect, using 1970 Census Data, Borjas (1995) estimates that the probability that a second generation ethnic family group lives near family groups of the same ethnic origin is much higher than one would expect if families were spread across neighborhoods independently of their ethnic origin. For instance, among second generation workers, the typical family of Polish ancestry lives in a neighborhood that is 7.8% Polish, even though first and second generation Polish make up only 1.7% of the population. Similarly, second generation Italians live in 12.1% Italian neighborhoods, even though Italians first and second generation immigrants account for only 2.8% of the population.[16] Moreover, according to Borjas (1995), high segregation rates persist for third generation immigrants, and there is little evidence that only economically disadvantaged groups are geographically segregated.

2.3.3 Segregation and divorce

Our model implies that a bias in favor of homogamous marriage in the unrestricted pool has a negative effect on each cultural group's effort in marriage segregation, because agents react to the bias by decreasing their effort to enter the restricted pool. Johnson (1980) finds higher 'intrinsic homogamy' rates in urban environment than in rural environments, which is consistent with the implications of our model if urban environments are characterized by easier intercultural relationships.

When extending the analysis to single parent families and divorce, we expect less

[16] Even stronger segregation patterns by ethnicity are revealed in the National Longitudinal Survey of Youth (Borjas, 1995).

direct socialization effort for single parent families than for homogamous families. This is consistent with Thomson-McLanahan-Curtin (1992), which find weaker control of and fewer demand placed on children of single parent families (independent of the parent's gender). We would also expect a decline in homogamy rates especially starting from the 60s, as a consequence of higher divorce rates (see for example Davis, 1985, for a survey of the main trends in marriage relationships in the U.S.). This is broadly consistent with the trends toward cohabitations in the U.S. from the 60s (Spanier, 1985), since, as we already noted, cohabitations are relatively heterogamous. Also, and more directly, the average fraction of religiously homogamous marriages in the General Social Survey sample slowly declines from .9 in the 20s to .83 in the 60s, and then drops to .75 in the 70s (and remains constant in the 80s).

3 The dynamics of the distribution of cultural traits

In the previous sections, we analyzed how marital strategies across cultural communities are affected by the agents' concern for transmitting cultural values, assuming the distribution of cultural traits in the population, q^i, was exogenously determined. However, patterns of marital segregations and socialization across cultural groups have effects on the dynamics of cultural traits in society, or on the dynamics of q^i.

Taking the dynamics of cultural traits explicitly into account allows us to ask questions like: What distribution of traits will prevail in the long-run? Does the population remain multicultural in the limit, or do we observe a tendency towards cultural homogeneity? What are the effects of various structural changes in institutional arrangements within marriage?

In this section we investigate these issues by analyzing the explicit dynamics of cultural traits in the population, and the dependence of the dynamics on various historical institutional changes in marriage relationships, like a greater availability of intercultural relationships (due for instance to urbanization or information technologies); a greater freedom of choosing ones' mate; a greater acceptance of divorce, single parent families, and female labor market participation.

Let us first consider the model with a bias in the common pool ($\gamma \neq 0$) but no divorce and single parent families ($c = 0$). The probability that a child with a father with trait i will develop trait i is

$$P^{ii} = \pi^i(q^i;\gamma)[\tau^i(q^i;\gamma) + (1 - \tau^i(q^i;\gamma))q^i] + [1 - \pi^i(q^i;\gamma)]q^i$$

where $\pi^i(q^i;\gamma)$ is the equilibrium homogamy rate probability of population i. We note its dependence in equilibrium on the parameter γ. Similarly, the probability that a child with a father with trait j will develop trait i is

$$P^{ji} = \pi^j(q^j;\gamma)[(1 - \tau^j(q^j;\gamma))q^i] + [1 - \pi^j(q^j;\gamma)]q^i$$

Let q^i_t denote the fraction of the population with trait i at time t (we omit the index t when not necessary). The dynamics of the population of agents with trait i is then determined by the difference equation:

$$q^i_{t+1} = P^{ii}_t q^i_t + P^{ji}_t(1 - q^i_t) = q^i_t + q^i_t(1 - q^i_t)[\pi^i(q^i_t;\gamma)\tau^i(q^i_t) - \pi^j(q^j_t;\gamma)\tau^j(q^j_t)]$$

This dynamical process has corner stationary states, $q^i = 0$ and $q^i = 1$, and possibly interior stationary states, q^{i*}, which satisfy

$$\pi^i(q^{i*};\gamma)\tau^i(q^{i*}) = \pi^j(1 - q^{i*};\gamma)\tau^j(1 - q^{i*}); \quad i;j \in \{a;b\};\ i \neq j \tag{8}$$

The following result states that corner stationary states are unstable, and that there exists at least one interior locally stable stationary state.

Proposition 3 The corner stationary states, $q^i = 0$ and $q^i = 1$, are locally unstable. There always exists one interior steady state q^{i*}, which, under convexity conditions on cost functions (in the Appendix), is locally stable.[17]

The mechanism of marriage and cultural transmission we study generates dynamics of the distribution of cultural traits which tend to multicultural populations and away from complete assimilation of minorities. This is because the transmission mechanism has the property that cultural minorities tend to react in equilibrium to the prospect of cultural assimilation with marriage segregation, homogamous marriages, and with more intense strategies for the direct socialization of children. Even though majorities have higher socialization rates, due simply to the effect of peers and role models, the dynamics of the distribution of traits in the population, when one traits is close to becoming extinct, depends essentially on direct socialization effort, which is higher for minorities.[18]

It is important to stress that such a result depends on the traits not having effects on the agents' economic opportunities. This is, of course, an abstraction. The results of Proposition 3 are most properly interpreted as identifying a form of persistence in the dynamics of cultural traits, a non-linearity in the degree of cultural assimilation. Such persistence of traits, and the difficulty in acculturation of minorities, while hard to measure and document, is evident in many historical and ethnographic accounts of the evolution of ethnic and religious traits, as discussed in the Introduction.[19] One of the few econometric attempts at measuring the persistence of cultural traits is Borjas's

[17] Multiple interior stationary states might arise. The reason is that while the probability of being married in the restricted pool, $\alpha^i(q^i)$, is a decreasing function of the frequency of the trait in the population, the probability of being homogamously married, $\pi^i(q^i)$, may be increasing with q^i. As a consequence equation (8) may have more than one solution in q^{i*}.

[18] For an example of how instead peer pressure and social interactions might lead to homogeneity, see Glaeser-Sacerdote-Scheinkman, 1996.

[19] The 'Renaissance' of Orthodox Jews is one such accounts (Mayer, 1985). It is not just explained by extreme homogamy rates, but also by relatively high fertility rates. The average number of children per family of Orthodox Jews in 1990, according to the National Jewish Population Survey, was above

1995 study of the assimilation of immigrants' 'ethnic capital' in the U.S. Consistently with our results, he finds quite slow rates of cultural convergence, explained mainly by neighborhood fixed effects, which we interpret as a proxy for homogamy rates and direct socialization effort.

How will changes in the marital and social environment affect the long-run distribution of cultural traits? We will consider three such changes. First, observe that the condition for an interior stationary state, equation (8), can be restated as:

$$\frac{q^{a*} - HT^{ab}(q^{a*};\gamma)}{(1-q^{a*}) - HT^{ab}(q^{a*};\gamma)} = \frac{q^{a*}}{1-q^{a*}}\frac{\tau^{b}(1-q^{a*})}{\tau^{a}(q^{a*})}$$

where $HT^{ab}(q^{a*};\gamma)$ measures the heterogamy of the population in equilibrium at the stationary state fraction of population with trait a, q^{a*}. This equation is represented in Figure 1, where the LL and RR curves represent respectively the left and the right hand-side of equation (8) as a function of q^{a*}.

i) Decrease in γ; increase in δ. Consider a negative change in γ, the distortion towards homogamy in the unrestricted pool. Typically, urbanization and the development of communication and transportation technologies should be associated with a negative change in γ; as such structural changes tend to increase and facilitate intercultural contacts. A negative change in γ increases equilibrium marriage segregation, α^i, of both cultural groups. It generally increases heterogamy, HT^{ab}, and it does not affect the socialization effort of homogamous marriages (the RR curve in Figure (1) does not move). Note that an increase in HT^{ab} shifts up (down) the LL curve, to LL$'$, when q^{a*} is larger (smaller) than $\frac{1}{2}$ (see Figure 1). The reason is that an increase in HT^{ab} decreases for both groups the probability $\pi^i(q^i;\gamma)$ of getting an homogamous marriage. However the decrease is more pronounced for the minority group than for the majority group, since random matching in the unrestricted pool favors by definition homogamy of the majority group. As the LL curve represents the ratio of homogamous marriages in group a to group b, it is then increasing (decreasing) with HT^{ab} when a is the majority (minority) group (i.e., q^{a*} larger (smaller) than $1/2$). A reduction in γ, though leading in the short run to higher effort to marital segregation by both groups, generally tends to increase heterogamy in society, and, as shown in Figure 1, favors in the limit the majority trait (the stationary state frequency of the majority group, i.e., the group i with $q^{i*} > \frac{1}{2}$, increases).

An increase in δ, a measure of the cost of marriage segregation, captures, for instance, greater freedom in choosing ones' mate, a relatively recent development in marriage in-

4, as opposed to less than 2 for Conservative and Reform Jews. Our model of socialization, extended to endogenous fertility, would explain such positive correlation between fertility, homogamy and socialization, since high level of homogamy and socialization are equivalent to high expected 'quality' of children (Bisin-Verdier, 1996). As already noted, higher intended fertility for homogamous couples is also documented by Lehrer (1996).

stitutions across many ethnic groups at least in the western world (see e.g., Davis, 1985). An increase in ± decreases equilibrium marriage segregation, $®^i$, thereby increasing HT^{ab}, while it does not a¤ect the socialization e¤ort of homogamous marriages (the RR curve in Figure) does not move). An increase in ±, implying an increase in HT^{ab}, decreases for both groups the probability $¼^i(q^i; °)$ of getting an homogamous marriage match. However, as before, the decrease is more pronounced for the minority group than for the majority group. An increase in ±, then favors the majority trait in the limit (the stationary state frequency of the majority group, i.e., the group i with $q^{i¤} > \frac{1}{2}$, increases).
ii) Increase in ¯. It is also interesting to consider the impact of changes in the cost of direct family socialization, ¯. Such changes may be associated with structural changes in gender roles inside the family, like the increased female participation rate in the labor market. This phenomenon increases the opportunity costs to women of spending time socializing children inside the family, and therefore, should be associated with a positive change in the cost of direct cultural socialization. Another historical structural change moving in the same direction, is the shift from a family-labor based economy towards a market-wage based economy, making it again more costly for the family to directly transmit its own cultural trait. Formally, the impact of a less e¢cient socialization technology, by changing directly family socialization, $¿^i(q^i)$, and indirectly marital segregation strategies, $®^i(q^i_t)$, a¤ects both the LL and the RR curves in Figure 1. As it induces a reduction in the marital segregation strategy, $®^i$, and in the family socialization e¤ort, $¿^i$; the impact on the marriage game is to induce a larger equilibrium heterogamy, HT^{ab}. As before, this e¤ect decreases the probability of homogamous matching for the minority group more than for the majority group, hence implying a larger fraction of agents of the majority group in the long run distribution of the population. However, there is now in principle another e¤ect emanating from the direct decrease in $¿^i$ stimulated by the parameter's change. If the increase in socialization costs, ¯, a¤ects the technology of family socialization in the same way for both groups, the ratio of socialization e¤orts $\frac{¿^b(q^b)}{¿^a(q^a)}$ is not a¤ected: the RR curve does not shift. The e¤ect of an increase in the cost of direct family socialization, ¯, is equivalent, then, to a decrease in °: it increases in the limit the fraction of agents with the majority trait (i.e., $q^{i¤}$, for the trait i such that $q^{i¤} > \frac{1}{2}$).
iii) Changes in $¢V^i$. As in the case of changes in the costs of family socialization, a change in the perceived cultural distance of group i, $¢V^i$, with respect to the other group will a¤ect both the LL and RR curves. For instance, if the minority group (say, group b) tends to be more tolerant towards the majority group ($¢V^b$ decreases), then that group becomes less homogamous and the equilibrium heterogamy rate HT^{ab} consequently increases, meaning an upward shift of LL. At the same time, family socialization $¿^b(q^b)$ is also reduced, implying a downward shift of RR. Both e¤ects tend to increase the fraction of the majority group a, and the 'cultural assimilation' of the minority group. An increase in cultural tolerance of the majority group, group a, similarly increases intermarriage between the two communities. On the other hand, it also implies a reduction

of the intensity of family socialization of that group. The first effect positively affects the long run proportion of the majority group, while the second effect tends, on the contrary, to favor the minority. The total effect is ambiguous. However, it is easy to see that when the majority group is large enough (q^{a*} close enough to 1), the impact of a change in ΔV^a only marginally affects the socialization effort, $\tau^a(q^a)$, leaving the RR curve almost unaffected. In that case, only the positive impact of a decrease in ΔV^a on LL remains, implying an increase in the steady state frequency of the majority group, and, conversely, a smaller sized minority group. For example, as noted in the Introduction, American Jews' faster acculturation since the end of World War II might be explained by other major religious groups' increasing tolerance of inter-marriage with Jews (see Dershowitz, 1997).

Finally, we briefly discuss the implications of increasing the probability of divorce, c, on the long run distribution of cultural traits in the population. The dynamics equation is now given by:

$$q^i_{t+1} - q^i_t = q^i_t(1 - q^i_t)\left[(1 - c)[\pi^i(q^i_t)\tau^i_m(q^i_t) - \pi^j(q^j_t)\tau^j_m(q^j_t)] + c[\tau^i_s(q^i_t) - \tau^j_s(q^j_t)]\right] \quad (9)$$

In equation (9) we see that the cultural selection forces operate through two socialization channels. Homogamous couples who have not divorced (in proportion $(1 - c)\pi^a(q_t)$ and $(1 - c)\pi^b(1 - q_t)$) socialize their children with direct family socialization effort, $\tau^i_m(q^i_t)$. Divorced couples and single parent families (in proportion $c\pi^a(q_t)$ and $c\pi^b(1 - q_t)$) socialize their children with direct family socialization effort $\tau^i_s(q^i_t)$. Clearly when the total effective socialization effort of group i (homogamous couples plus single parent families) is larger than the other group's, then the frequency of trait i increases in the population. As we have pointed out in Section 2.3, an increase in c reduces the resources spent to match in the restricted pools and brings more heterogamy in the short-run. As homogamy for both cultural groups decreases, homogamy rates also decrease for both groups, but less rapidly for the majority group than for the minority group. This implies a bias in the evolution of traits which favors the majority group. At the same time, an increase in divorce rates increases the importance of single parent socialization in the dynamics of the distribution of traits. Clearly, it brings an advantage to the group which is more successful at socializing in single parent contexts. When both groups are equally successful at socializing their children in single parent family contexts (i.e., they have access to the same technologies of socialization), this effect tends to favor the minority cultural group, as agents of that group have larger incentives to spend resources for cultural transmission. Hence, it appears that while reducing homogamy the overall effect of higher divorce rates on preferences is ambiguous. When, however, single parent families are not able to significantly bias the cultural transmission process, we get some clearer implications. In this case the term $c(\tau^a_s(q) - \tau^b_s(1 - q))$ is close to zero in equation (9). We are therefore left with only the effect of c on the groups' marital strategies. That is, an increase in the probability of divorce, c, reduces marital segregation strategies of both groups and increases heterogamy. This favors, in the long-run, the cultural trait of the majority group.

4 Conclusion

This paper analyzes marital segregation decisions and their impact on the transmission of ethnic and religious traits. We concentrate on the interaction between direct family socialization and oblique socialization by teachers, peers and role models. While most research on cultural transmission has stressed this interaction (e.g., Cavalli Sforza-Feldman, 1981, Boyd-Richerson, 1985), we complement this emphasis by modelling marriage and direct family socialization as economic decisions of agents. This economic approach generates many interesting restrictions, as well as testable implications, which we attempt to identify and study in the paper.

Our analysis of socialization is relatively abstract, and, hence, in principle, can be extended to analyze the evolution of other cultural traits or different socialization mechanisms. However, the assumption that cultural traits are 'pure', or do not have relevant effects on agents' economic opportunities, is quite restrictive. This assumption needs to be relaxed in particular to apply our analysis to study the evolution of many interesting cultural traits and preference parameters, like political attitudes, risk aversion, and intertemporal discounting. Such traits, in fact, affect how agents interact economically and socially, especially in strategic environments.

Appendix

The problem of an individual of type i is to choose $\alpha^i \in [0;1]$, for a given A^i, A^j, q^i, to maximize

$$\pi^i(\alpha^i;A^i;A^j;q^i)W^i(q^i) + [1 - \pi^i(\alpha^i;A^i;A^j;q^i)]V^i(q^i) - C(\delta\alpha^i) \tag{10}$$

where $W^i(q^i)$ is given by

$$W^i(q^i) = \max_{\tau^i}[\tau^i + (1-\tau^i)q^i]V^{ii} + (1-\tau^i)(1-q^i)V^{ij}] - H(\beta\tau^i)$$

and $V^i(q^i) = q^iV^{ii} + (1-q^i)V^{ij}$

We assume:

Assumption A. For $i \in \{a;b\}$, $C(\delta\alpha^i)$ and $H(\beta\tau^i)$ are monotonic increasing, of class C^3, and convex. Moreover,

A-i) $\frac{\partial^3 C}{\partial \alpha^{i3}} \leq 0$

A-ii) $\delta\frac{\partial C}{\partial \alpha^i}(\delta) > [W^i(0) - V^i(0)]$;

A-iii) $(1-\alpha^i)\frac{\partial^2 C}{\partial(\alpha^i)^2} - \frac{\partial C}{\partial \alpha^i} > 0$ at $\alpha^i = \alpha^i_{max}$ such that $\delta\frac{\partial C}{\partial \alpha^i}(\delta\alpha^i_{max}) = W^i(0) - V^i(0)$:

Assumptions A-1) - A-iii) provide sufficient conditions for the existence and uniqueness of the Nash equilibrium in the marriage game. A-i) requires that the marginal cost of marriage segregation is increasing and concave. A-ii) ensures that matching with probability 1 in the restricted pool is prohibitively costly. Finally, A-iii) requires that, at some largest possible restricted pool matching probability, α^i_{max}; the cost function $C(.)$ is convex enough.

For an individual of type i, the first order condition for the choice of α^i is:

$$\delta\frac{\partial C}{\partial \alpha^i}(\delta\alpha^i) = p^i(A^i;A^j;q^i)[W^i(q^i) - V^i(q^i)]; \tag{11}$$

with

$$p^i(A^i;A^j;q^i) = \frac{(1-A^j)(1-q^i)}{(1-A^i)q^i + (1-A^j)(1-q^i)}$$

A symmetric Nash equilibrium of the marriage game has the propery that all agents of type i choose the same α^i, and is represented by mappings $\alpha^i(q^i)$ which are fixed points of the best replies of agents $i \in \{a;b\}$ derived from the maximization of equation (10). Best replies must then satisfy equation (11), which can be rewritten as

$$\delta\frac{\partial C}{\partial \alpha^i}(\delta\alpha^i) = \frac{(1-\alpha^j)(1-q^i)}{(1-\alpha^i)q^i + (1-\alpha^j)(1-q^i)}[W^i(q^i) - V^i(q^i)] = 0 \tag{12}$$

for $i, j \in \{a, b\}$ and $i \neq j$.

Proof of Proposition 1 (under Assumption A). At a symmetric Nash equilibrium $\alpha^i = A^i$ and the first order condition of an individual of type i for the choice of α^i is equation (12). Denote by $\Phi^i(\alpha^i, \alpha^j, q^i)$ the left hand side of equation (12). Then

$$\frac{\partial \Phi^i}{\partial \alpha^i} = \frac{\partial^2 C}{\partial \alpha^{i2}}(\delta \alpha^i) - \frac{(1-\alpha^j)(1-q^i)q^i}{[(1-\alpha^i)q^i + (1-\alpha^j)(1-q^i)]^2}[W^i(q^i) - V^i(q^i)]$$

and

$$\frac{\partial^2 \Phi^i}{\partial \alpha^{i2}} = \frac{\partial^3 C}{\partial \alpha^{i3}}(\delta \alpha^i) - \frac{2(1-\alpha^j)(1-q^i)(q^i)^2}{[(1-\alpha^i)q^i + (1-\alpha^j)(1-q^i)]^3}[W^i(q^i) - V^i(q^i)] < 0,$$

because of A-i). Hence Φ^i is continuous and concave in α^i for any $(\alpha^j, q^i) \in [0,1]^2$. Also $\Phi^i(0, \alpha^j, q^i) \leq 0$ and $\Phi^i(1, \alpha^j, q^i) > 1$, because of A-ii). Hence, for any $(\alpha^j, q^i) \in [0,1]^2$, there exists a unique $\alpha^i \in [0,1]$ satisfying $\Phi^i(\alpha^i, \alpha^j, q^i) = 0$. Let us denote such α^i by $\hat{\alpha}^i(\alpha^j, q^i)$. $\hat{\alpha}^i(\alpha^j, q^i)$ can be viewed as a best response function of the marital segmentation effort of group i. Because of the concavity of Φ^i, a simple argument by contradiction shows that, at $\hat{\alpha}^i(\alpha^j, q^i)$, necessarily $\frac{\partial \Phi^i}{\partial \alpha^i}(\hat{\alpha}^i; \ldots) > 0$. Also, equation (12) implies $0 < \hat{\alpha}^i(0, q^i) < 1$ and $\hat{\alpha}^i(1, q^i) = 0$. Finally,

$$\frac{\partial \hat{\alpha}^i(\alpha^j, q^i)}{\partial \alpha^j} = -\frac{\frac{\partial \Phi^i}{\partial \alpha^j}(\hat{\alpha}^i; \ldots)}{\frac{\partial \Phi^i}{\partial \alpha^i}(\hat{\alpha}^i; \ldots)},$$

which has the sign of $-\frac{\partial \Phi^i}{\partial \alpha^j}(\hat{\alpha}^i; \ldots)$. But

$$-\frac{\partial \Phi^i}{\partial \alpha^j}(\hat{\alpha}^i; \ldots) = -\frac{(1-\alpha^i)q^i(1-q^i)}{[(1-\alpha^i)q^i + (1-\alpha^j)(1-q^i)]^2}[W^i(q^i) - V^i(q^i)] < 0,$$

and therefore $\hat{\alpha}^i(\alpha^j, q^i)$ is a decreasing function of α^j. Differentiation of equation (12) shows that

$$\frac{\partial \Phi^i}{\partial q^i} = \frac{(1-\alpha^j)(1-\alpha^i)}{[(1-\alpha^i)q^i + (1-\alpha^j)(1-q^i)]^2}[W^i(q^i) - V^i(q^i)] - \frac{(1-\alpha^j)(1-q^i)}{(1-\alpha^i)q^i + (1-\alpha^j)(1-q^i)} \frac{d[W^i(q^i) - V^i(q^i)]}{dq^i},$$

but $W^i(q^i) - V^i(q^i) = \tau^i(q^i)[V^{ii} - V^{ij}](1-q^i) - H(\tau^i(q^i))$. Applying the Envelope Theorem we have $\frac{d[W^i(q^i) - V^i(q^i)]}{dq^i} < 0$. Hence $\frac{\partial \Phi^i}{\partial q^i} > 0$, implying that $\frac{\partial \hat{\alpha}^i}{\partial q^i} < 0$.

Consider now the mapping $\Psi(\alpha^a)$, defined on $[0;1]$ and given by $\Psi(\alpha^a) = \hat\alpha^a[\hat\alpha^b(\alpha^a)]$. A symmetric Nash equilibrium of the marriage game is a fixed point of this mapping. As both best responses functions $\hat\alpha^a(\alpha^b)$ and $\hat\alpha^b(\alpha^a)$ are continuous functions from $[0;1]$ into $[0;1]$, $\Psi(\alpha^a)$ is also a continuous mapping from $[0;1]$ into $[0;1]$. Hence the Kakutani Fixed Point Theorem implies the existence of a symmetric Nash equilibrium in the marriage game.

To prove uniqueness of the symmetric Nash equilibrium it suffices to show that $\Psi(\alpha^a) - \alpha^a$ is strictly decreasing in α^a. Continuity of $\alpha^i(q^i)$ then follows directly. Since $\Psi(\alpha^a)$ is differentiable, $\Psi(\alpha^a) - \alpha^a$ is strictly decreasing in α^a iff $\Psi'(\alpha^a) < 1$; or, more precisely,

$$\frac{\partial \hat\alpha^a}{\partial \alpha^b} \times \frac{\partial \hat\alpha^b}{\partial \alpha^a} < 1$$

Letting $D = (1-\alpha^a)q^a + (1-\alpha^b)(1-q^a)$ and $K^i(q^{a\,i}) = [W^i(q^i) - V^i(q^i)]$, we have

$$\frac{\partial \hat\alpha^a}{\partial \alpha^b} \times \frac{\partial \hat\alpha^b}{\partial \alpha^a} = \frac{\frac{(1-\alpha^a)q^a(1-q^a)}{D^2}K^a}{\delta\frac{\partial^2 C}{\partial \alpha^{a2}}(\delta\alpha^a) - \frac{(1-\alpha^b)(1-q^a)q^a}{D^2}K^b} \times \frac{\delta\frac{\partial^2 C}{\partial \alpha^{b2}}(\delta\alpha^b) - \frac{(1-\alpha^a)(1-q^a)q^a}{D^2}K^a}{\frac{(1-\alpha^a)q^a(1-q^a)}{D^2}K^b}$$

With this notation, the first order condition, equation (12), can be rewritten as

$$\delta\frac{\partial C}{\partial \alpha^i}(\delta\alpha^i) = \frac{(1-q^i)(1-\alpha^j)}{D}K^i(q^i)$$

Substituting, we obtain that $\frac{\partial\hat\alpha^a}{\partial\alpha^b} \times \frac{\partial\hat\alpha^b}{\partial\alpha^a} < 1$ holds iff

$$\frac{\frac{\partial C}{\partial \alpha^b}\frac{(1-q^a)}{D}\frac{K^a}{K^b}}{\frac{d^2C}{d\alpha^{a2}} - \frac{q^a}{D}\frac{\partial C}{\partial\alpha^a}} \times \frac{\frac{\partial^2 C}{\partial\alpha^{b2}} - \frac{(1-q^a)}{D}\frac{\partial C}{\partial \alpha^b}}{\frac{\partial C}{\partial\alpha^a}\frac{q^a}{D}\frac{K^b}{K^a}} < 1;$$

which is equivalent to:

$$q^a\frac{\partial^2 C}{\partial\alpha^{b2}}\frac{\partial C}{\partial\alpha^a} + (1-q)\frac{\partial^2 C}{\partial\alpha^{a2}}\frac{\partial C}{\partial\alpha^b} < D \times \frac{\partial^2 C}{\partial\alpha^{a2}} \times \frac{\partial^2 C}{\partial\alpha^{b2}}$$

As a consequence $\frac{\partial\hat\alpha^a}{\partial\alpha^b} \times \frac{\partial\hat\alpha^b}{\partial\alpha^a} < 1$ holds iff

$$\frac{\partial^2 C}{\partial\alpha^{b2}}q^a[(1-\alpha^a)\frac{\partial^2 C}{\partial\alpha^{a2}} - \frac{\partial C}{\partial\alpha^a}] + \frac{\partial^2 C}{\partial\alpha^{a2}}(1-q^a)[(1-\alpha^b)\frac{\partial^2 C}{\partial\alpha^{b2}} - \frac{\partial C}{\partial\alpha^b}] > 0;$$

which is satisfied under Assumption A. More precisely, as $\frac{\partial^3 C}{\partial\alpha^{i3}} \le 0$, $(1-\alpha^i)\frac{\partial^2 C}{\partial\alpha^{i2}} - \frac{\partial C}{\partial\alpha^i}$ is decreasing in α^i, and is therefore positive for all relevant α^i, since, by condition A-iii), it is positive for the largest possible α^i, α^i_{max}, given by $\delta\frac{\partial C}{\partial\alpha^i}(\delta\alpha^i_{max}) = K^i(0)$.

The choice of τ^i is derived from the following optimization problem:

$$W^i(q^i) = \max_{\tau^i} [\tau^i + (1-\tau^i)q^i]V^{ii} + (1-\tau^i)(1-q^i)V^{ij}] - H(\beta\tau^i)$$

which is a convex problem under Assumption A. This immediately implies the continuity of the solution as a function of the parameters, $\tau^i(q^i)$. ∎

Proof of Proposition 2 (under assumption A). Note that $\frac{\partial\alpha^a}{\partial q^a} = -\frac{\frac{\partial\Omega}{\partial q^a}}{\frac{\partial\Omega}{\partial\alpha^a}-1}$ has the sign of $\frac{\partial\Omega}{\partial q^a}$. Using the fact that $\hat{\alpha}^a(\alpha^b, q^a)$ is decreasing in α^b, and $\frac{\partial\hat{\alpha}^a}{\partial q^a} < 0$, it is easy to see that $\frac{\partial\Omega}{\partial q^a} = \frac{\partial\hat{\alpha}^a}{\partial q^a} + \frac{\partial\hat{\alpha}^a}{\partial\alpha^b} \times \frac{\partial\hat{\alpha}^b}{\partial q^a} < 0$. Hence the result that $\alpha^a(q^a)$ is decreasing in q^a. By a symmetric argument $\alpha^b(q^b)$ is decreasing in $q^b = 1 - q^a$.

The first order condition for the choice of τ^i, is

$$\beta\frac{\partial H}{\partial\tau^i}(\beta\tau^i) = [V^{ii} - V^{ij}](1-q^i)$$

Because of the convexity of $H(.)$, the second order condition is satisfied and differentiating the previous equation, we get

$$\frac{\partial\tau^i}{\partial q^i} = -\frac{[V^{ii} - V^{ij}]}{\beta^2\frac{\partial^2 H}{\partial\tau^2}} < 0. \quad ∎$$

The comparative statics results in Section 2.2, and the extensions and the comparative statics analysis of Section 2.2.1, are studied in an Appendix available from the authors.

We now study the dynamics of the distribution of traits, following the analysis of Section 3, where $\gamma \neq 0$ and $c = 0$. The general case in which $c \neq 0$ is studied in the Appendix available from the authors. The equation for the dynamics of the distribution of traits in the population is

$$q^i_{t+1} = q^i_t\pi^i(q^i_t)P^{ii}_m + q^i_t(1-\pi^i(q^i_t))P^{ii}_h + + q^j_t\pi^j(q^j_t)P^{ji}_m + q^j_t(1-\pi^j(q^j_t))P^{ji}_h, \qquad (13)$$

where P^{ii}_m, P^{ii}_h, (resp. P^{ji}_m, P^{ji}_h) are the transition probabilities for a parent of type i (resp. j) of an homogamous and heterogamous family, of having children of type i, that is,

$$\begin{aligned} P^{ii}_m &= \tau^i_m + (1-\tau^i_m)q^i_t, \qquad P^{ii}_h = q^i_t \\ P^{ji}_m &= (1-\tau^j_m)q^i_t, \qquad P^{ji}_h = q^i_t \end{aligned}$$

Substituting these transition probabilities in equation (13), and subtracting q^i_t on both sides, we get, after rearrangement,

$$q^i_{t+1} - q^i_t = q^i_t(1-q^i_t)\left[\pi^i(q^i_t)\tau^i_m(q^i_t) - \pi^j(q^j_t)\tau^j_m(q^j_t)\right]$$

Proof of Proposition 3. Let q_t^i denote the fraction of the population with trait i at time t.

i) From the first order conditions of the socialization problem in equation (6), $\tau_m^i(1) = 0$. Also $\tau_m^i(0) > 0$, $\pi^i(1) = 1; \pi^i(0) = \alpha^i(0) + (1 - \alpha^i(0))\gamma > 0$. Hence

$$\left[\frac{\partial\left(q_{t+1}^a - q_t^a\right)}{\partial q_t^a}\right]_{q^a=0} = \left[\pi^a(0)\tau_m^a(0) - \pi^b(1)\tau_m^b(1)\right] = \left[\pi^a(0)\right]\tau_m^a(0) > 0$$

and

$$\left[\frac{\partial\left(q_{t+1}^a - q_t^a\right)}{\partial q_t^a}\right]_{q^a=1} = -\left[\pi^a(1)\tau_m^a(1) - \pi^b(0)\tau_m^b(0)\right] = \left[\pi^b(0)\right]\tau_m^b(0) > 0$$

The two previous expressions ensure that the corner stationary states $q^{a\star} = 0$ and $q^{a\star} = 1$ are locally unstable.

ii) Consider the function

$$\Theta(q^a) = \pi^a(q^a)\tau_m^a(q^a) - \pi^b(1 - q^a)\tau_m^b(1 - q^a)$$

This function is continuous on $[0;1]$. Moreover

$$\Theta(0) = \pi^a(0)\tau_m^a(0) > 0$$

and

$$\Theta(1) = -\pi^b(0)\tau_m^b(0) < 0$$

By continuity of $\Theta(.)$ there exists an interior point $q^{a\star} \in (0;1)$ such that $\Theta(q^{a\star}) = 0$ and $\Theta'(q^{a\star}) < 0$. Such a point is an interior stationary state and satisfies

$$\pi^a(q^{a\star})\tau_m^a(q^{a\star}) = \pi^b(1 - q^{a\star})\tau_m^b(1 - q^{a\star})$$

iii) An interior stationary state $q^{a\star}$ will be locally stable if

$$\left[\frac{\partial\left(q_{t+1}^a - q_t^a\right)}{\partial q_t^a}\right]_{q=q^{a\star}} = q^{a\star}(1 - q^{a\star})\Theta'(q^{a\star}) \in (-2;0)$$

But $\left[\frac{\partial(q_{t+1}^a - q_t^a)}{\partial q_t^a}\right]_{q=q^{a\star}} < 0$ is ensured by $\Theta'(q^{a\star}) < 0$. Moreover, $\left[\frac{\partial(q_{t+1}^a - q_t^a)}{\partial q_t^a}\right]_{q=q^{a\star}} > -2$ can be rewritten as

$$q^{a\star}(1 - q^{a\star})\left|\Theta'(q^{a\star})\right| < 2 \qquad (14)$$

A sufficient condition for equation (14) to be satisfied is: $\left|\Theta'(q^{a\star})\right| < 8$, which in turn is satisfied if $\frac{\partial\tau^i}{\partial q^a}$ and $\frac{\partial\alpha^i}{\partial q^a}$ are sufficiently bounded, i.e., if $H(\beta\tau^i)$ and $C(\delta\alpha^i)$ are convex enough in τ^i and α^i. $\blacksquare$

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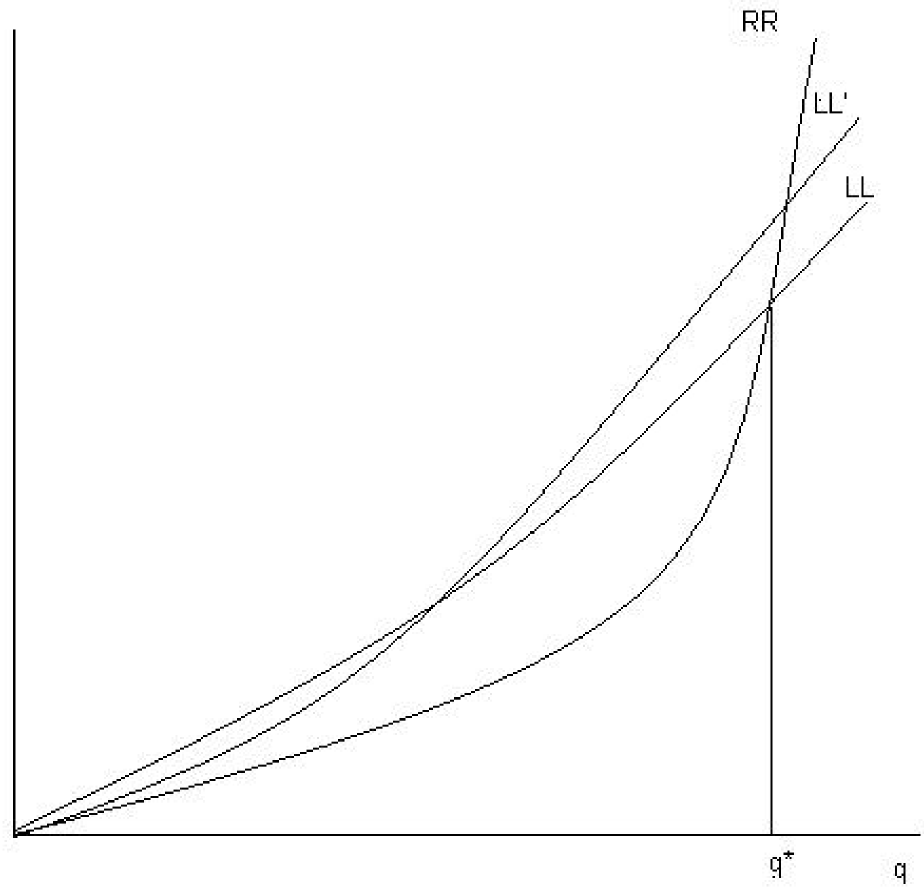

FIGURE 1