Culture, human capital, and marital homogamy in France*

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This version: November 14, 2022
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Abstract

What economic sacrifices are people willing to make to transmit their culture? Using data on religious affiliation in France, I study the intergenerational transmission of religion and how it interacts with children's educational outcomes. A reduced-form analysis suggests that mothers contribute to religious transmission more than fathers; religious minorities more than majorities; and lower-educated parents more than higher-educated ones. A mechanism that can explain these patterns is that higher-educated parents have a higher opportunity cost of transmitting their religion to their children. I investigate this mechanism through a structural model, in which parents endogenously decide their time investments in their child's culture on the one hand, and in their formal education on the other hand. The analysis suggests that heterogeneities in transmission patterns are driven primarily by heterogeneities in preferences for religious transmission across genders and religious groups, rather than by differences in parents' education. Furthermore, religious minorities pay a higher price for religious transmission in terms of their children's educational outcomes. For instance, by measuring this cost in terms of the probability that the child will obtain a college education, Muslim parents pay a cost between 8 and 13 times greater than that for Christians.

JEL classification: Z10, Z12, D12, D13, J15, J24

*I am grateful to my advisor Paul Seabright, as well as to Bernard Salanié and François Salanié, who provided extensive guidance for this project. I also thank Ishani Chatterjee, Pierre-André Chiappori, Roberta Dessi, Victor Gay, Laurence Iannaccone, Michael McBride, Karine Van Der Straeten, as well as participants at the TSE PhD workshop, ASREC 2022 conference, CIREQ 2022 conference, TSE Applied Micro workshop, TSE Behavior, Institutions and Development workshop, and IRES workshop for helpful comments. All errors are my own.

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1 Introduction

What sacrifices are people willing to make to transmit their culture? Whether implicitly or explicitly, cultural transmission shapes the trade-offs that people make on consumption and investment decisions on a daily basis.[1] Routine economic choices, such as how to dress their children, or whether the family attends a sports game rather than church on Sunday, are influenced by culture. But considerations of cultural transmission also influence major decisions in families' lives, such as which neighborhood to move to, or which school to enroll children in. Moreover, these considerations do not only apply to current parents. Even before having children, people anticipate how their choices will affect their ability to transmit their culture later on, in particular when they choose a partner. In turn, efforts to find a suitable partner might influence other life-changing decisions such as where to live, or whether to go to college. Thus, a wide range of critical choices and behaviors, which have independently been studied by economists for decades, are in fact shaped by cultural transmission. However, we still know very little about how and to what extent cultural transmission influences these economic decisions and outcomes.

In this paper, I address this issue by studying an important economic decision: investments in children's education by parents; and its relationship with a crucial cultural trait: religion. Specifically, I examine how parents trade off between intergenerational religious transmission and investments in their children's educational attainment, in the context of modern France.[2] The main argument of this paper is that parents from different religious and educational backgrounds face unequal trade-offs on this issue. In particular, religious minorities are more likely to invest in religious transmission at the expense of their children's educational attainment, and they pay a higher opportunity cost for it.[3] For instance, my results suggest that, at the margin, investments in religious transmission made by Muslim parents (the main religious minority in France) are between 8 and 13 times more costly than those made by Christian parents (the religious majority) in terms of the probability that their child will obtain a college degree.

To understand the nature of this trade-off, first I investigate the patterns of religious

[1] Intergenerational transmission is one of culture's defining features: following for instance Guiso, Sapienza and Zingales (2006), culture designates "those customary beliefs and values that ethnic, religious, and social groups transmit fairly unchanged from generation to generation."

[2] The tension between religion and formal education has long been a particularly striking illustration of the trade-offs that cultural transmission entails. Modern schooling emphasizing rationality and the scientific approach has long clashed with religion, in part because their respective teachings are sometimes incompatible, but also because they must compete for children's limited attention (see for instance Squicciarini 2020, Chaudhary and Rubin 2011, or Carvalho, Koyama and Sacks 2017 for historical examples). In the United States this clash is still unfolding, for instance with the ever-lasting debates around the inclusion of creationism in the public school curriculum.

[3] Anecdotal evidence of this phenomenon is extensive. Some religious groups, such as the Amish or Jehovah's Witnesses, even explicitly discourage their affiliates from pursuing college or even high school education – arguably because these groups implicitly acknowledge these trade-offs. In September 2022, the *New York Times* reported on the dismal state of education in New York City's Hasidic Jewish schools, which have prioritized religious teachings at the expense of basic skills such as English and math ("In Hasidic Enclaves, Failing Private Schools Flush With Public Money", NYT, Sep. 11, 2022).

transmission and children's education by using French survey data from 2008. Both an extensive descriptive analysis and a reduced-form approach suggest that mothers invest in the transmission of their religious affiliation more than fathers, and that religious minorities (Muslims and Jews) invest more than majorities (Christians and Unaffiliated). Furthermore, lower-educated parents transmit their religious affiliation more successfully than higher-educated parents on average. Conversely, children of Christian parents are more educated than those of Muslim parents, even when controlling for the parents' education. The reduced-form analysis, which uses a multilogit specification to explain children's choice of religious affiliation as a function of their parents' characteristics and of the religious mix of their environment, successfully fits the data on parents' and children's religious affiliations.

In a second step, I explicitly address the trade-off between religious transmission and education by building a structural model in which parents must invest in the child's formal education, on the one hand, and in the child's religious socialization, on the other hand. In this model, the trade-off arises because both the *socialization* process, whereby children learn the tenets and principles of the previous generation's culture, and the investments in the child's formal education, are time-consuming activities for the parents. Crucially, the model incorporates three key mechanisms which explain differences in how parents choose to invest in religion versus education for their children. The first mechanism is that higher-educated parents are more productive than lower-educated parents in furthering their children's formal education. This mechanism is directly inspired by the stylized facts derived from the reduced-form analysis, which suggest that higher-educated parents have a higher opportunity cost to transmit religion to their children. Here, I model this opportunity cost as foregone investments in the child's formal education. The second mechanism, called *cultural substitution*, is adapted from the literature on the economics of cultural transmission (Bisin and Verdier 2000). This mechanism entails that while parents from religious majorities can extensively rely on their environment to socialize their children, the same is not true for religious minorities. Consequently, religious minorities must invest comparatively more in religious socialization to achieve the same religious transmission outcomes. The third and last mechanism is preference heterogeneity across parents. I allow parental preferences for the child's religion versus education to vary across two dimensions, namely, parents' gender and religious affiliation. With these assumptions, I model parental behavior by using a collective household model, and I derive closed-form solutions for how parents invest in their children's religion versus education.

Finally, I estimate this model, leveraging the variation in children's religious affiliation and educational attainment. To exploit this double variation and to estimate parameters despite nonlinearities (for which standard logit regression is not suitable), I develop a maximum likelihood approach that combines elements from both multinomial logit (for religious affiliation) and ordered logit (for educational attainment) estimation. My results indicate that the three mechanisms discussed above matter for the parental trade-off between religious transmission and investments in their children's education, albeit at different scales. A log-likelihood decomposition analysis allows me to rank these three mechanisms by order of importance in terms of explanatory power. I find that parental preferences matter the most in explaining the variation in children's religious affiliation and educational attainment, followed by the economic mechanism involving a higher opportunity cost of religious socialization for higher-educated parents, and finally by the cultural substitution mechanism.[4] Through counterfactual analysis, my estimation results also allow me to quantify the trade-offs that different parents face between investments in their child's religious socialization versus formal education. To do so, I use the estimates to reconstruct the households' production possibility frontier in terms of two household outputs, the religious transmission rate and the probability that the child will obtain a college degree. By measuring the slope of this frontier (i.e. the household's marginal rate of transformation) I recover the cost of religious transmission in terms of children's educational attainment, finding for instance that Muslim parents pay a cost 8 to 13 times greater than Christians parents.

These results have far-reaching implications for the way that we understand incentives, inequality, and education policy in relation to religion and, more broadly, to culture. First, they indicate that cultural minorities may have comparatively higher incentives to invest in cultural transmission for their children, over the acquisition of skills which are validated by diplomas and valued on the labor market. These incentives to invest in cultural transmission rather than education are likely to be reinforced by the fact that many cultural minorities typically face weaker job opportunities. The dynamic implications for inequality are severe, since these incentives would amplify any existing educational gap between cultural majorities and minorities across generations, on top of other structural reasons such as access to lower-quality public schools. Second, the fact that preferences play a large role in the trade-offs between culture and education is an important challenge for policy-makers. In this respect, an important policy objective is to conciliate formal education with cultural transmission for cultural minorities. There are many available options to advance this objective, such as public funding for denominational schools (accompanied by a proper amount of oversight on school curricula) and for cultural associations (which can take the burden of cultural transmission away from parents), or even revising the public school curriculum to make it more inclusive of pupils' diversity. My results suggest that such efforts could alleviate the educational gap between cultural minorities and majorities.

[4] Although I cannot rule out that parental preferences are in fact rooted in an economic value of children's religious affiliation, in the absence of further evidence it seems reasonable to interpret the results as religious transmission to children to matter *per se* to the parents. A reason for cultural affiliation to have an economic value could for instance be the existence of economic networks based on such affiliations; see Munshi (2011, 2019) on Indian caste-based networks. Starting with Iannaccone (1992), the economics of religion literature has also pointed out the 'club good' dimension of religion.

Contributions and related literature. By documenting how parents transmit their religion and human capital to their children in the context of contemporary France, this paper speaks to a recent literature that has explored investments in religious versus formal education in various settings and, more broadly, to the literature on the economics of religion (see Iannaccone 1998 and Iyer 2016 for reviews). For instance, Squicciarini (2020) shows that in 19th-century France, Catholic education competed with the secular curriculum in schools, ultimately hampering economic development in regions with higher religiosity. Chaudhary and Rubin (2011) and Saleh (2016) document a similar phenomenon for Muslims in colonial India and 20th-century Egypt, respectively. Carvalho, Koyama and Sacks (2017) and Carvalho, Koyama and Williams (2022) consider models in which cultural minorities protect their culture by resisting formal education, taking as illustration the 19th-century Jewish emancipation in Europe. Here, I contribute by exploring new reasons why parents may decide to invest in religion versus education, and by quantifying their effects.

As opposed to educational institutions, my paper focuses on how parents spend their time investing in religion versus education for their children, and in this respect it fits within the literature on time allocation theory and the human capital formation of children (Becker 1965, Cunha and Heckman 2007). Indeed, parental time investments have been shown to be important factors in children's human capital formation (Del Bono et al. 2016) and cultural capital formation (Botticini and Eckstein 2007, 2012, Patacchini and Zenou 2016). In particular, my model of cultural socialization takes inspiration from the technology of children's human capital formation in Del Boca, Flinn and Wiswall (2014, 2016). I use a collective household framework (Chiappori 1992) to model parental time investment decisions. In that respect, a paper close to mine is Chiappori, Salanié and Weiss (2017), which models trade-offs between time investments in children's human capital and time spent working in order to explain the evolution of the marital college premium. Here, I aim to explain heterogeneities in the patterns of religious and human capital transmission, and to that end I adapt this model to focus instead on time investments in children's religious versus human capital formation. For this purpose I consider religious capital as an intensive measure of religion[5] which is built by purposeful investments. This approach can be traced to Iannaccone (1990) who initially considered a human capital approach to religion.

Finally, this paper relates most directly to the literature on the economics of cultural transmission spurred by Bisin and Verdier (2000, 2001) and reviewed twice since then (Bisin and Verdier 2011, 2022). On the empirical side, it joins other works that use cross-sectional data on parental and children's cultural affiliations to recover values for the

[5]Rather than just religious affiliation, which is a discrete, extensive measure. The literature on cultural transmission has mostly focused on the latter for now, but see Cheung and Wu (2018) who consider a continuous trait and Patacchini and Zenou (2016) who consider discrete intensity (low or high religiosity) of the same trait. This focus on intensity has remained at the expense of a possible multiplicity of traits, however.

primitive parameters of cultural transmission models.[6] Close papers include Bisin, Topa and Verdier (2004), who also study the transmission of religious affiliation but using US data; Patacchini and Zenou (2016) who study parental religious socialization efforts as a function of the child's religious environment, also in the US; or Bisin and Tura (2020) who study language transmission among Italian migrants. Methodologically however, these papers rely mainly on aggregate moments (probability of transmission or of homogamous marriage) to estimate structural parameters. As far as I know, using discrete choice theory (McFadden 1973) to empirically explain children's choice of cultural affiliation, as I do in this paper, is a new contribution to this strand of literature. This methodological shift reflects the fact that I also depart from the usual Bisin and Verdier framework, which focuses on discrete cultural affiliations, for an approach that emphasizes cultural capital formation. Another recent effort to include a cultural capital approach in the theory of cultural transmission is Carvalho and McBride (2022). In their model, parental socialization investments contribute to determining the child's cultural type (extensive margin). Later, children can then build their cultural capital upon this type (intensive margin). This differs from my model, wherein parental investments directly contribute to the cultural capital, from which individuals derive their type. Furthermore, starting with Bisin and Verdier (2000) the cultural transmission literature has mostly considered costs to cultural socialization efforts in an abstract way. Here I contribute by considering a very concrete cost, namely, the time opportunity cost of socialization on investments in children's education. This allows me to measure the cost of religious transmission in terms of children's educational attainment, an economic outcome of primary concern. Finally, by using a collective household model to explain socialization decisions I depart from the standard unitary model used in the cultural transmission literature (an approach also taken recently by Bisin and Tura 2020). Most notably, this modelling choice lets me model the behavior of heterogamous households in a non-trivial way, and identify the separate contributions and characteristics of mothers and fathers in the transmission process – something which is not possible with the unitary model.

The paper is organized as follows. In section 2 I describe the data along several dimensions of interest: education, religion, and patterns of marriage and of intergenerational transmission. In section 3 I use reduced-form analysis to focus on empirical patterns of religious socialization. In section 4 I introduce the theoretical framework of cultural socialization in the household, in which parents must trade off investments in their child's culture versus formal education. In section 5 I describe my procedure for estimating this model, and present my results. Finally, section 6 concludes.

[6] In their review, Bisin and Verdier (2011) label these papers collectively as *structural socialization studies*.

2 Data

To investigate the relationship between culture and human capital in marriage and transmission to children, I use data from the Trajectories and Origins survey (*Trajectoires et Origines*, or TeO for short; see Beauchemin et al. 2016 for details). The TeO survey was conducted in metropolitan France in 2008. With over 21,000 respondents, it aimed to document the life experiences of migrants living in France and their descendants. Because of this specific aim, the TeO survey is particularly relevant for studying intergenerational transmission. First, it includes questions not only about the respondents, but also about their parents. This information is obviously critical to the study of intergenerational transmission. Second, it is one of the few large-scale surveys in France that collects answers on respondents' religious affiliation and practices. Indeed, collecting such information is generally prohibited by law in France (*loi informatique et libertés* of 1978) and requires a special derogation. For the purpose of this paper, it means that the TeO database is a rare opportunity to study religion as an example of cultural trait in France. Last, the TeO survey oversamples migrants and their descendants by design. In doing so, it provides a sizeable sample for several religious minorities in France, most notably Muslims, thus allowing me to draw comparisons across different religious groups.

Respondents were between 18 and 60 years old at the time of the survey (cohorts born between 1948 and 1990). The sample is slightly skewed toward women (52.8%). In the following, not only do I use data on the respondents themselves, I also rely extensively on the answers regarding their parents to study time trends, as well as marriage and transmission patterns. Respondents' parents were born as early as 1900, but I ignore pre-1920 parental cohorts on graphical representations (those have fewer than 100 observations per cohort). I provide more general statistics about the TeO survey in Table A1 (Appendix A). In the rest of this section, I describe the TeO data and some stylized facts regarding education and religion, in terms of both transmission and marriage patterns.

2.1 Education

In the TeO survey, educational attainment is reported through the International Standard Classification of Education (ISCED) 1997. From this variable, I construct three simplified educational attainment categories: (1) "Primary or less," for individuals who completed at most primary education; (2) "Secondary," for individuals who obtained a middle- or high-school diploma, or a technical diploma from an age-equivalent training program; (3) "Tertiary or more," for individuals who hold a postsecondary diploma. The proportions of these categories in the respondent sample are 8% (primary or less), 64% (secondary), and 28% (tertiary or more). Among the respondents' parents, these proportions are 57%, 31%, and 12%, respectively.

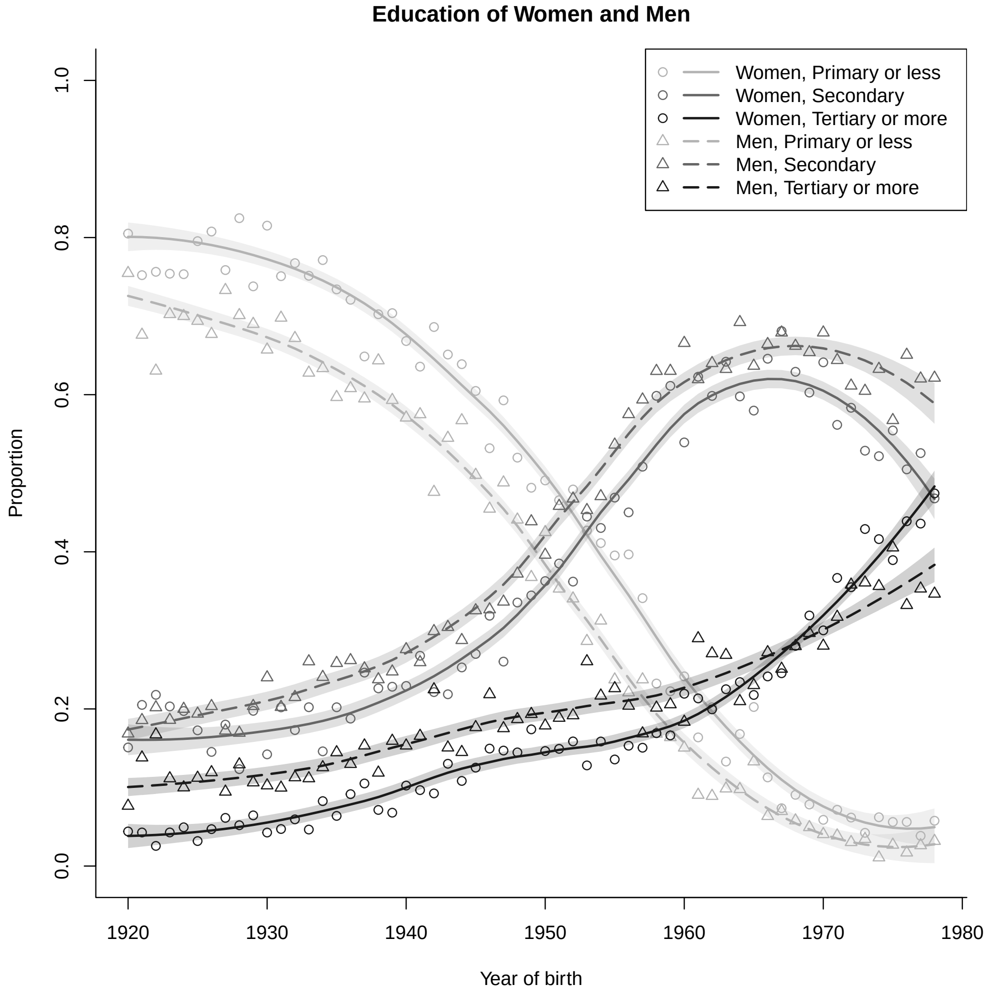

Figure 1: Education of women and men.

Educational attainment. Figure 1 shows the evolution of educational attainment by gender for the 1920–1978 cohorts, mixing data on respondents and their parents.[7] In this figure I omit the youngest cohorts, who may not yet have completed their education at the time of the survey. (I chose the 1978 cohort, who was 30 years old at the time of the survey, as the endpoint.) Educational attainment increases for both genders across the cohorts under study. Beginning approximately with the 1970 cohort, women overtake men in tertiary education.

[7] A note on graphical representations: the data can be quite noisy and the graphics difficult to interpret when observations are split across the three dimensions of cohorts, religion, and education. For this reason, graphical representations throughout the paper feature nonparametric predictions (LOESS) of different outcomes of interest on birth cohorts. This approach allows me to obtain smoothed curves that provide a better picture of the evolution of these outcomes across cohorts (see for instance Figure 1 on education in the sample). These curves are systematically accompanied by representations of the corresponding 95% confidence interval. On some graphs I represent the actual data with dots (such as in Figure 1), but when doing so would hamper readability I represent only the nonparametric predictions (such as in Figure 4).

Marital assortment. Although 72.5% of respondents declared that they had a partner, information on this partner was collected only when they lived in the same house (60.9% of respondents). Once again, I also use answers on the respondents' parents to draw a long-term picture of marital assortment in the sample, which I present in Figure 2. We can discern some time trends in educational homogamy. The proportion of couples with the same educational attainment is high overall. It decreases for the oldest cohorts, from 80% in 1920 to approximately 65% in 1950. This decrease might be simply a mechanical consequence of the increasing diversification of educational attainments for these cohorts (early cohorts mostly had only a primary education, so there could not be many mixed-education couples). After 1950, this proportion stagnates between 65% and 70%. The proportion of couples with a more educated husband increases slightly across the oldest cohorts, and then starts to decrease around the 1950 cohort to reach 15%. The proportion of couples with a more educated wife increases across all cohorts, from 5% to almost 20%, overtaking the proportion of couples with a more educated husband by the 1965 cohort.

Could these trends be driven by the simplification of the education variable into three categories? In Figure A1 I construct the same graph with the detailed diploma categories (8 levels, from no diploma to university graduate). While the proportion of couples with the same educational attainment mechanically falls when considering more education levels, the trends discussed above mostly hold. In particular, the proportion of couples with a more educated wife clearly increases over the cohorts considered, overtaking the proportion of couples with a more educated husband.

Finally, in Figure 3 I report detailed educational assortment patterns for three different cohorts, defined as those couples with a husband born in 1930, 1950, or 1970. (Figure A3 does the same for wives born in 1930, 1950, or 1970.) In accordance with the trends discussed above, we observe that more men marry "up" among younger cohorts (the number of educated women has increased more than the number of educated men). As Figure 2 already suggested, by the 1970 cohort marriage patterns are almost symmetric for men and women: approximately as many women marry up as men do.

In Appendix E I also study educational homogamy through local log-odds ratios, following Siow (2015). Statistical tests of the TP2 criterion (i.e. Total Positivity of order 2 for the local log-odds ratios) provide strong evidence of educational homogamy, both on the complete sample and conditional on spousal religious affiliations.

2.2 Religion

In the survey, religious affiliation is recorded via 13 possible answers. To simplify the analysis, and because some answers are associated with few observations, I aggregate them into five broad categories: No religion or "Nones" (29% of respondents), Christian (39%), Muslim (27%), Jewish (1%), and Other religion (4%).

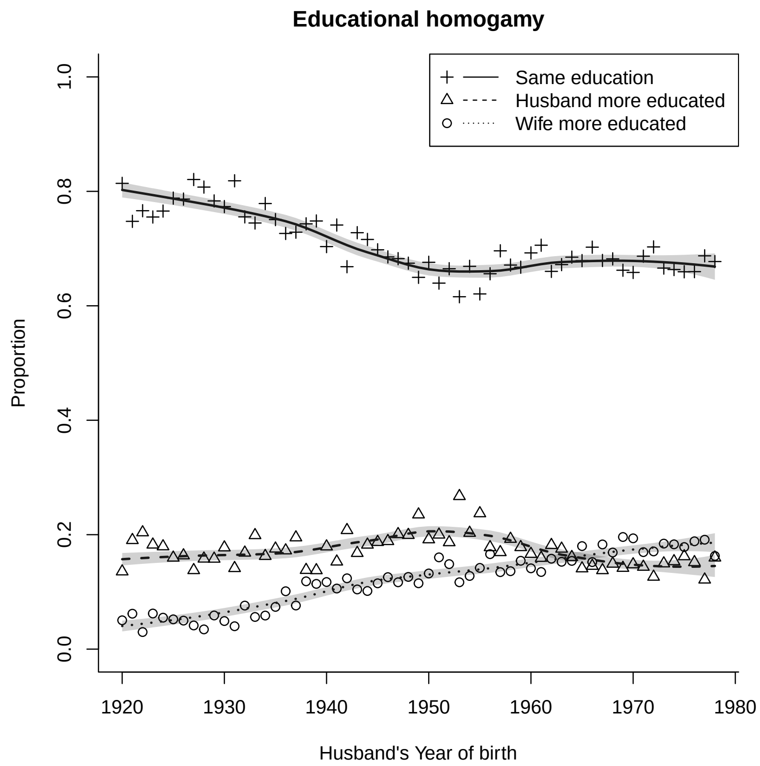

Figure 2: Educational homogamy.

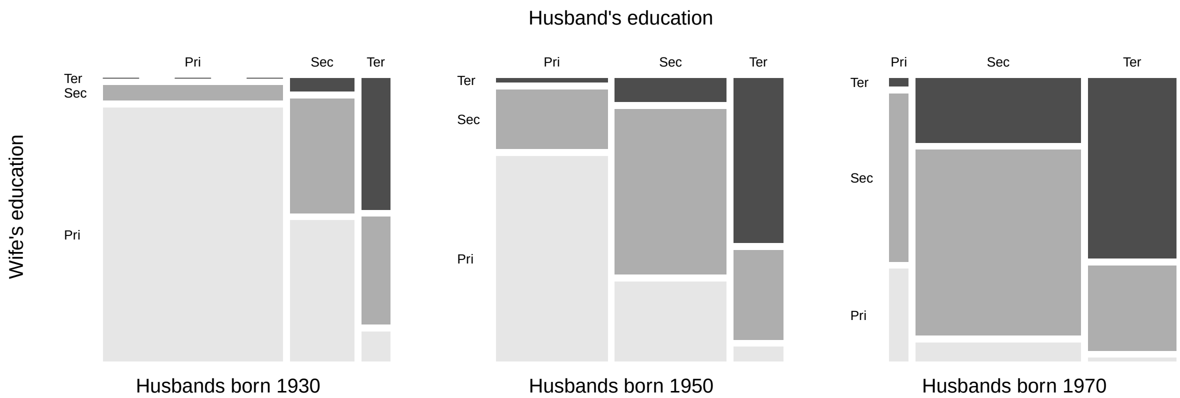

Figure 3: Educational assortment in couples with a husband born in 1930, 1950, and 1970.

Religious affiliation. Figure 4 presents religious affiliation across cohorts in the sample by gender (including parents). For both genders, younger cohorts show a higher representation of Muslims and Nones, and fewer Christians. The representation of Jews and other religious affiliations remains low and stable across cohorts. Interestingly, while Muslims, Jews, and Others are well balanced in terms of gender, there is an important asymmetry among Christians and Nones. Indeed, Christian women are more numerous than Christian men (48% of women vs. 43% of men are Christian). This difference is almost perfectly balanced by the excess of None men compared to None women (24% vs. 19%).

It is worth noting that religious affiliation in the sample is not especially representative

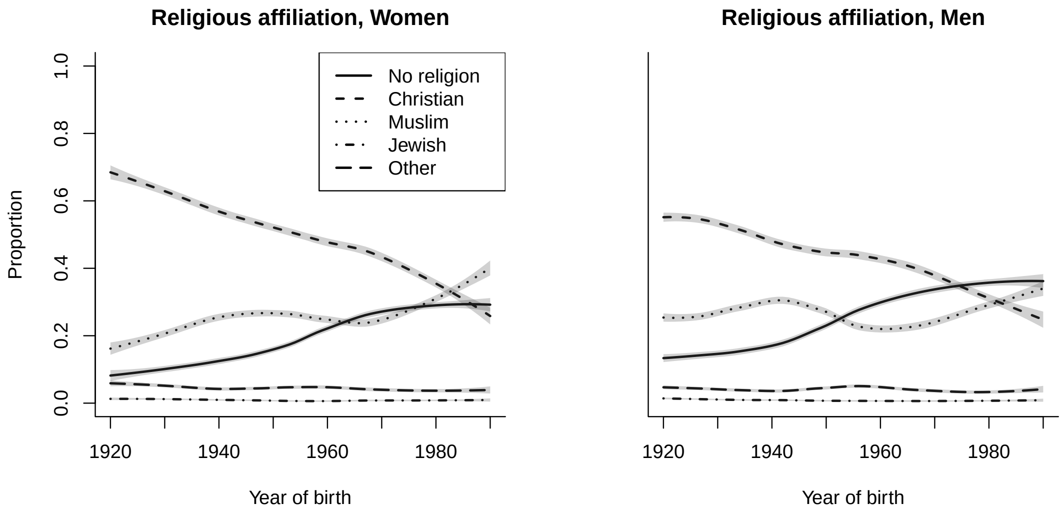

Figure 4: Religious affiliation, women and men.

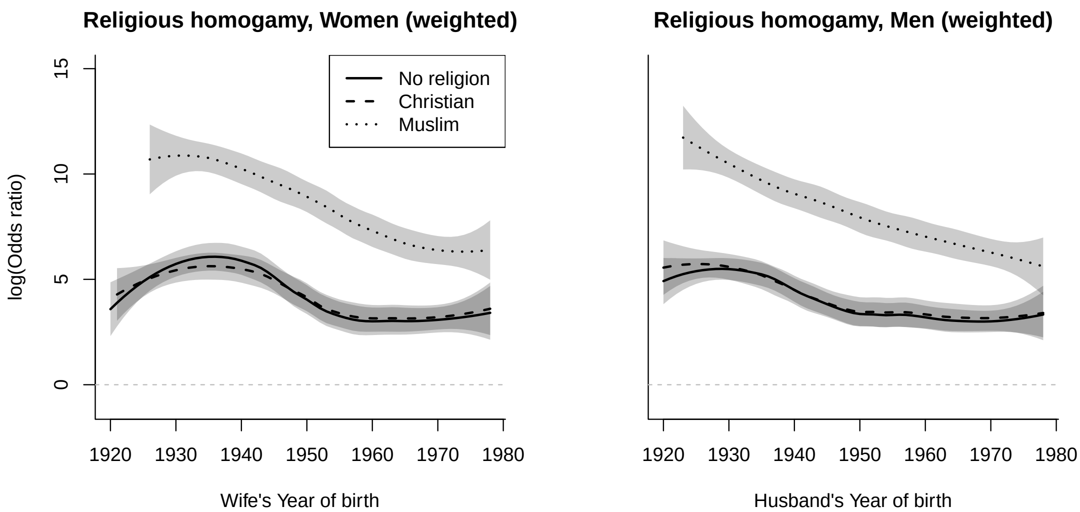

Figure 5: Religious homogamy (log-odds ratios), Women and Men.

of the French religious mix (for instance, 27% of respondents identified as Muslim, even though usual estimates for the share of Muslims in France hover between 5% and 10% for 2008). This bias is a natural consequence of the TeO survey oversampling individuals with a family history of immigration. Figure A5 reproduces the graphs of Figure 4 by using the sampling weights provided by the survey, providing a better (but still imperfect) picture of the share of each religious affiliation in France.

Marital assortment. A common way to measure partner assortativity along one dimension (here, religious affiliation) is to compute the log-odds ratios:

$$\ln \left(\frac{n_{aa}\, n_{\bar{a}\bar{a}}}{n_{a\bar{a}}\, n_{\bar{a}a}} \right),$$

where n_{aa} is the number of individuals from affiliation a with a partner a, $n_{a\bar{a}}$ that of individuals a with a partner non-a, and so on. Log-odds ratios are equal to 0 when couples are formed randomly,[8] while positive log-odds ratios are evidence of homogamy (positive assortative matching), and negative log-odds ratios are evidence of heterogamy (negative assortative matching).

Figure 5 presents these log-odds ratios for any birth cohort of husbands and wives, considering sampling weights. All computed log-odds ratios are positive for the cohorts considered, providing evidence of strong religious homogamy in the sample. Assortativity is stronger among Muslims than among Christians or Nones, although it decreases across cohorts: younger Muslims are less prone to religious homogamy than older Muslims. Christians and Nones exhibit similar and stable rates of homogamy from the 1950 cohort onward. (There is a decline in homogamy rates for these affiliations from approximately 1950, but this decline could be due to selection issues with the parents' generation in the sample.) I have omitted the log-odds ratios for Jewish and Other religions, since these affiliations have few observations per cohort, resulting in noisy patterns. It is however worth noting that despite this noise, both these affiliations exhibit high average assortativity rates that are closer to those for Muslims than for Christians or Nones. Figures A6 and A7 show assortativity patterns for the three cohorts born in 1930, 1950, and 1970, and provide further evidence of strong religious homogamy in the sample. Table A2 presents the 2×2 matrix of couples by religious affiliation.

Education by religious affiliation. Educational attainment is not distributed equally among religions, as shown in Figure 6. While religious Nones and Christians exhibit similar levels of educational attainment for the cohorts considered, Muslims have lower educational attainment throughout. Regarding the interaction between gender and religion, for the oldest cohorts (1920–1950) men are more educated across all religions. Beginning with approximately the 1950 cohort, this gender gap starts to close among Christians and Nones (a slight gender gap in favor of women even appears among Nones), while it persists until 1970 among Muslims. It is only for the very latest cohorts that a discernable gender gap appears in favor of women for all three religious affiliations.

[8] When couples are formed randomly, individuals a and non-a have the same odds of being matched with a partner a over a partner non-a, i.e.

$$\frac{n_{aa}}{n_{a\bar{a}}} = \frac{n_{\bar{a}a}}{n_{\bar{a}\bar{a}}}.$$

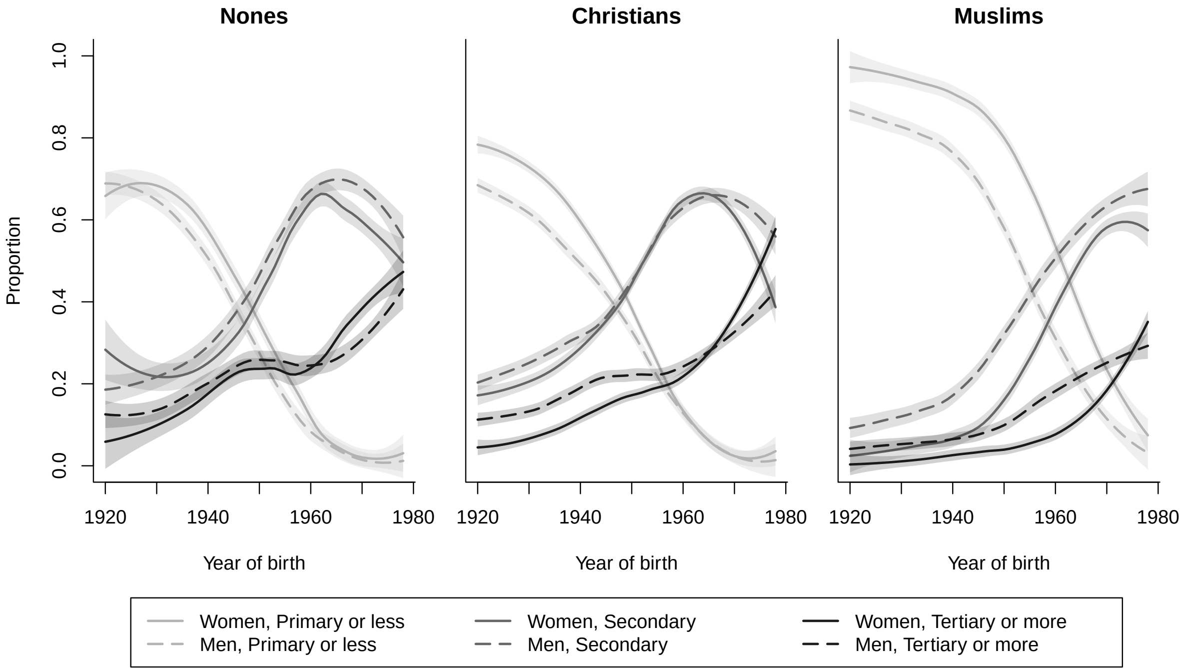

Figure 6: Education by religion and gender.

2.3 Marital assortment on education and religion

On education conditional on religion. Figure 7 presents the patterns of educational assortment for same-religion couples. Nones and Christians exhibit similar patterns of high educational assortment: partners have the same education level in approximately 70% of couples, although this rate decreases slightly over the cohorts considered. Muslims show a greater proportion of couples for which the husband is more educated, but this is expected as a mechanical consequence of the educational gap in favor of men in that population, as discussed above. Again, as in the case of Figure 2 for the complete sample, I verify that these results hold when considering more detailed diploma categories (see Figure A2).

On religion conditional on education. Figure 8 again shows log-odds ratios, but this time compares education levels to see how they might affect religious assortment. In the complete sample (first row of the graph), there appears to be a negative correlation between religious homogamy and educational attainment: religious homogamy is strongest among individuals with a "Primary or less" education, and weakest among individuals with a "Tertiary or more" education. This difference could however be due to a correlation between religious affiliation and educational attainment (we have seen for instance that Muslims in the sample are simultaneously less educated and more homogamous on average). To alleviate this concern, I examine how religious homogamy differs across education levels within religious affiliations (rows 2 to 4 of the graph). Importantly, the evidence becomes fragmentary when considering such interactions, because data become

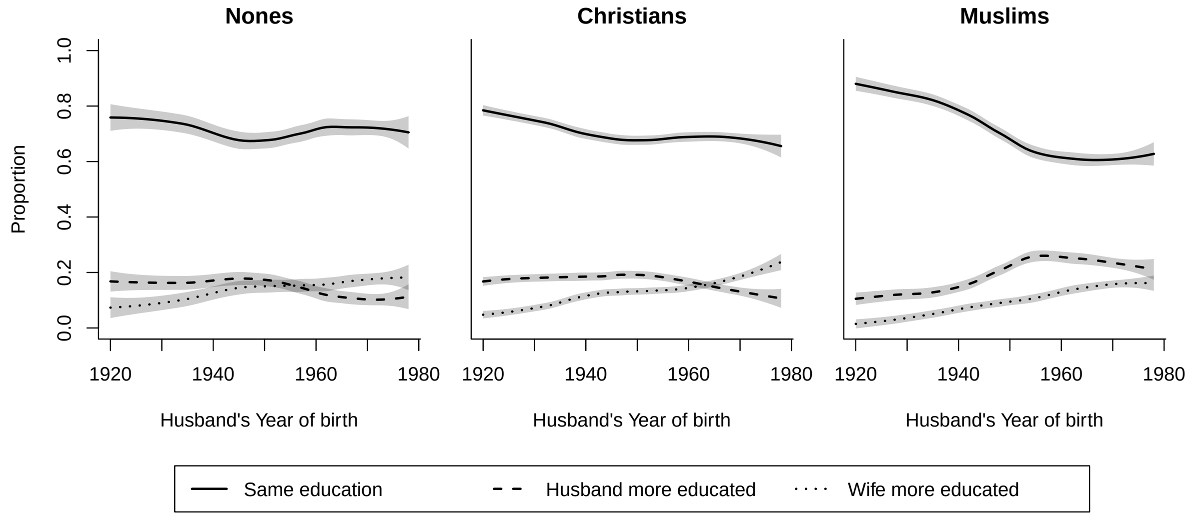

Figure 7: Educational homogamy, same-religion couples.

thinly spread across categories. However, the negative correlation between religious homogamy and educational attainment seems to hold within religious affiliations. It is most pronounced for Muslims, as well as for None women and Christian men, and especially for older cohorts. The correlation is less pronounced for Christian women and None men, who have overall lower levels of homogamy because of the asymmetry documented above (there are more Christian women than men, and more None men than women).

Table 1 confirms this negative correlation between religious homogamy and partners' education with a simple linear regression. According to the second specification, which includes religion fixed effects for both partners, an increase in the husband's or wife's educational attainment from Primary to Secondary is associated with a 3 p.p. decrease in the probability that he or she belongs to a homogamous couple. An increase from Secondary to Tertiary leads to a 1 p.p. decrease in the same probability.

2.4 Transmission of education

Education of the parents. Unsurprisingly, the children of higher-educated parents have higher education themselves, as seen in Figure 9. This finding is confirmed in Table 2 by an ordered logit regression with the child's education as the outcome, and the parents' educational attainment as the main explanatory variable. Corresponding specifications that use a linear model instead of an ordered logit model yield similar results (see Table A4).

Religion of the parents. To see whether religion plays a role in the transmission of education, in Figure 10 I plot the educational attainment of children as a function of both parental religion and parental education (focusing on parents who have the same religion and education). This approach shows that even if we hold the education of the

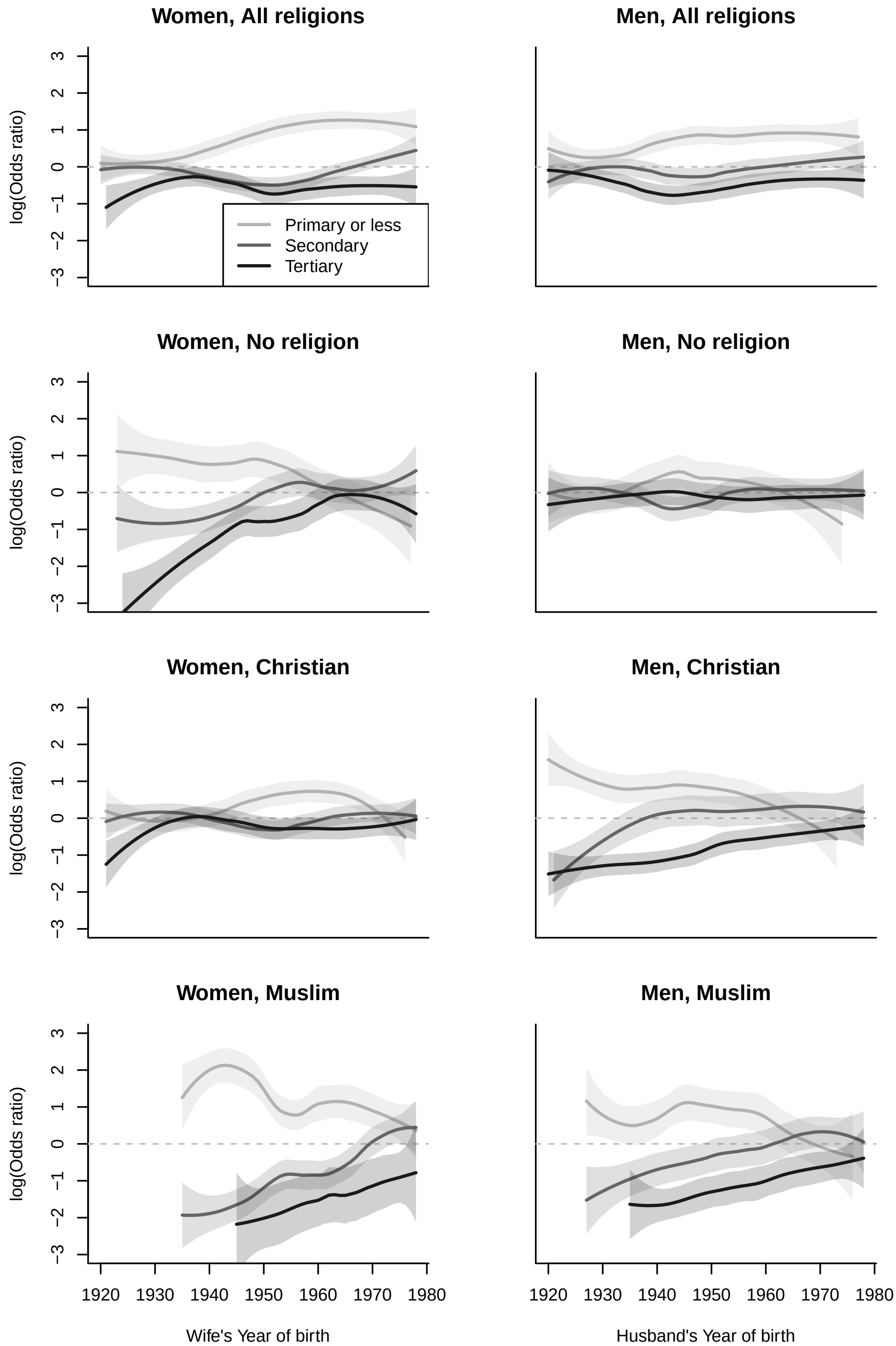

Figure 8: Religious homogamy of women and men, by Religion and Education. Here, log-odds ratios are computed within a religion category. For instance, in the "Women, Muslim" graph the "Primary or less" line is obtained by computing the odds of a Primary–Muslim woman being partnered with a Muslim man, divided by the odds of a Secondary– or Tertiary–Muslim woman being partnered with a Muslim man.

Table 1: Religious homogamy and education.

	Religious homogamy	
	(OLS)	(OLS)
Wife's education		
Secondary	−0.05*** (0.01)	−0.03*** (0.01)
Tertiary	−0.06*** (0.01)	−0.04*** (0.01)
Husband's education		
Secondary	−0.04*** (0.01)	−0.03*** (0.01)
Tertiary	−0.04*** (0.01)	−0.04*** (0.01)
Wife's religion		
Christian		−0.30*** (0.01)
Muslim		0.16*** (0.02)
Jewish		0.15*** (0.04)
Other		−0.38*** (0.03)
Husband's religion		
Christian		0.40*** (0.01)
Muslim		−0.06*** (0.02)
Jewish		−0.26*** (0.03)
Other		0.14*** (0.03)
Observations	31150	31150
Sampling weights	Yes	Yes
Adjusted R^2	0.01	0.17

Note: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Reference category for wife/husband education fixed effects is "Primary."
Reference category for wife/husband religion fixed effects is "No religion."

parents fixed, the children of Christian parents tend to be more educated on average, as do the children of Jewish parents (although that sample size is much smaller). In contrast, children of None parents and Muslim parents seem to have lower education.

To inquire further, I include parents' religion as an explanatory variable in the previous ordered logit regressions of Table 2. The religious affiliations of the parents do seem to play a role in the transmission of education. Compared to the "No religion" baseline, Christian and Other mothers, and Christian and Jewish fathers, are associated with higher-educated children. Conversely, Other fathers are associated with lower-educated children. Note that these results might be dependent on patterns of religious homogamy. For this reason, I add interactions between mothers' and fathers' religious affiliations as explanatory variables (due to the lack of space given the numerous interactions, I only report these results in the Appendix, Table A3). The estimates of Table 2 remain robust when these interactions are added, while the estimated coefficients for these interactions are generally not statistically significant. At this point, it is however impossible to say whether these potential differences in children's education across parental religious affiliations are driven by trade-offs between religious socialization and education, or (for instance) by different cultural preferences for children's education. The structural model

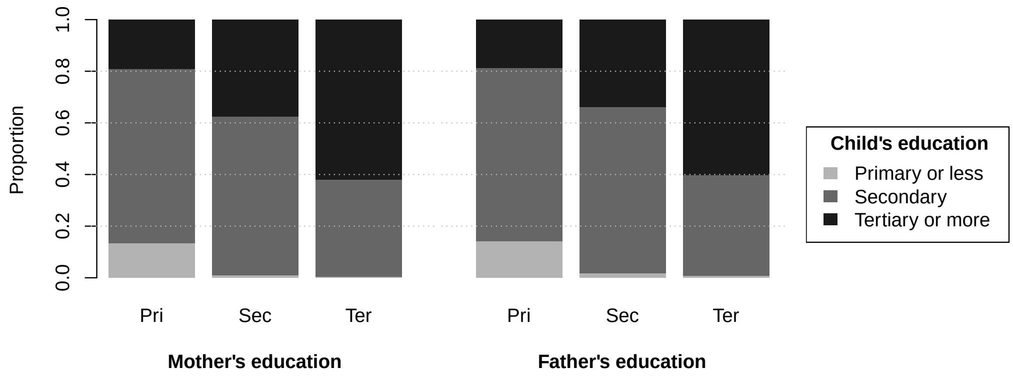

Figure 9: Transmission of education.

Table 2: Transmission of education (Ordered logit).

	Child's education		
	(Ord. logit)	(Ord. logit)	(Ord. logit)
Mother's education			
Secondary	0.64*** (0.02)	1.04*** (0.03)	0.97*** (0.03)
Tertiary	1.00*** (0.03)	2.60*** (0.10)	2.57*** (0.10)
Father's education			
Secondary	0.63*** (0.02)	0.99*** (0.03)	0.96*** (0.03)
Tertiary	1.56*** (0.03)	1.74*** (0.05)	1.72*** (0.05)
Mother's × Father's education			
Secondary × Secondary		−0.76*** (0.04)	−0.68*** (0.04)
Secondary × Tertiary		−0.40*** (0.06)	−0.36*** (0.07)
Tertiary × Secondary		−2.03*** (0.11)	−2.10*** (0.11)
Tertiary × Tertiary		−1.76*** (0.12)	−1.75*** (0.12)
Mother's religion			
Christian			0.25*** (0.02)
Muslim			0.03 (0.28)
Jewish			−0.02 (0.16)
Other			0.63*** (0.16)
Father's religion			
Christian			0.28*** (0.02)
Muslim			−0.11 (0.28)
Jewish			1.23*** (0.16)
Other			−0.74*** (0.21)
Child's year of birth /100	0.30*** (0.06)	0.40*** (0.06)	1.07*** (0.07)
Cut-off: Primary → Secondary	3.56 (1.24)	5.58 (1.25)	19.03 (1.28)
Cut-off: Secondary → Tertiary	7.70 (1.24)	9.76 (1.25)	23.25 (1.28)
Observations	18 793	18 793	18 222
Sampling weights	Yes	Yes	Yes
Deviance ($-2 \ln L$)	27 098	26 947	25 901

Note: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Reference category for mother/father education is "Primary."
Reference category for mother/father religion is "No religion."

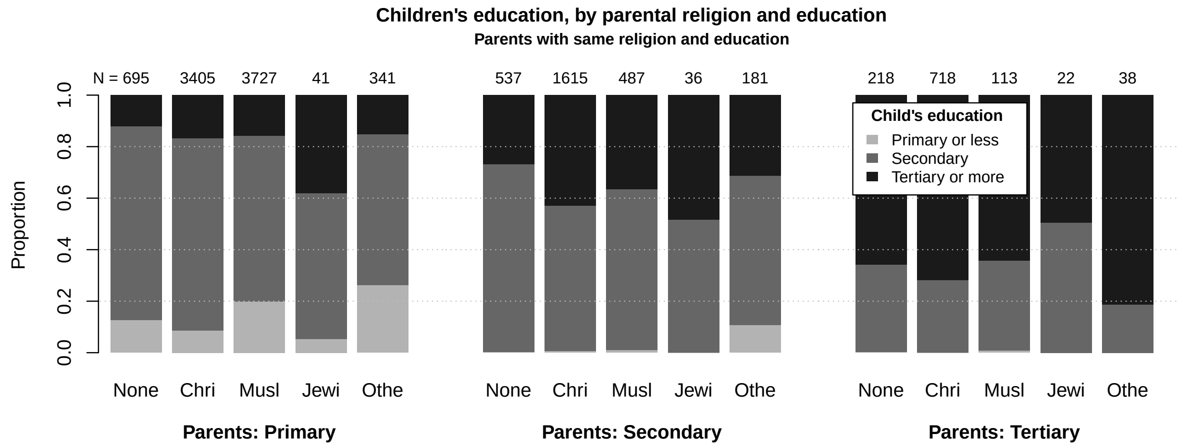

Figure 10: Transmission of education by parental characteristics.

will address this question in section 4.

2.5 Transmission of religion

Homogamous vs. heterogamous couples. It is well-documented that parents in homogamous couples (i.e. couples in which both parents have the same religious affiliation) pass on their religion more reliably than parents in heterogamous couples (see e.g. Bisin and Verdier 2000, p. 960). This stylized fact remains true for the TeO data, as suggested by Figure 11. The *transmission rate*, defined as the probability that a child will have the same religion as their parent, is more than 80% among homogamous couples, and increases slightly across cohorts. This increase could simply be due to the change in the religious mix of the sample, with more Nones, more Muslims, and fewer Christians among younger cohorts (cf. Figure 4). However, other explanations are possible: younger cohorts could transmit more accurately, or this increase could be the result of individuals switching affiliation during their lifetime, so that older individuals would be less likely to continue to share their parents' affiliation. In contrast, the transmission rate for mothers and fathers in heterogamous couples is approximately 40%, half that of homogamous couples.

Figures A10 and A11 also describe religious transmission patterns across parental religious affiliations, this time aggregating all cohorts. They provide evidence for a homogamy advantage in religious transmission, except for the None affiliation.

By religion. Figure 12 presents transmission rates of mothers and fathers of the three main religious affiliations. Muslim transmission rates are higher overall, which might in part be a consequence of stronger homogamy among Muslims. However, Muslim transmission rates have also increased across recent cohorts, despite decreasing Muslim homogamy rates (cf. Figure 5). There are at least two possible explanations for this increase. First, since the population share of Muslims has increased over the period, it is possible that oblique socialization has become a better vector of religious transmission for Muslims.

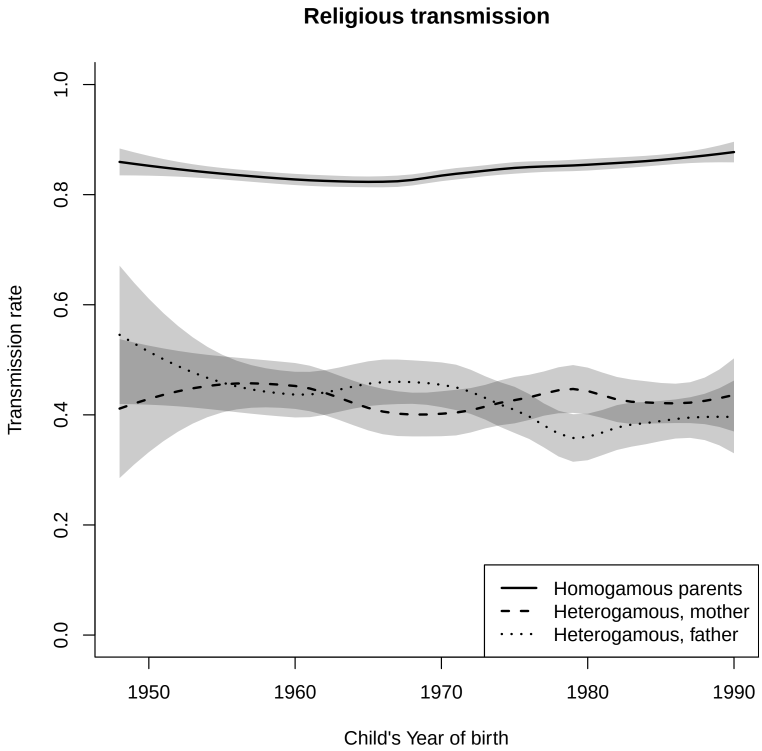

Figure 11: Religious transmission by parents in homogamous and heterogamous couples.

Second, as already discussed above, older individuals may be more likely to have switched affiliation from the one they inherited from their parents. The transmission rates of None parents follow a similar pattern, and are subject to the same interpretations.

In contrast, Christian transmission rates are decreasing, falling behind Muslim and None transmission rates beginning with the 1960 cohort. Two facts discussed above might contribute to this decrease: the population share of Christians is decreasing (cf. Figure 4), which may worsen oblique socialization, and homogamy rates among Christians are decreasing for the parental cohorts.

There are also comparisons to draw between mothers' and fathers' transmission rates. First, Christian mothers have lower transmission success than Christian fathers. A possible explanation for this difference is the asymmetry in the religious distribution of men and women. Indeed, since there is an excess of Christian women compared to Christian men, more Christian women end up partnered in heterogamous couples (most often, with None men), thus hurting their transmission rate. Conversely, None mothers have higher transmission success than None fathers, for the opposite reason: there is an excess of None men compared to None women. For Muslims, for whom there is less distributional gender asymmetry, there is no such stark difference between mothers' and fathers' transmission rates.

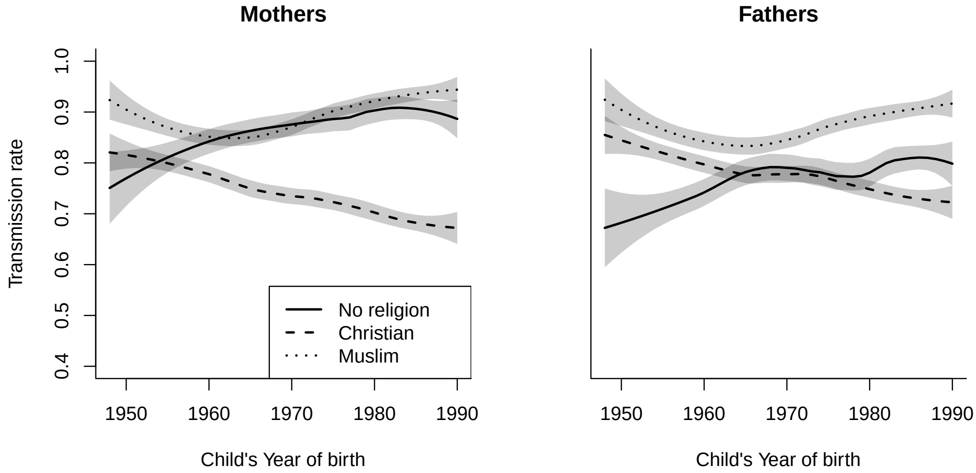

Figure 12: Religious transmission by mothers and fathers.

By educational attainment. Does the education of the parents matter in the transmission of religious affiliation? Figure 13 shows the transmission rates of mothers and fathers by educational attainment for all religious affiliations combined, and then separately for Nones, Christians, and Muslims. Despite the noise (data become thinly spread across the four dimensions considered: gender, birth cohort, religion, and education), the pattern that emerges is that parents with lower educational attainment have higher transmission rates. This finding is relatively clear when all religions are combined. When considering specific affiliations, the educational gap in the transmission rate is most pronounced for Muslims, and least pronounced for Nones. This result closely mirrors the pattern observed for homogamy rates and partner education (cf. Figure 8). For this reason, from Figure 13 it is unclear whether education affects transmission rates directly, or through its effect on religious homogamy. We can alleviate this concern by restricting attention to homogamous households only. In Figure 14, I present the transmission rates for mothers and fathers in homogamous households, excluding Nones. The pattern observed above persists: transmission rates are negatively correlated with parental education.

To clarify this finding I perform a simple linear regression and report the results in Table 3. Fathers' educational attainment is negatively correlated with the transmission rate (thus conforming to the pattern observed in Figure 13), consistent with the finding on homogamy: higher-educated fathers marry less homogamously, and thus can be expected to transmit religion less accurately. In contrast, mothers' educational attainment is positively correlated with the transmission rate. This positive correlation might seem puzzling: higher-educated mothers marry less homogamously and yet transmit religion more accurately. Note also that parents' education by itself has very little explanatory power for the transmission rates, as measured by the adjusted R^2.

A first step to disentangling the effect of education from the effect of religious homogamy, is to control for the religious composition of the parent couple. However, the

Table 3: Religious transmission and education of the parents.

	Transmission rate, Mother			Transmission rate, Father		
	(OLS)	(OLS)	(OLS)	(OLS)	(OLS)	(OLS)
Mother's education						
Secondary	0.00	0.00	0.00	0.00	0.00	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Tertiary	0.04***	0.04***	0.05***	0.02	0.04***	0.06***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Father's education						
Secondary	−0.03***	−0.02**	−0.01	−0.02***	−0.01**	−0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Tertiary	−0.07***	−0.05***	−0.05***	−0.06***	−0.05***	−0.04***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Child's year of birth /100			−0.13***			−0.11***
			(0.03)			(0.03)
Mo.'s × Fa.'s religion FE		✓	✓		✓	✓
Observations	18 343	18 115	18 115	18 175	18 115	18 115
Sampling weights	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.00	0.12	0.12	0.00	0.11	0.11

Note: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Reference category for mother/father education is "Primary."

correlations mentioned above persist even after adding these controls. According to the estimates from the last model specification (which also includes the child's year of birth as control), for instance, a father with a tertiary education is 4 p.p. less likely to pass on his religion than a father with primary education, while a mother with a tertiary education is 5 p.p. more likely to pass on hers than a mother with primary education.

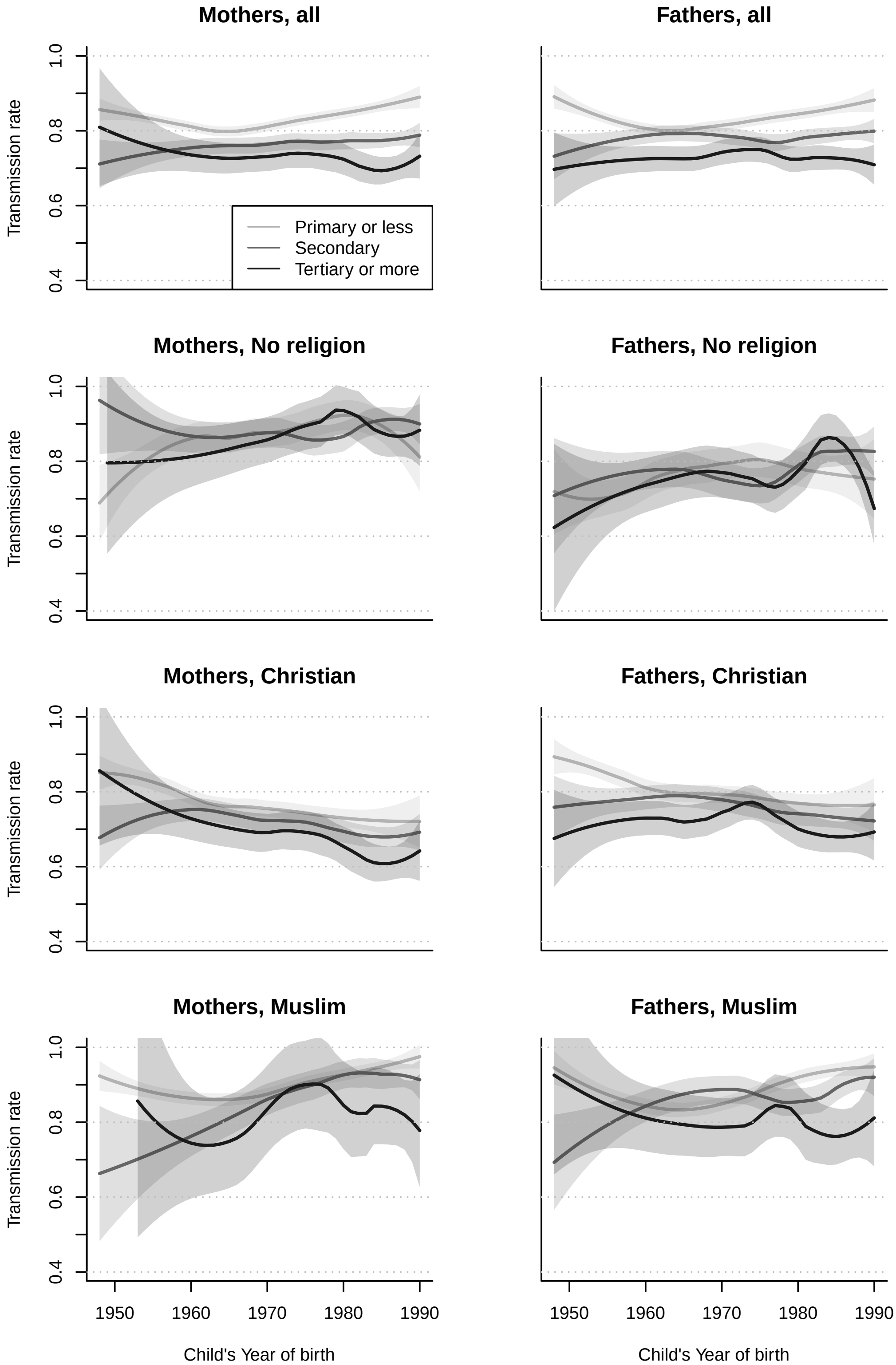

Figure 13: Religious transmission by mothers and fathers, by Education.

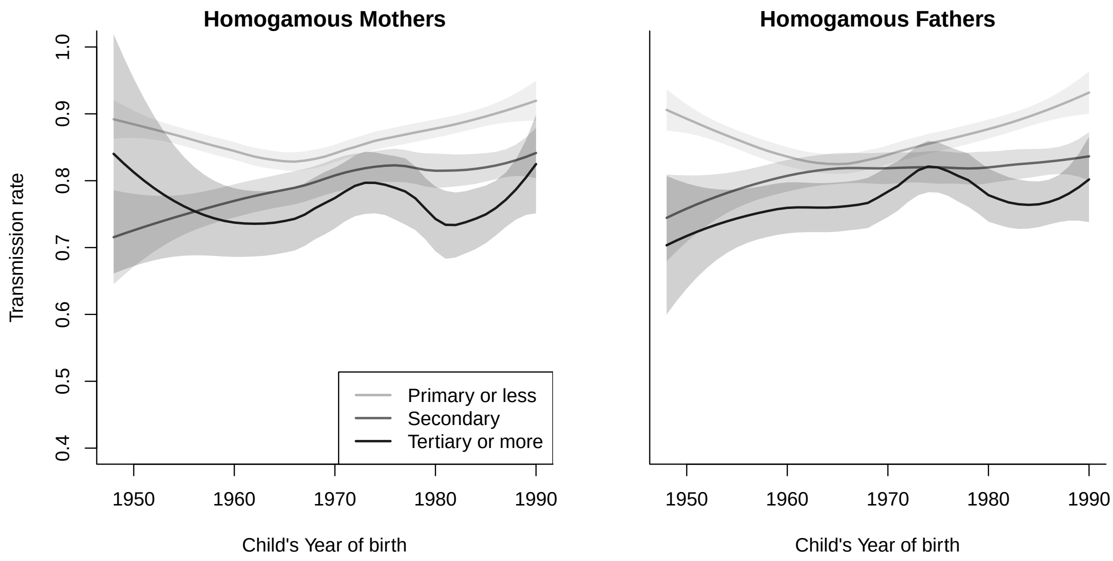

Figure 14: Religious transmission by homogamous mothers and fathers, by Education and excluding Nones.

3 Reduced-form analysis

The descriptive analysis of section 2 yielded several useful insights regarding the intergenerational transmission of religious affiliations. First, vertical transmission from parents to children is very strong, with approximately 87% of respondents in the sample sharing the religious affiliation of at least one parent (Figure 11). Second, there is strong heterogeneity in transmission patterns across parental religious affiliations and genders (Figure 12). Third, parental education seems to have a detrimental overall effect on religious transmission (Figure 13). However, it remains unclear to what extent these differences are driven by marriage patterns rather than by different contributions to socialization across affiliations and genders. For instance, Muslims transmit more on average than Christians or Nones (Figure 12), but they also marry more homogamously (Figure 5). In this case, is the higher transmission rate of Muslims driven by higher contributions to their children's religious socialization, or by higher homogamy? Can we quantify these contributions?

In this section I turn to a reduced-form model to analyze the transmission of religious affiliation in the TeO data. Religious affiliation is a discrete trait, and I choose a multinomial logit model to investigate its determinants (McFadden 1973). Following the theory of Bisin and Verdier (2000) and subsequent empirical work on cultural transmission,[9] I focus on two main predictors for the probability that an individual will report a given religious affiliation: the affiliations of her parents, and the shares of each religion in the population. This approach allows me to quantify the importance of parental contributions (vertical socialization) according to their gender, religious affiliation, and educational attainment; versus the role played by the environment (oblique socialization)

[9]See for instance Bisin and Topa (2003), Bisin, Topa and Verdier (2004), Patacchini and Zenou (2016), Bisin and Tura (2020).

in determining respondents' affiliations. Furthermore, controlling for parents' religious affiliations in the transmission process also allows to disentangle the effect of homogamy from that of heterogeneous parental contributions.

This section is organized into two parts. In section 3.1 I introduce and estimate the baseline econometric specification (a multinomial logit model). The results suggest that vertical socialization plays a more important role than oblique socialization in the transmission process. Furthermore, within vertical socialization, mothers contribute more than fathers, and religious minorities contribute more than religious majorities. Overall, I find that this reduced-form model is very efficient at predicting religious transmission patterns, thereby confirming that parents' religion is a very powerful predictor of the child's religion. In section 3.2 I refine the specification to focus on the role of parental education in the transmission process. My results suggest that effects are heterogeneous across religious affiliations, but the general trend indicates that parental contributions to religious socialization rather decrease with their education level.

3.1 Multi-logit transmission

Econometric model. Consider a sample of individuals indexed by i, each of whom ultimately chooses one religious affiliation among N available. The propensity for individual i to choose religious affiliation n is measured by a latent variable, which can be written as the product of two components: a component K_{in}, which depends on her observable characteristics, and a component ξ_{in}, which is random. Prefiguring the model of section 4.1, I call the observable component K_{in} the *religious capital* of individual i in religion n.

As is standard in discrete choice models, assume now that individual i ultimately chooses to report the affiliation associated with the largest value among all latent variables:

$$\arg\max_{n} \; K_{in} \times \xi_{in}.$$

If the ξ_{in} are i.i.d. Fréchet (that is, if their logarithms $\ln(\xi_{in})$ are i.i.d. Gumbel), then the probability that i will choose affiliation n is

$$\pi_{in} = \frac{K_{in}}{\sum_{\ell=1}^{N} K_{i\ell}} = \frac{\exp(\ln K_{in})}{\sum_{\ell=1}^{N} \exp(\ln K_{i\ell})}, \tag{1}$$

where the second expression makes explicit the link with the multilogit model by using the standard softmax function (generalization of the logistic function to multiple dimensions). Hence, log-religious capital $\ln(K_{in})$ plays a role equivalent to mean utility in the usual discrete choice with random utility framework.

To complete the multilogit model, I must select an econometric specification for the log-religious capital $\ln(K_{in})$ as a function of the observable individual characteristics. I consider a simple model in which the propensity for individual i to choose affiliation n depends on whether her parents have affiliation n and on the share of affiliation n in her environment. This choice can be understood as a broad interpretation of the Bisin and Verdier (2000) cultural transmission model, in which transmission is carried out by parents and by role models outside the family (vertical and oblique socialization). As a starting point, I suppose that parental contributions to religious socialization depend only on their gender and religious affiliation. Thus, mothers n (resp. fathers n) provide a fixed contribution m_n (resp. f_n) toward individuals' propensity to choose affiliation n.

To capture the influence of the environment, I use religions' population shares q_{in} as a proxy. Note that these population shares q_{in} are individual-specific, reflecting that different individuals may be socialized in different cultural environments. Ideally, one could exploit individual variation in two dimensions to explain these differences in oblique socialization. First, the individual's geographical location: the religious mix varies locally, leading to different patterns of oblique socialization. Second, the individual's date of birth: the religious environment has also evolved with time. Unfortunately, religions' population shares in France are comprehensively available neither at the local level nor across time. On locality, the available data is insufficient to obtain credible measures: this would require a dense, large-scale collection of individual religious affiliation in France (which is prohibited by law) or, for instance, a comprehensive survey of places of worship of all religions across the country. On time variation however, the TeO data is sufficiently dense to build a credible measure of religious shares in the country across the period of interest. In Appendix B.1, I explain how I reconstruct such a time series of religions' population shares in France: the idea is to consider the religious shares in the subsample of individuals (respondents and their parents) who were alive in a given year. These reconstructed population shares, from 1948 to 1990, are presented in Figure 15. In practice, for q_{in} I use the countrywide population shares corresponding to the year in which individual i turned 18 years old.

To summarize, I use the following econometric specification:

$$\ln K_{in} = k_n + m_n \,\mathbf{1}_{\{i\text{'s mother is } n\}} + f_n \,\mathbf{1}_{\{i\text{'s father is } n\}} + \alpha\, q_{in}. \tag{2}$$

In this expression, the parameters to estimate are k_n, m_n, f_n (for each religion n), and α. I have already mentioned that m_n and f_n correspond to the contributions to religious socialization by mothers n and fathers n respectively. In addition, α measures the importance of oblique socialization. Finally, the constant k_n captures religion-specific effects in the socialization process. In the abstract, k_n measures the probability of an individual reporting the religious affiliation n in the hypothetical scenario in which she would not have received any socialization, vertical or oblique. In practice, a higher k_n may reflect that the religious affiliation n demands little in terms of knowledge of its affiliates; or that it makes particular efforts to gain new affiliates (beyond the role played by its population share). For this reason, we can expect the "No religion" affiliation to have a high k_n because, by definition, it requires little if any active teaching. In contrast, we can expect

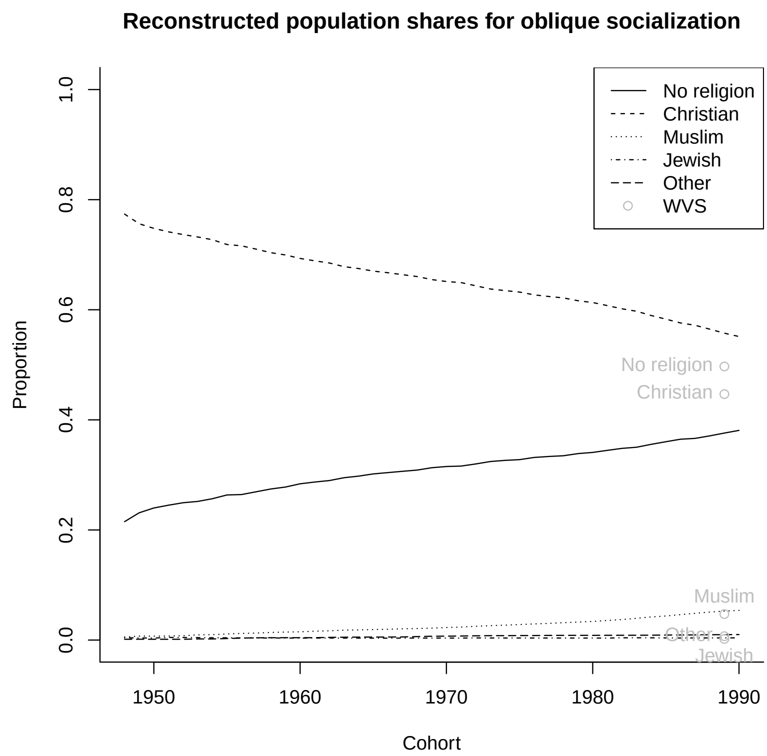

Figure 15: Religions' population shares, reconstructed from the TeO survey. Comparison points are taken from the World Values Survey (5th wave, 2005–2009).

the Jewish affiliation to have a low k_n, because it is mostly passed on vertically from the mother.

If we gather all these parameters into a vector $\boldsymbol{\beta}$ and define vectors of individual characteristics $\mathbf{z}_{in}$ appropriately, we can rewrite $\ln(K_{in})$ concisely as

$$\ln K_{in} = \mathbf{z}_{in} \cdot \boldsymbol{\beta}.$$

Thus, equations (1) and (2) together define a conditional logit model (McFadden 1973, Greene 2008). The conditional logit structure implies that all the parameters m_n and f_n are identified, unlike in the more standard multinomial logit where they are only determined up to a constant. This is because the model (2) imposes restrictions compared to a standard multinomial logit model. Specifically, in a multinomial logit model the variable $\mathbf{1}_{\{i\text{'s mother is } n\}}$ would be allowed to have an effect on any latent variable predictor $\ln(K_{i\ell})$; here this effect is assumed to be zero if $\ell \neq n$. The same can be said for the variables $\mathbf{1}_{\{i\text{'s father is } n\}}$ and q_{in}, which have no effect on $\ln(K_{i\ell})$ if $\ell \neq n$. In contrast, the parameters k_n are identified only up to an additive constant.

Testable restrictions. The model imposes restrictions on the transmission probabilities. These restrictions ultimately originate from the independence of irrelevant alternatives assumption inherent to the conditional logit model,

$$\ln\left(\frac{\pi_{in}}{\pi_{i\ell}}\right) = (\mathbf{z}_{in} - \mathbf{z}_{i\ell}) \cdot \boldsymbol{\beta} \qquad (\forall n, \ell). \tag{3}$$

Call $\pi_{in\,|\,yab}$ the probability that an individual i will acquire trait n conditional on belonging to the cohort y, and having a mother a and a father b. We can use the last expression to show (see Appendix B) that (3) implies

$$\ln\left(\frac{\pi_{ia\,|\,yaa}}{\pi_{ib\,|\,yaa}}\right) - \ln\left(\frac{\pi_{ia\,|\,yab}}{\pi_{ib\,|\,yab}}\right) - \ln\left(\frac{\pi_{ia\,|\,\tilde{y}ba}}{\pi_{ib\,|\,\tilde{y}ba}}\right) + \ln\left(\frac{\pi_{ia\,|\,\tilde{y}bb}}{\pi_{ib\,|\,\tilde{y}bb}}\right) = 0 \quad (\forall a, b, y, \tilde{y}). \tag{4}$$

The issue with formally testing this equality however, is that many of these cells (individuals born in year y with a mother a and a father b) have very few or even no observations. For this reason, as an approximation I ignore the role of cohorts y, $\tilde{y}$, and I test whether the equality

$$\ln\left(\frac{\pi_{ia\,|\,aa}}{\pi_{ib\,|\,aa}}\right) - \ln\left(\frac{\pi_{ia\,|\,ab}}{\pi_{ib\,|\,ab}}\right) - \ln\left(\frac{\pi_{ia\,|\,ba}}{\pi_{ib\,|\,ba}}\right) + \ln\left(\frac{\pi_{ia\,|\,bb}}{\pi_{ib\,|\,bb}}\right) = 0 \qquad (\forall a, b) \tag{5}$$

holds in the sample, where $\pi_{in\,|\,ab}$ is the probability that an individual i will acquire trait n conditional on having a mother a and a father b (but no longer conditional on the birth cohort y). This simplification relies on the assumption that the population shares q_{in} are not moving drastically over the period considered (see Figure 15). In total there are $N^2 = 25$ such tests to perform. Those for which $a = b$ are trivially verified. Those for which $b > a$ have a symmetric equivalent with $a > b$. This leaves 10 tests to perform. Estimators for $\pi_{in\,|\,ab}$ follow binomial distributions, which I use to construct 95% confidence intervals through simulation (parametric bootstrap; see Appendix B for details). Among these 10 tests, 5 tests cannot reject the null hypothesis that (5) holds (None–Christian, None–Jewish, None–Other, Christian–Muslim, Muslim–Other); 3 tests reject the null hypothesis (None–Muslim, Christian–Jewish, and Christian–Other); and the 2 other tests cannot be computed due to lack of observations. Overall, Bonferroni's method for global testing rejects (5), and the multiple testing procedure by Benjamini and Hochberg (1995) leads to the rejection of the same 3 hypotheses as the separate individual tests (see Appendix B).

We cannot rule out that this rejection stems from ignoring cohort effects (i.e. testing (5) instead of (4)) – in other words, that it arises ultimately from the sparseness of observations along the dimensions considered. Similarly, one would ideally want to test this hypothesis with population shares q_{in} that vary not only across time but also across locality. Nevertheless, rejection of the restriction (5) might also warrant the inclusion of other explanatory variables in the econometric specification (2). I tackle this issue below by adding an interaction term to the model (2), and by considering the effect of parental education on socialization contributions.

Estimation. We can now proceed with the estimation of the model defined by equations (1) and (2). Identification comes from the variation in the respondents' religious affiliation. The mothers' contributions to socialization m_n are identified through variation in the father's religion; the fathers' contributions f_n are identified symmetrically; and the oblique socialization coefficient α is identified through cohort variation in population shares. As in a multinomial logit, the intercepts k_n are only identified up to a constant: I choose the most common affiliation, Christian, as the baseline category. With $N = 5$ traits under consideration (None, Christian, Muslim, Jewish, and Other), this leaves a total of $3N - 1 + 1 = 15$ free parameters. I estimate $\boldsymbol{\beta}$ by maximum likelihood, where the log-likelihood is

$$\begin{aligned}\ln L &= \sum_i w_i \sum_{n=1}^{N} \mathbf{1}_{\{i \text{ is } n\}} \times \ln \pi_{in} \\ &= \sum_i w_i \left[\left(\sum_{n=1}^{N} \mathbf{1}_{\{i \text{ is } n\}} \ln K_{in} \right) - \ln \left(\sum_{\ell=1}^{N} K_{i\ell} \right) \right],\end{aligned} \tag{6}$$

where the w_i are probabilistic sampling weights provided in the TeO survey. For the covariance matrix I compute the BHHH estimator (Berndt, Hall, Hall and Hausman 1974), from which I obtain the standard errors reported throughout this section.

The results are presented in Table 4, column 1. First, consider the parental contributions m_n and f_n, measuring vertical socialization. These parental contributions are highest among minorities (Muslims and Jews, and to a lesser extent, Others), suggesting that the cultural substitution property proposed by Bisin and Verdier (2000) holds here. They are lower for Christians, and close to zero for Nones. Comparing maternal and paternal contributions within a given affiliation, we see that Jewish mothers make significantly higher contributions than Jewish fathers: this result is consistent with the fact that being Jewish is transmitted primarily through the mother. Mothers also contribute more than fathers among Nones and Others, although the difference is less striking. Finally, among Muslims and Christians, mothers and fathers contribute almost equally. Second, the magnitude of oblique socialization is comparable to but less than that of vertical socialization. The estimate for α implies, for instance, that a 50% population share induces an oblique socialization contribution equivalent to half the contribution of a Christian mother, or one-quarter of the contribution of a Jewish father. Third and last, the estimates for the intercepts k_n can be interpreted in light of the specificities of each affiliation. The intercept for None is the highest, reflecting the fact that while actual religions need to be taught, being nonreligious can simply result from the absence of any religious teaching. This characteristic makes the "No religion" trait special, as it can be acquired not only through active socialization (to secularism, atheism) but also through the lack of socialization in other religions. For this reason, it makes sense that transmission is biased by default toward the "No religion" trait. In the French context specifically, this bias could also account for the socialization influence of schools, which are mostly secular. The intercept for Jewish, in contrast, is significantly lower than the others, so that individuals are very unlikely to become Jewish unless they have a Jewish parent. This result is consistent with the fact that Judaism is not a proselytic religion and is mostly transmitted from parents to children. The intercepts for Muslim and Other are not significantly different from the Christian reference category, which suggests that no stark structural difference exists in the way these religions are transmitted.

Model fit. The specification (2) can be compared to the null model defined by an intercept only, $\ln(K_{in}) = k_n$, which has deviance 51 268. With an LR test statistic of $51\,268 - 20\,948 = 30\,320$ on 11 degrees of freedom (which is significant at any conventional confidence level), the model (2) explains the data significantly better than the null model. The associated pseudo-R^2 is 0.46, also indicating a good model fit.

Using the estimated parameters, I simulate transmission rates to see how well the model fits aggregate patterns in the data. Figure 16 presents observed vs. estimated transmission rates for the three main religious affiliations. Overall, the estimated rates very closely match the observed rates. Sharp turns in the observed transmission rate which are due to cohort variations in parental homogamy rates (e.g. in 1955 for Muslim fathers) are even well replicated by the simulations, thus suggesting that the model indeed manages to disentangle the effect of homogamy from that of parental contributions.

Complementarities. The baseline model (2) rules out complementarities between the affiliations of the parents. I address this by adding interaction effects to the model,

$$\begin{aligned}\ln K_{in} = k_n + m_n \mathbf{1}_{\{i\text{'s mother is } n\}} + f_n \mathbf{1}_{\{i\text{'s father is } n\}} \\ + b_n \mathbf{1}_{\{i\text{'s mother is } n\}} \times \mathbf{1}_{\{i\text{'s father is } n\}} + \alpha\, q_{in},\end{aligned} \tag{7}$$

so that b_n measures the additional effect of having both parents of religion n on the log-religious capital $\ln(K_{in})$.

The estimation results are presented in Table 4, column 2. Compared to the model without interaction effects, the likelihood ratio test statistic is $21\,937 - 20901 = 36$ on 5 degrees of freedom (p-value $\simeq 10^{-6}$), validating the inclusion of these interaction terms as relevant predictors. The interaction parameters are positive for Nones, Christians, and Jews; and negative for Muslims and Others. However, the most precise estimates are for Nones and Christians, pointing toward a complementarity of the parents' religious affiliations in their socialization contributions.

3.2 Religious socialization and parental education

To learn more about the potential effect of parents' education levels on the transmission of religion, I extend the previous model by allowing socialization contributions to differ

Table 4: Conditional logit transmission, estimates.

	Conditional logit estimates	
	model (2)	model (7)
Constant k_n		
None	2.86^{***} (0.08)	2.76^{***} (0.08)
Christian	0 (baseline)	0 (baseline)
Muslim	-1.32^{***} (0.08)	-1.58^{***} (0.09)
Jewish	-2.93^{***} (0.11)	-3.00^{***} (0.16)
Other	-0.66^{***} (0.08)	-0.79^{***} (0.09)
Mother's contribution m_n		
None	0.11 (0.08)	-0.61^{***} (0.13)
Christian	2.24^{***} (0.08)	1.92^{***} (0.10)
Muslim	3.80^{***} (0.21)	4.67^{***} (0.33)
Jewish	5.33^{***} (0.28)	5.17^{***} (0.32)
Other	3.90^{***} (0.13)	3.85^{***} (0.13)
Father's contribution f_n		
None	0.30^{***} (0.07)	0.05 (0.08)
Christian	1.30^{***} (0.07)	0.62^{***} (0.14)
Muslim	3.22^{***} (0.22)	3.66^{***} (0.32)
Jewish	3.45^{***} (0.43)	2.77^{**} (1.31)
Other	0.78^{***} (0.18)	1.51 (1.06)
Interaction contribution b_n		
None		1.10^{***} (0.16)
Christian		0.90^{***} (0.16)
Muslim		-1.20^{**} (0.47)
Jewish		0.93 (1.39)
Other		-0.68 (1.06)
Oblique socialization coefficient α	1.36^{***} (0.08)	1.37^{***} (0.08)
Observations	20 547	20 547
Sampling weights	Yes	Yes
Deviance ($-2\ln L$)	21 937	21 901
Pseudo-R^2	0.46	0.46
LR test p-value	baseline	0.000

Note: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

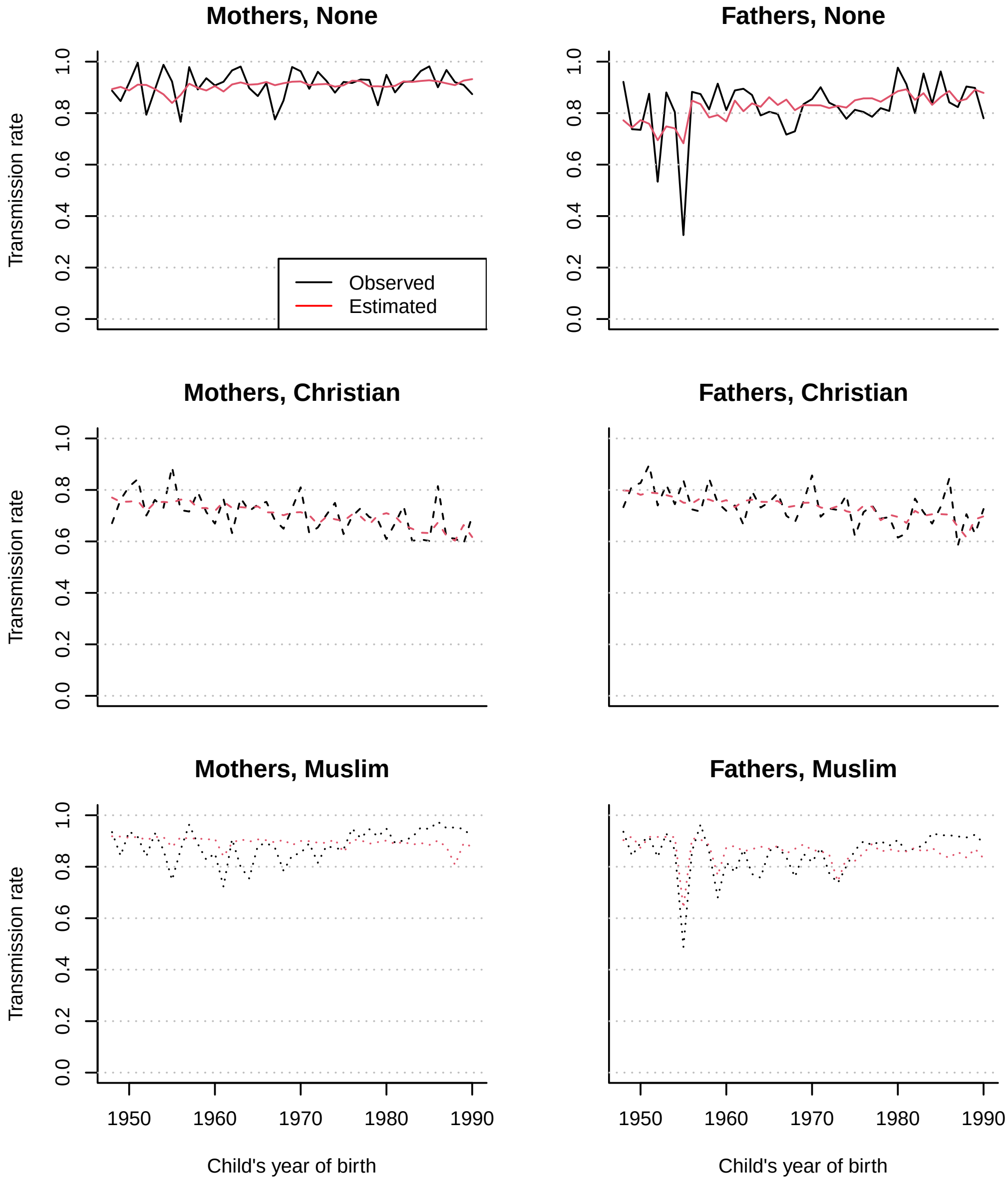

Figure 16: Conditional logit transmission, observed vs. estimated transmission rates (by Religion).

across education levels. Suppose that contributions to socialization now depend not only on the parent's religion n but also on their education level $e \in \{1, \ldots, E\}$. Mothers' contributions are thus denoted m_{ne} and fathers' f_{ne}, with ne the bidimensional trait {religion, education} of the parent. The religious capital of i in trait n is now predicted by the following equation:

$$\ln K_{in} = k_n + \sum_e (m_{ne} \mathbf{1}_{\{i\text{'s mother is } ne\}} + f_{ne} \mathbf{1}_{\{i\text{'s father is } ne\}}) + \alpha \, q_{in}. \tag{8}$$

The requirement that parents' educational attainments be known in addition to their religious affiliation leads to some sample attrition, down to 18 155 observations from 20 547 previously. As a baseline, I re-estimate the specification (2) on this subsample (Table 5, column 1). The estimates do not vary significantly from those obtained when using the full sample.

Primary vs. Secondary vs. Tertiary. The estimation procedure for the model with education effects remains the same, except that we now have $N + 2NE = 35$ free parameters to estimate. First, I consider the three education levels that I used in section 2: Primary or less, Secondary, and Tertiary or more. The results are presented in Table 5, column 2. The likelihood ratio test statistic is $19\,198 - 19\,139 = 59$ on 20 degrees of freedom for a p-value smaller than 10^{-5}, providing evidence that the parents' education levels matter in predicting transmission rates. Regarding the estimates, there is no clear pattern for the relationship between education and socialization contributions. The estimated parameters remain qualitatively close to those estimated in the model without educational effects.

Primary vs. Secondary. I attempt to estimate the effect of education more precisely by reducing the number of educational categories to two: Primary or less ($e = 1$), and Secondary or more ($e = 2$). The results are presented in Table 5, column 3. The likelihood ratio test statistic is $19\,198 - 19\,174 = 24$ on 10 degrees of freedom, for a p-value of 0.007. Once again, estimated contributions are qualitatively close to their level in the absence of education effects.

With only two education levels, it is also easier to verify whether human capital has a discernable effect on socialization contributions. To do so, I test the two hypotheses $m_{n1} = m_{n2}$ and $f_{n1} = f_{n2}$ for every religion n. I recover the distributions of $\hat{m}_{n1} - \hat{m}_{n2}$ and $\hat{f}_{n1} - \hat{f}_{n2}$ by the delta method, which I use to construct 95% confidence intervals for $m_{n1} - m_{n2}$ and $f_{n1} - f_{n2}$ (Figure 17, left panel). Differences between the socialization contributions of Primary or less parents and Secondary or more parents are not statistically significant at the 5% level, except for Other parents. This result is consistent with the estimates from the linear model of Table 3 in the descriptives, which showed that a Secondary education had little to no significant effect on transmission rates for either mothers or fathers.

Table 5: Conditional logit transmission with education effects, Estimates.

		model (2)	model (8) $E = \{1, 2, 3\}$	model (8) $E = \{1, 2 \text{ or } 3\}$	model (8) $E = \{1 \text{ or } 2, 3\}$
Constant k_n					
None		2.82 (0.09)	2.80 (0.14)	2.76 (0.14)	2.83 (0.13)
Christian		0.00 (base)	0.00 (base)	0.00 (base)	0.00 (base)
Muslim		–1.37 (0.09)	–1.42 (0.21)	–1.48 (0.21)	–1.35 (0.20)
Jewish		–2.72 (0.12)	–2.83 (0.47)	–2.85 (0.44)	–2.76 (0.46)
Other		–0.72 (0.09)	–0.76 (0.22)	–0.83 (0.22)	–0.70 (0.21)
Mother's contributions m_{ne}					
None		0.07 (0.09)			
	Primary or less		–0.09 (0.13)	–0.11 (0.13)	
	Secondary (or more / or less)		0.16 (0.14)	0.22 (0.12)	0.03 (0.11)
	Tertiary or more		0.36 (0.19)		0.35 (0.19)
Christian		2.26 (0.09)			
	Primary or less		2.21 (0.11)	2.23 (0.11)	
	Secondary (or more / or less)		2.23 (0.11)	2.27 (0.11)	2.22 (0.10)
	Tertiary or more		2.52 (0.12)		2.52 (0.12)
Muslim		3.82 (0.23)			
	Primary or less		3.80 (0.13)	3.79 (0.13)	
	Secondary (or more / or less)		4.26 (0.16)	3.98 (0.15)	3.90 (0.12)
	Tertiary or more		2.74 (0.28)		2.83 (0.28)
Jewish		5.79 (0.32)			
	Primary or less		4.71 (0.78)	4.66 (0.79)	
	Secondary (or more / or less)		5.58 (0.64)	6.06 (0.49)	5.26 (0.55)
	Tertiary or more		6.53 (0.80)		6.52 (0.79)
Other		3.76 (0.16)			
	Primary or less		3.97 (0.18)	3.97 (0.18)	
	Secondary (or more / or less)		3.21 (0.20)	3.23 (0.19)	3.78 (0.17)
	Tertiary or more		3.27 (0.28)		3.45 (0.28)
Father's contributions f_{ne}					
None		0.39 (0.07)			
	Primary or less		0.41 (0.11)	0.41 (0.11)	
	Secondary (or more / or less)		0.34 (0.11)	0.38 (0.10)	0.37 (0.10)
	Tertiary or more		0.59 (0.14)		0.60 (0.14)
Christian		1.24 (0.07)			
	Primary or less		1.32 (0.10)	1.31 (0.10)	
	Secondary (or more / or less)		1.23 (0.10)	1.18 (0.09)	1.28 (0.09)
	Tertiary or more		1.00 (0.11)		1.01 (0.11)
Muslim		3.28 (0.23)			
	Primary or less		3.19 (0.14)	3.20 (0.14)	
	Secondary (or more / or less)		3.54 (0.16)	3.48 (0.15)	3.22 (0.14)
	Tertiary or more		3.70 (0.21)		3.69 (0.21)
Jewish		3.04 (0.48)			
	Primary or less		3.34 (0.78)	3.24 (0.80)	
	Secondary (or more / or less)		2.86 (0.72)	3.39 (0.51)	3.06 (0.52)
	Tertiary or more		5.65 (0.79)		5.65 (0.79)
Other		1.13 (0.23)			
	Primary or less		0.86 (0.19)	0.86 (0.19)	
	Secondary (or more / or less)		1.20 (0.19)	1.53 (0.17)	1.09 (0.17)
	Tertiary or more		1.60 (0.21)		1.34 (0.21)
Oblique socialization coefficient α		1.41 (0.08)	1.37 (0.28)	1.25 (0.28)	1.46 (0.27)
Observations		18 155	18 155	18 155	18 155
Sampling weights		Yes	Yes	Yes	Yes
Deviance ($-2 \ln L$)		19 198	19 139	19 174	19 158
Pseudo-R^2		0.47	0.47	0.47	0.47
LR test p-value		baseline	0.000	0.007	0.000

Note: Standard errors in parentheses.

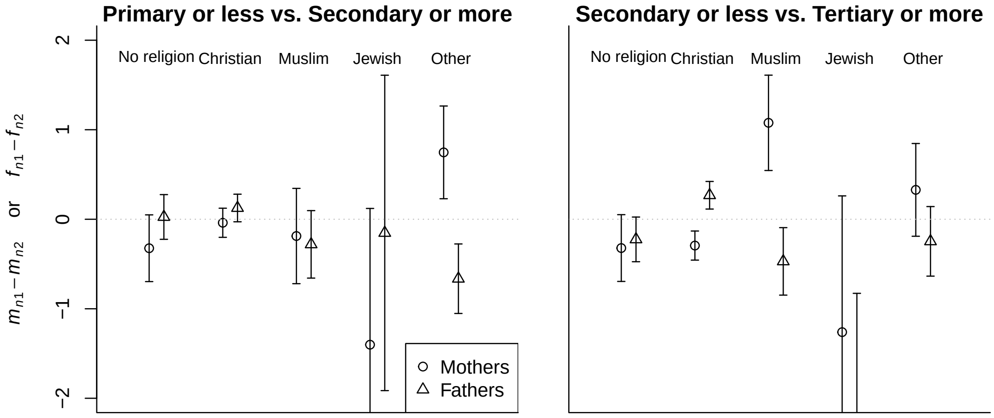

Figure 17: Differences in socialization contributions across education levels. 95% confidence intervals for $m_{n1} - m_{n2}$ and $f_{n1} - f_{n2}$ are reported for each religion n. Left panel: Primary or less ($e = 1$) vs. Secondary or more ($e = 2$). Right panel: Secondary or less ($e = 1$) vs. Tertiary or more ($e = 2$).

Furthermore, note that among Others education has opposite effects on socialization contributions for mothers and fathers.

Secondary vs. Tertiary. Finally, I replicate this exercise with the following two education levels: Secondary or less, and Tertiary or more (Table 5, column 4). The likelihood ratio test statistic is $19\,198 - 19\,158 = 40$ on 10 degrees of freedom, for a p-value close to 10^{-5}. Again, I test whether education has a significant effect on socialization contributions for mothers and fathers of all religions (Figure 17, right panel). However, the effect of education remains heterogeneous across mothers and fathers, and across religions.

It is difficult to say whether these differences across religions are structural or if they are the result of a model misspecification. The education of the parents could impact their opportunity cost of socializing their child. It could also shift the power balance in the couple, or be associated with different preferences for religious socialization. The estimation of the structural model in section 5 will allow me to shed some light on the possible mechanisms at play.

3.3 Alternative model for the influence of education

Suppose instead that education has a uniform multiplicative effect on contributions across religious affiliations, so that

$$\begin{aligned}\ln K_{in} = k_n &+ \left(1 + \kappa_1 \mathbf{1}_{\{i\text{'s mother has } e \geq 2\}} + \kappa_2 \mathbf{1}_{\{i\text{'s mother has } e \geq 3\}}\right) \times m_n \mathbf{1}_{\{i\text{'s mother is } n\}} \\ &+ \left(1 + \rho_1 \mathbf{1}_{\{i\text{'s father has } e \geq 2\}} + \rho_2 \mathbf{1}_{\{i\text{'s father has } e \geq 3\}}\right) \times f_n \mathbf{1}_{\{i\text{'s father is } n\}} + \alpha\, q_{in}. \quad (9)\end{aligned}$$

This model is still linear in the observables, but it imposes more structure than the previous model from section 3.2. Indeed, here I impose $m_{n2} = (1 + \kappa_1) m_{n1}$ and $m_{n3} =$

$(1+\kappa_1+\kappa_2)m_{n1}$ for all religions n, where the parameters κ_1 and κ_2 do not depend on n (and similarly for the f_{ne} with ρ_1 and ρ_2). The goal is to observe the effects of education by measuring κ_1, κ_2, ρ_1, and ρ_2. Negative values, for instance, would provide evidence of lower average contributions for higher-educated parents.

The results are presented in Table 6. In the first column I re-estimate the baseline model on the subsample of individuals for whom the educational attainment of both parents is available. The estimates remain comparable to those from the full sample estimation. In the second column, I estimate the new model with multiplicative education effects. The estimates for κ_1, κ_2, ρ_1, and ρ_2 suggest that education has opposite effects on contributions to socialization across genders: positive for mothers and negative for fathers. For mothers, more education is associated with higher contributions: mothers with a Tertiary education or more make contributions that are 10% higher than mothers who have a Primary education or less. For fathers it is the opposite: a Tertiary education is associated with contributions that are 13% lower. The effect of having a Secondary education goes in the same direction (1% higher contributions for mothers, 2% lower for fathers) but is not statistically significant. The LR test value is 10 on 4 degrees of freedom (p-value $= 0.033$), so the added parameters provide significant explanatory power to the model.

Table 6: Conditional logit transmission with education effects, estimates.

	Conditional logit estimates	
	(2)	(9)
Constant k_n		
None	2.82^{***} (0.09)	2.87^{***} (0.09)
Christian	0 (baseline)	0 (baseline)
Muslim	-1.37^{***} (0.09)	-1.32^{***} (0.10)
Jewish	-2.72^{***} (0.12)	-2.70^{***} (0.12)
Other	-0.72^{***} (0.09)	-0.67^{***} (0.10)
Mother's contribution m_n		
None	0.07 (0.09)	0.14 (0.09)
Christian	2.26^{***} (0.09)	2.15^{***} (0.09)
Muslim	3.82^{***} (0.23)	3.75^{***} (0.23)
Jewish	5.79^{***} (0.32)	5.60^{***} (0.31)
Other	3.76^{***} (0.16)	3.70^{***} (0.16)
Father's contribution f_n		
None	0.39^{***} (0.07)	0.30^{***} (0.07)
Christian	1.24^{***} (0.07)	1.37^{***} (0.07)
Muslim	3.28^{***} (0.23)	3.38^{***} (0.24)
Jewish	3.04^{***} (0.48)	3.17^{***} (0.49)
Other	1.13^{***} (0.23)	1.20^{***} (0.23)
Multiplicative education effets		
Secondary or more mother κ_1		0.01 (0.01)
Tertiary or more mother κ_2		0.09^{***} (0.02)
Secondary or more father ρ_1		-0.02 (0.02)
Tertiary or more father ρ_2		-0.11^{***} (0.02)
Oblique socialization coefficient α	1.41^{***} (0.08)	1.48^{***} (0.09)
Observations	18 115	18 115
Sampling weights	Yes	Yes
Deviance ($-2 \ln L$)	19 198	19 188
Pseudo-R^2	0.47	0.47
LR test p-value	baseline	0.033

Note: Standard errors in parentheses. $^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

4 Structural model

Section 3 mostly confirmed the patterns documented by the descriptive analysis of section 2: mothers contribute more to the religious socialization of their children than fathers, religious minorities contribute more than majorities, and parents' education levels are relevant predictors of their contributions to religious socialization. This section also provided a first quantified measure of these various heterogeneities in the transmission process. Because, in the data, mothers are less educated than fathers and religious minorities less than majorities, it is tempting to use an economic argument involving education to explain these differences in socialization patterns. The estimates from the reduced-form analysis are indeed broadly consistent with an economic explanation, namely, that higher-educated individuals have a higher opportunity cost of socializing their children and, therefore, they socialize them less. In particular, in light of the possible substitution between culture and education discussed in the introduction, we can wonder whether higher-educated parents reallocate resources from cultural socialization toward formal education because they have a comparative advantage in the latter.

To investigate this potential mechanism, in this section I construct a model of intergenerational cultural socialization and human capital formation. First, I focus on modeling the technology available to parents for the cultural socialization of their child. Similar to Iannaccone (1990) in the case of religion, I take a human capital approach to culture, introducing the notion of *cultural capital* as an intensive and multidimensional measure of culture for individuals.[10] This approach considers that culture is not simply a static affiliation but a gradually built ensemble of knowledge and practices in which individuals can invest. Here, I specifically consider the role of parental time investments in building children's cultural capital: this is the socialization process.

Second, I embed this model of socialization within a collective household framework in which parents care about passing on both human capital and cultural capital to their child. To do so, they can allocate their time between two activities: human capital production, and cultural socialization. The goal of the model is to describe a simple trade-off between these two activities. Crucially, the human capital of the parents is assumed to be productive in the human capital formation of the child but not in cultural socialization. Thus by construction, parents with higher human capital have a comparative advantage in human capital formation relative to cultural socialization. Given this advantage, an increase in the parents' human capital will lead to a reallocation of time in favor of the child's human capital formation and at the expense of her cultural socialization. This mechanism also interacts with one of the main ideas developed by Bisin and Verdier (2000) on cultural transmission: cultural minorities must make more effort to transmit their culture than majorities because majorities can rely on the public provision of cultural

[10]This terminology has of course a long tradition in sociology (Bourdieu 1979), which was itself influenced by the work of Gary Becker.

socialization, or *oblique socialization*. In my framework, such effort happens at the expense of human capital formation, thus creating an imbalance between minorities and majorities: all else equal, minorities devote less time to their child's human capital formation than majorities.

This section is divided into three parts. In section 4.1, I present a time allocation theory of cultural socialization. In section 4.2, I describe the household's decision framework. Finally, in section 4.3, I solve the model and provide a short analysis of the trade-offs involved.

4.1 A time allocation theory of socialization

To model socialization within the household, I start with the technology of cultural socialization available to the parents. My theoretical approach is grounded in the seminal work on cultural transmission by Bisin and Verdier (2000). In particular, I adopt the distinction between *vertical socialization*, performed by the parents, and *oblique socialization*, performed by the rest of the population. However, my approach also builds upon this work, most notably by considering a continuous, multidimensional *cultural capital* for the child, and by incorporating insights from the literature on human capital formation.

In their model Bisin and Verdier consider culture as a discrete, exclusive trait that is transmitted probabilistically. Instead, I model the culture transmitted to children as multidimensional and with an intensive measure, and I label this the cultural capital of children. Behind this label is the idea that culture is an example of task-specific human capital (Gibbons and Waldman 2004), an approach that has already been adopted in the economics of religion by Iannaccone (1990). As such, cultural capital associated with Christianity for instance, serves a different purpose from cultural capital associated with Islam.[11] Furthermore, rather than considering all the different possible channels of cultural capital formation, I focus here on the role of parental time investments in their child's cultural socialization. Keeping religion as an illustrative example, the child's cultural capital is then a measure of the intensity of her socialization to Christianity, Islam, Atheism... This modeling choice proves important in disentangling the different influences involved in the cultural socialization process. It is also particularly convenient for transposition to the empirical analysis – indeed, I will show how it maps naturally to the reduced-form analysis from section 3. Finally, because I consider cultural capital as a specific modality of human capital, I adapt existing insights from the literature on children's human capital formation (Del Boca et al. 2014, 2016, Chiappori et al. 2017) and the theory of time allocation (Becker 1965) to represent the production of children's

[11] This example also emphasizes a possible complementarity between the different dimensions of cultural capital: as Abrahamic religions, there is significant overlap between Christianity and Islam in terms of religious knowledge or practice. If we consider the example of language, the same could be said about languages that share a common script, vocabulary, or grammatical structure. While I will not consider it here for the sake of simplicity, this complementarity between different dimensions of cultural capital could easily be added to the model, at the cost of additional complexity in the number of parameters.

cultural capital. Doing so provides tractable solutions to the collective household model in section 4.2 while maintaining the intuitive results that would derive from a more agnostic approach.

The formation of cultural capital. Consider a household formed by two parents, indexed by $i \in \{1, 2\}$. For simplicity, I assume that each household has one child. Parent i possesses a single cultural trait n_i among N possible traits. In this model, parents domestically produce the child's cultural capital by spending time on cultural socialization.

To model the accumulation of the child's cultural capital, I rely on existing results from the literature on human capital formation. Specifically, Cunha and Heckman (2007) and Aizer and Cunha (2012) provide evidence that investments in the human capital of children are dynamic complements, in the sense that existing human capital increases the returns of current investments. (Thus, past investments indirectly increase the returns of current investments, hence the "dynamic" complementarity.) This model feature was for instance adopted in an empirical structural framework by Del Boca et al. (2014, 2016). As a specific type of human capital, it is reasonable to assume that cultural capital is produced similarly. Interpreted here in a continuous time setting, this dynamic complementarity means that the cultural capital returns $\mathrm{d}K$ on a marginal time investment $\mathrm{d}s$ are proportional to the stock of cultural capital already produced. Following this logic, the law of accumulation of the cultural capital K is

$$\mathrm{d}K = K \times a \, \mathrm{d}s \tag{10}$$

where a is a positive parameter denoting the time productivity of the individual.[12] Integrating equation (10), we find that the log-cultural capital is produced from the time investment s by a linear technology:

$$\ln K = k + a \, s. \tag{11}$$

Equation (11) thus describes the accumulation of cultural capital when one individual is involved in the child's socialization. In reality however, the cultural socialization of children involves several individuals, most notably the parents. Here, I follow the literature on cultural transmission by assuming that the child is subject to both *vertical* and *oblique* socialization (Bisin and Verdier 2000, 2011). Vertical socialization, on the one hand, results from "purposeful socialization decisions inside the family." In my time allocation framework, it is carried out in the form of (endogenous) parental time inputs s_i spent socializing the child. Oblique socialization, on the other hand, summarizes other

[12]This is equivalent to the way that an investment I grows with time under an interest rate r,

$$\mathrm{d}I = I \times r \, \mathrm{d}t \implies I = I_0 \, e^{rt}.$$

socialization processes that happen outside of the family. To model oblique socialization, I first assume that the child has a fixed time attention span for being socialized, which I normalize to 1. Deducting the time taken by the parents leaves time $1 - s_1 - s_2$ during which the child is subject to oblique socialization. Second, I assume that this remaining socialization time is spent randomly with the rest of the population. This means that if a culture has a population share q, the child spends time $(1 - s_1 - s_2)q$ being socialized to that culture. Thus, as in the standard Bisin and Verdier model, oblique socialization to a given culture is proportional to that culture's share in the population: more widespread cultures exert a stronger influence. Accounting for these different socialization channels into account, the child's cultural capital is produced via the technology

$$\ln K = k + a_1\, s_1 + a_2\, s_2 + a_0\, (1 - s_1 - s_2)q \tag{12}$$

where a_1 and a_2 are the productivities of parents 1 and 2 respectively, and a_0 is the productivity of oblique socialization.

The socialization technology (12) still describes a unidimensional accumulation process. Culture, however, is multidimensional: the child receives socialization in all N cultural traits present in the population. This process constitutes a N-dimensional vector $(K_n)_{1\leq n\leq N}$, where each K_n corresponds to the child's cultural capital in a different trait. The component K_n is increasing in the parental time investments in the child's socialization to trait n, and in the population share q_n of trait n. In the most general case, parents would be able to contribute to the child's socialization to any trait. However, to simplify the analysis, it is useful to consider that a parent can only socialize the child to their own trait. There are at least two reasons to justify this assumption. First, a parent is likely to prioritize transmitting their own culture, and therefore to use their available time doing so. Second, they simply might not have the capacity to transmit another culture if they are not affiliated or familiar with it themselves (e.g. ethnicity, but also language, religion). For this reason, I assume that the time s_i devoted by parent i is fully counted toward the socialization of the child to that parent's trait, n_i. Thus, the child's cultural capital in trait n is formed according to

$$\ln K_n = k_n + a_1\, s_1\, \mathbf{1}_{\{n_1=n\}} + a_2\, s_2\, \mathbf{1}_{\{n_2=n\}} + a_0\, (1 - s_1 - s_2)\, q_n \tag{13}$$

where $\mathbf{1}_{\{n_i=n\}}$ is an indicator equal to 1 if and only if parent i has trait n.

Examples. *For fixed parental time inputs s_1, s_2, a child with homogamous parents of culture n will receive the cultural capital*

$$\ln K_n = k_n + a_1\, s_1 + a_2\, s_2 + a_0\, (1 - s_1 - s_2)\, q_n, \qquad \ln K_\ell = k_\ell + a_0\, (1 - s_1 - s_2)\, q_l \quad (\forall \ell \neq n),$$

while a child with heterogamous parents of cultures $n_1 \neq n_2$ will receive

$$\ln K_{n_1} = k_{n_1} + a_1\, s_1 + a_0\, (1 - s_1 - s_2)\, q_{n_1}, \qquad \ln K_{n_2} = k_{n_2} + a_2\, s_2 + a_0\, (1 - s_1 - s_2)\, q_{n_2},$$

$$\ln K_\ell = k_\ell + a_0\, (1 - s_1 - s_2)\, q_l \quad (\forall \ell \neq n_1, n_2).$$

The model is also readily extendable to single-parent families: for instance, a child with only parent 1 will receive

$$\ln K_{n_1} = k_{n_1} + a_1\, s_1 + a_0\, (1 - s_1)\, q_{n_1}, \qquad \ln K_\ell = k_\ell + a_0\, (1 - s_1)\, q_l \quad (\forall \ell \neq n_1).$$

Below I will introduce the decision framework in which parents choose their time inputs s_i endogenously. We can already imagine, however, how the functional form (13) will impact the socialization decisions of the household. First, if the parental productivities a_1 and a_2 are different, one parent has a comparative advantage over the other in the child's socialization. This feature of the model opens up the possibility of productivity-driven specialization in the household, which is one possible way to explain disparities in transmission rates between mothers and fathers. Second, the model assumes that vertical socialization comes at the expense of oblique socialization. Consequently, parents who belong to a more widespread culture have lower returns on the time they spend socializing their children. This point relates to the *cultural substitution* property introduced by Bisin and Verdier (2001), to which I will return during the analysis.

Link with the reduced-form. In the theory above, individuals have a complex cultural identity that is represented by a multidimensional cultural capital. Empirically however, this multidimensional approach to culture can prove problematic. Indeed, to implement this theoretical framework directly with data, the researcher should ideally have an intensive measure of culture along multiple dimensions (e.g. the level of proficiency in several languages). However, in most cases, surveys do not report this kind of measure of the respondents' culture(s). Rather, survey respondents are often categorized into a single, exclusive affiliation (e.g. religion, ethnicity). This is notably the case for the respondents' religious affiliation in the TeO data.

In section 3 we have seen that the multinomial logit model addresses this issue by mapping the multidimensional, intensive measure of culture from the theory into an extensive, discrete cultural affiliation as reported in the data. This approach amounts to considering the reporting of a single cultural affiliation as a choice among coexisting cultural identities. Following the discrete choice theory logic, individuals are then more likely to report a cultural affiliation in which they have higher cultural capital. Moreover, we have seen how the linear form of log-cultural capital naturally fits into a multilogit regression framework.

Note that equation (13) bears a striking resemblance to the econometric specification

(2) used in the reduced-form analysis of section 3. This equation provides a theoretical foundation for the log-religious capital $\ln(K_{in})$ being a linear function of the observables $\mathbf{1}_{\{i\text{'s mother is } n\}}$, $\mathbf{1}_{\{i\text{'s father is } n\}}$, and q_{in}. Furthermore, it suggests the use of measures of parental time spent on religious socialization to predict individuals' choice of religious affiliation. Unfortunately, there is no such measure in the TeO data. In its absence, we can interpret the estimated socialization contributions from section 3 as proxies of parental socialization time investments. Recall that according to the reduced-form estimates, religious minorities contribute more to the socialization of their children than majorities, and mothers contribute more than fathers. The model can rationalize the difference between mothers and fathers in two ways: mothers are more productive at socialization ($a_1 > a_2$), or they simply spend more time on religious socialization than fathers ($s_1 > s_2$).[13] In contrast, the model can only rationalize the difference between religious minorities and majorities through higher socialization time investments on the part of minorities. Because the econometric specification (2) ignored the adverse role of vertical socialization on oblique socialization present in the model (13), there is no such direct interpretation of the oblique socialization coefficient. Finally, the constant k_n from the reduced-form analysis could be understood as a measure of the initial stock of religious capital across the different religious affiliations.

Decreasing returns to socialization. For simplicity of exposition, I have assumed that socializing individuals have a constant productivity of socialization, equal to a_1, a_2, or a_0. In fact, it may be more accurate to assume that the socialization time investments of the parents exhibit decreasing returns, in the sense that the marginal productivity of their time declines as they spend more time socializing the child. (See for instance Chiappori et al. 2017 for children's human capital formation). Such declines could occur because parents eventually run out of new knowledge to transmit, or because children progressively lose attention when taught by a single teacher.

To account for this possibility, I assume that individuals' socialization productivity decreases with the time s spent socializing the child. To keep the model tractable, I consider that productivity decreases linearly: after having spent time s on socialization, an individual has marginal productivity $a \times (1 - \gamma s)$. Under this assumption, a is the initial socialization productivity at $s = 0$, and γ is a positive parameter representing how quickly productivity declines. (Note also that above $s > 1/\gamma$, socialization becomes counterproductive.) The law of accumulation of cultural capital (10) is modified to

$$\mathrm{d}K = K \times a \times (1 - \gamma s)\,\mathrm{d}s. \tag{14}$$

[13] If we denote by s_{1n} and s_{2n} the socialization time investments of mothers n and fathers n respectively, then m_n and f_n are defined as

$$m_n = a_1\, s_{1n}, \qquad f_n = a_2\, s_{2n}.$$

By integrating this equation we obtain the total cultural capital output produced from a socialization time investment s,

$$\ln K = a\left(s - \frac{\gamma}{2}s^2\right).$$

Since they spend a significant amount of time with their children, it is reasonable to assume that parents are subject to this decline in socialization productivity. Oblique socialization, in contrast, is by assumption carried out by many different individuals who each spend a marginal amount of time socializing the child. For this reason, the time $1 - s_1 - s_2$ dedicated to oblique socialization still produces cultural capital at a constant rate and does not suffer from a decrease in productivity. To summarize, incorporating decreasing returns in socialization yields the following production function for cultural capital:

$$\ln K_n = k_n + a_1\left(s_1 - \frac{\gamma_1}{2}s_1^2\right)\mathbf{1}_{\{n_1=n\}} + a_2\left(s_2 - \frac{\gamma_2}{2}s_2^2\right)\mathbf{1}_{\{n_2=n\}} + a_0\left(1 - s_1 - s_2\right)q_n. \quad (15)$$

Note that compared to equation (13), here I also included the constant k_n. This is the functional form that I will use in the household model below and in section 5 for the structural econometric model.

4.2 Household model

After describing the technology of socialization, I now turn to the trade-offs faced by the parents when choosing their socialization time investments. As mentioned above, parents' human capital will play a role here. In addition to the cultural trait n_i, parent i is now also characterized by a human capital level h_i (continuous). Parents have a fixed time budget, which they must allocate between the production of the child's human capital and cultural capital.

The child's cultural capital is produced from the parents' socialization time inputs s_i according to the technology (15). I assume that the child's human capital is produced with a fundamentally similar technology from time inputs t_i of the parents. Unlike for cultural socialization however, I assume that the parental human capital h_i increases the productivity of parent i during human capital production.[14] These two assumptions are consistent with existing models of children's human capital formation (Del Boca et al. 2016, Chiappori et al. 2017). Thus the child's human capital H is produced from parental inputs and characteristics according to

$$\ln H = (b_1 + h_1)\left(t_1 - \frac{\gamma_1}{2}t_1^2\right) + (b_2 + h_2)\left(t_2 - \frac{\gamma_2}{2}t_2^2\right). \quad (16)$$

As for a_1 and a_2 in the case of cultural capital production, the parameters b_1 and b_2 denote

[14]The theoretical results of this section would still hold if, instead of parental human capital having no effect of the production of cultural capital, it simply had a smaller effect.

the baseline productivities of parents 1 and 2 respectively. Note also that I have taken a constant equal to 0 in the production function – this is without loss of generality for the model. (For this reason, one could also add a source of "oblique" production of human capital, without consequence for the model's insights.)

Parents care about their child's human capital and cultural capital. To simplify, I assume that parent i values only the cultural capital of the child in their own trait, n_i. Based on this assumption, I consider a Cobb–Douglas utility for parent i of the following form:

$$u_i = \nu_i \ln(K_{n_i}) + \ln H.$$

The parameter ν_i is an important primitive of the model, representing the value of the child's cultural capital (relative to her human capital) for parent i.

I use a collective household model (Chiappori 1992) to represent the parents' decision-making, so that parental decisions lead to an outcome on the Pareto frontier of the household. In other words, the intrahousehold decisions must maximize a weighted sum of the parents' utilities:

$$\max_{t_i, s_i} \left\{ \mu\, u_1 + u_2 = \mu\, \nu_1 \ln K_{n_1} + \nu_2 \ln K_{n_2} + (\mu + 1) \ln H \right\}, \tag{17}$$

where μ is the relative power (Pareto weight) of parent 1, fixed exogenously. The constraints concern the time available to the parents: I assume a fixed time budget T_i for parent i, so that the household constraints are

$$t_i + s_i \leq T_i, \qquad i = 1, 2. \tag{18}$$

These constraints must be saturated at the optimal time allocation as long as γ is small enough compared to T_i.

Discussion. This framework shares similar features with existing models of cultural transmission and human capital formation. The seminal model of cultural transmission was proposed by Bisin and Verdier (2000), in which parents also care about passing on their culture to their children, and can contribute to their child's cultural socialization to their own traits. The fact that parents might want to transmit a different culture than their own is therefore not considered in their model or in mine. A reason for such a preference could be discrimination against or in favor of a given culture. Such a phenomenon has been documented for instance by Saleh (2018), who shows how differential taxation in medieval Egypt incentivized Coptic Christians (who faced higher taxes) to adopt the Muslim affiliation. Botticini and Eckstein (2007, 2012) also show how economic incentives had an impact on conversions from Judaism to Christianity across history. The crucial feature of the Bisin and Verdier model, namely the substitution between vertical and oblique socialization, is also embedded in my model through the cultural capital production technology (section 4.1).

My model also departs from Bisin and Verdier in several ways. First, in their model, parents' efforts to socialize the child have an abstract convex cost. In my model, these efforts are specified as time allocations, which are made at the expense of the child's human capital production.

Second, in my model parents care about the cultural capital in their own trait, as opposed to the transmission probability of every trait in Bisin and Verdier (2000). The two formulations are in fact theoretically equivalent in cases with two traits (which is the case considered by Bisin and Verdier), but this is no longer true when there are three or more traits.[15] However, fewer theoretical results exist beyond the two-traits case (see Montgomery 2010). Assuming that parents care about cultural capital, not transmission probabilities, greatly facilitates the analysis when there are three or more traits, and is therefore well-suited to an empirical framework.

Third and last, in my model the socialization technology extends to both culturally homogamous and heterogamous households. This approach is not possible in the Bisin and Verdier model, which uses a unitary framework and for this reason assumes that heterogamous households have no available socialization technology (because then it would be unclear which culture the representative agent would want to transmit). Instead, in my model the technology of cultural capital production extends naturally to heterogamous households, yielding a trade-off between the socialization to the two parents' traits.

Regarding the production of the child's human capital, as in Chiappori et al. (2017) parents produce their child's human capital by using complementary time inputs. Furthermore, parental human capital improves the productivity of these time inputs. In their model, time investments into the child's human capital production are made at the expense of the household income – in my model, they are made at the expense of the child's cultural socialization.

4.3 Model analysis

With the technologies (15) and (16), the household problem (17)–(18) has closed-form solutions s_i^*, t_i^*. For the sake of clarity in the exposition, I make the following simplifying assumption.

Assumption 1: $\gamma_i = \dfrac{1}{T_i}$.

This assumption imposes that a parent's time productivity in socialization or human capital formation reaches exactly 0 when they spend all of their time budget on only

[15] This is because with only two traits, an increase in the population share of trait 1 mechanically leads to a decrease in the share of trait 2. Thus, a parent who cares about the population share of trait 1 must indirectly care about that of trait 2 as well. This is no longer true, however, when there are three or more traits. For instance, in the Bisin and Verdier framework Catholics could reduce their socialization effort if the population share of Protestants increases at the expense of Muslims'. This is not the case in my model.

one activity. It guarantees interior solutions, while providing simpler formulas for the solutions s_i^* and t_i^*. I now describe these solutions as well as some of their properties, first for homogamous households, and then for heterogamous ones.

Homogamous households. In a homogamous household the two parents have aligned interests. They both wish to transmit their common culture as well as human capital to the child, although they may disagree on how much to favor one over the other. With n denoting the common trait of the two parents, the first-order conditions are

$$(\mu\,\nu_1 + \nu_2)\big(a_i(1-\gamma_i s_i^*) - a_0\, q_n\big) = (\mu+1)(b_i+h_i)(1-\gamma_i t_i^*) \qquad (i=1,2).$$

At the optimum, parent i's marginal returns from investing time in cultural capital or human capital formation should be equal. On the left-hand side, the marginal return from the socialization time s_i is increasing in the two parents' relative preferences for cultural capital ν_1 and ν_2, and in parent i's productivity a_i; and is decreasing in the productivity and intensity of oblique socialization, a_0 and q_n. On the right-hand side, the marginal return from time t_i spent on human capital formation is increasing in productivity b_i and the human capital of parent i, h_i.

The solution is obtained by using the saturated time constraint (18) and assumption 1:

$$s_i^* = T_i \times \frac{(\mu\,\nu_1+\nu_2)(a_i - a_0\, q_n)}{(\mu\,\nu_1+\nu_2)a_i + (\mu+1)(b_i+h_i)} \tag{19}$$

whenever this expression is positive (i.e. when $a_i > a_0 q_n$, so that parent i has an incentive to vertical socialization), and $s_i^* = 0$ otherwise. Note that the ratio in expression (19) is always inferior to 1, so that parent i never devotes their whole time budget to socialization. The following proposition describes how this optimal time allocation changes with the characteristics of the parents and of the population.

Proposition 1: In homogamous households, the time that parent i spends on cultural socialization is decreasing in his or her human capital level, h_i; and in the population share of the parents' common trait, q_n; and it is increasing in both parents' relative preference for cultural capital, ν_1 and ν_2. Furthermore, it is increasing in parent's 1 relative power μ if and only if $\nu_1 > \nu_2$, and decreasing otherwise.

The proof is obtained by differentiating the solution (19) with respect to the parameters of interest. Proposition 1 confirms that the model encapsulates the trade-offs between human capital formation and cultural socialization mentioned at the beginning of this section. Taking parental preferences as fixed, two types of time substitution occur in the model: parents with higher human capital reallocate their time toward human capital formation, as do cultural-majority parents. The first kind of substitution results from the comparative advantage of parents with higher human capital in the child's human capital production. The second is a consequence of vertical socialization coming at the expense of oblique socialization, which relates to the *cultural substitution* property introduced by Bisin and Verdier (2001).

If the preference for cultural capital changes for one parent, both parents respond to that change by reallocating their time in the same direction, as a consequence of the cooperativeness implied by the collective household framework. The same is true for changes in the power balance. Finally, the comparative statics with respect to the parental productivities a_i and b_i are straightforward: if their productivity in one activity increases, parents reallocate their time toward that activity.

Heterogamous households. In a heterogamous household, parents have different objectives: parent 1 wants to socialize the child to trait n_1 and parent 2 to trait n_2. Compared to the homogamous case, this divergence in the parents' interests modifies how they react to changes in the model's parameters. First, changes in parental preferences or in the power balance lead them to reallocate their time in opposite directions: when one parent increases their socialization time investment, the other parent reduces it. Second, a higher population share for any parent's trait decreases the incentive for vertical socialization for both parents, because vertical socialization happens at the expense of oblique socialization in all traits. Thus, if oblique socialization improves for one of the two parents, the household's incentive for vertical socialization decreases.

Formally, the first-order conditions are

$$\mu\,\nu_1\big(a_1(1-\gamma_1 s_1^*)-a_0\,q_{n_1}\big)-\nu_2\,a_0\,q_{n_2}=(\mu+1)(b_1+h_1)(1-\gamma_1 t_1^*)$$
$$\nu_2\big(a_2(1-\gamma_2 s_2^*)-a_0\,q_{n_2}\big)-\mu\,\nu_1\,a_0\,q_{n_1}=(\mu+1)(b_2+h_2)(1-\gamma_2 t_2^*).$$

These conditions are mostly similar to the homogamous case. The novelty is the adverse effect of vertical socialization from parent i on the oblique socialization to parent $-i$'s trait (in the first line for instance, this effect is represented by the term $-\nu_2\,a_0\,q_{n_2}$).

Once again, the solution is obtained by using the time constraint (18):

$$s_1^*=T_1\times\frac{\mu\,\nu_1(a_1-a_0\,q_{n_1})-\nu_2\,a_0\,q_{n_2}}{\mu\,\nu_1\,a_1+(\mu+1)(b_1+h_1)} \tag{20}$$
$$s_2^*=T_2\times\frac{\nu_2(a_2-a_0\,q_{n_2})-\mu\,\nu_1\,a_0\,q_{n_1}}{\nu_2\,a_2+(\mu+1)(b_2+h_2)}. \tag{21}$$

The following proposition describes the mechanisms at hand in heterogamous households: in addition to the two kinds of substitution occurring in homogamous households, parents must also adapt their time investments to suit their diverging interests.

Proposition 2: In heterogamous households, the time that parent i spends on cultural socialization is decreasing in his or her human capital level, h_i; in the population shares of the two parents' traits, q_{n_1} and q_{n_2}; and in the relative preference for cultural capital of the other parent, ν_{-i}; and it is increasing in his or her relative power, and in his or her relative preference for cultural capital ν_i.

Contrary to the homogamous case, a concession is made between the two parents in producing the child's human capital, which is a public good, versus producing cultural capital in the parents' respective traits, which is a private good enjoyed separately by each parent. The power balance notably determines the importance of socializing the child to parent 1's trait versus parent 2's trait. As a parent obtains more power, they dedicate more time to the cultural socialization of the child (their private good), while the other parent reallocates time toward human capital production (the public good).

This concludes the short analysis of the model. In Appendix C I discuss implications for household formation by using a matching framework, and for population dynamics.

5 Estimation

In this section I estimate the structural model developed in section 4. The method used is very similar to that of the reduced-form model from section 3. Indeed, I still exploit the variation in the traits of the respondents and their parents as a source of identification. This time however, I use not only the respondents' religious affiliation but also their educational attainment as an explained variable. This approach is possible because the structural model predicts both the religious socialization and the human capital of individuals. As I will explain in this section, the estimation framework can thus be understood as a mixture of a multinomial logit and an ordered logit model.

In section 5.1 I present the framework for the estimation. In section 5.2 I present the results.

5.1 Methodology

This section describes how I apply the model to the data. The religious affiliation of respondents in the data is explained by their predicted level of religious capital in the model, using a multinomial logit framework. Similarly, their educational attainment is explained by their predicted level of human capital in the model through an ordered logit framework. I then combine these two frameworks in the log-likelihood function for the estimation.

Measuring parents' human capital. Before delving into the estimation, a discrepancy between the model and the data needs to be addressed. In the model, the parents have a human capital trait h, which is continuous. In the data however, I measure this level of human capital by using the educational attainment variable, which is discrete. Thus, when solving the household program for two parents with observed educational attainments e_1 and e_2, I must decide how e_1 and e_2 translate into human capital levels h_1 and h_2.

As a simple solution, I assume that each educational attainment e is associated with a fixed human capital level $\tilde{h}_e$. Rather than choosing the $\tilde{h}_e$ exogenously however, I consider them as parameters to be estimated. In the model, any parent with educational attainment e is thus assumed to have the human capital level $\tilde{h}_e$.

Religious affiliation. For each individual i, the model predicts the cultural capital of i in any religion n, K_{in}, as a function of her parents' religious and educational traits and of the religions' population shares. To map these predictions onto the data, assume as in section 3 that i ultimately selects the religious affiliation

$$\arg\max_{n} \ \ln(K_{in}) + \varepsilon_{in}, \tag{22}$$

where the ε_{in} are distributed i.i.d. Gumbel. Again, the probability that i will select religion n is then given by

$$\pi_{in} = \frac{\exp(\ln K_{in})}{\sum_{\ell=1}^{N} \exp(\ln K_{i\ell})}. \tag{23}$$

This is a nonlinear multinomial logit model, in the sense that the probability π_{in} takes the standard softmax form, but the $\ln(K_{in})$ are nonlinear functions of the model's primitive parameters through the optimal time allocations (19)–(20)–(21).

Educational attainment. Similarly, for each individual i the model also predicts the level of human capital of i, H_i. Compared to the model of section 4, I add several parameters to describe this predicted level of human capital. These parameters intervene as additive constants in the log-human capital of children, and therefore they do not modify the optimal time allocation in the structural model: the solutions (19)–(20)–(21) remain unchanged. The first addition is simply a time trend parameter λ, which accounts for the fact that educational attainment has been rising over the period considered (c.f. Figure 1).

Second, I introduce parameters that reflect the baseline contributions of parents from different religious affiliations to the human capital formation of their children. These parameters are meant to capture religion-specific heterogeneity in how parents transmit human capital, which is unrelated to the specific trade-off between investments in human capital and cultural capital. The idea that religious ideology might influence human capital outcomes goes back at least to Weber's *The Protestant Ethic and the Spirit of Capitalism* (2013) [1905]. More recently, Botticini and Eckstein (2007) and Becker and Woessmann (2009) have provided evidence that the comparatively higher educational outcomes of Jews during the Middle-Ages and of Protestants during the late-19th century, respectively, could be attributed to a religious incentive to educate children. Becker et al. (2020) also provided evidence that parents with a history of forced migration have more-educated children, which they explain by a stronger preference of such parents for mobile assets. In a historically Christian-majority country such as France, religious affiliation is correlated with migration ascendency, thus suggesting that patterns of investments in human capital could be dependent upon the parents' religion. In practice, I account for this heterogeneity by adding parental religion fixed effects, h_{1n} for mothers n and h_{2n} for fathers n, to the (log-)human capital of children. These fixed effects capture systematic differences in children's educational outcomes across parental religious affiliations while leaving space to identify trade-offs at the margin between investments in human versus religious capital as described in the model.

To map the predicted level of human capital onto the data, I consider H_i as the deterministic component of a latent variable which, in turn, predicts the educational level of i. Specifically, suppose that the actual level of (log-)human capital of individual i is $\ln(H_i) + \eta_i$, where η_i is a random shock. Suppose further that i attains the educational level e_i according to the rule

$$e_i = \begin{cases} 1 & \text{if} \quad \ln(H_i) + \eta_i \leq \bar{h}_1, \\ 2 & \text{if} \quad \bar{h}_1 < \ln(H_i) + \eta_i \leq \bar{h}_2, \\ \vdots & \\ E & \text{if} \quad \ln(H_i) + \eta_i > \bar{h}_{E-1}, \end{cases} \tag{24}$$

where E is the number of possible educational levels and $\bar{h}_1, \dots, \bar{h}_{E-1}$ are parameters to be estimated. If the η_i are distributed i.i.d. logistic, this is an ordered logit model, such that the probability that i will attain the educational level e is given by

$$\phi_{ie} = \begin{cases} \dfrac{1}{1 + \exp(\ln(H_i) - \bar{h}_1)} & \text{if } e = 1, \\ \dfrac{1}{1 + \exp(\ln(H_i) - \bar{h}_2)} - \dfrac{1}{1 + \exp(\ln(H_i) - \bar{h}_1)} & \text{if } e = 2, \\ \vdots & \\ 1 - \dfrac{1}{1 + \exp(\ln(H_i) - \bar{h}_{E-1})} & \text{if } e = E. \end{cases} \tag{25}$$

Again, this model is nonlinear because H_i is a nonlinear function of the model's parameters.

Log-likelihood function and parametrization. Finally, suppose that the error terms ε_{in} and η_i are independent as well.[16] Then the probability that i will select the religious affiliation n and attain the educational level e is simply $\pi_{in} \times \phi_{ie}$. The model's log-likelihood is then

$$\ln L = \sum_i w_i \sum_{n=1}^{N} \sum_{e=1}^{E} \mathbf{1}_{\{i \text{ is } ne\}} \ln(\pi_{in} \times \phi_{ie}), \tag{26}$$

where the probabilities π_{in} and ϕ_{ie} implicitly depend on the model's parameters, and the w_i are sampling weights.

For the estimation, I impose two restrictions on the parametrization of the model presented in section 4. First, I assume that relative preferences for religious capital versus human capital are homogeneous within a gender–religion category. In other words, all mothers of religion n are assumed to have the same preference, denoted by ν_{1n}. Similarly, all fathers of religion n have the same preference ν_{2n}. This assumption is consistent with the model by Bisin and Verdier (2000), who assume that preferences are culture-specific constants. I extend their approach by supposing that within a culture, preferences may differ between men and women (which Bisin and Verdier could not do because they

[16]In Appendix D I examine this hypothesis by analyzing the deviance residuals of the estimated model. I find that residuals on the religion and education dimensions are not strongly correlated, providing suggesting evidence that error terms are indeed independent.

used a unitary household model). Second, I assume away the productivity difference between mothers and fathers, both in cultural socialization and human capital formation: $a_1 = a_2 = a$ and $b_1 = b_2 = b$. The reason for doing so is that differences in preferences between mothers and fathers are not precisely identified from differences in productivity between them. Indeed, as seen from the solutions to the household problem (19)–(20)–(21), identifying one from the other relies on the variation in the population shares q_{in}, which in practice does not seem sufficient to obtain robust estimates on different specifications. Thus a choice must be made to allow for gender heterogeneity in preferences or in productivity: here I choose the former.

I summarize the parametrization of the model under these additional assumptions, also considering assumption 1:

$$\begin{aligned}
\ln K_n &= k_n + a\left(s_1 - \frac{s_1^2}{2T_1}\right)\mathbf{1}_{\{n_1=n\}} + a\left(s_2 - \frac{s_2^2}{2T_2}\right)\mathbf{1}_{\{n_2=n\}} + a_0\left(1 - s_1 - s_2\right)q_n \\
\ln H &= \lambda(y - 1948) + h_{1n_1} + h_{2n_2} + (b + h_1)\left(t_1 - \frac{t_1^2}{2T_1}\right) + (b + h_2)\left(t_2 - \frac{t_2^2}{2T_2}\right) \\
u_i &= \nu_{in_i}\ln(K_{n_i}) + \ln H.
\end{aligned}$$

For now, I exogenously fix the power balance in the couple by setting $\mu = 1$, so that the spouses have equal power. The parameters to estimate are thus the following:

- the relative preference for religious capital, ν_{1n} for mothers of religion n and ν_{2n} for fathers of religion n,
- the cultural adoption constants k_n for all n,
- the time productivities of religious socialization, a for vertical socialization by mothers and fathers, and a_0 for oblique socialization,
- the time productivity of human capital formation, b,
- the total time budgets of the parents, T_1 for mothers and T_2 for fathers,
- the human capital levels $\tilde{h}_e$ associated with the educational attainments e,
- the ordered logit thresholds $\bar{h}_e$,
- the religion-specific contributions to human capital, h_{1n} for mothers n and h_{2n} for fathers n,
- the time trend parameter in human capital formation, λ.

With $N = 5$ religions and $E = 3$ education levels, this makes a total of $5N + 2E + 5 = 36$ parameters. Of those, four are not identified. First, as in the reduced-form analysis of section 3, the k_n are identified only up to a common additive constant. Again, I normalize this constant to 0 for the most common denomination, Christians: $k_2 = 0$. Second, the time productivity in human capital formation of the lowest human capital level cannot be distinguished from the baseline time productivity of human capital formation.[17] As such, I normalize to 0 the added productivity of having a primary school diploma or less:

[17] The time allocation solutions depend on the sum $b_i + \tilde{h}_i$. Therefore, choosing the parameters $(b_1, b_2, \tilde{h}_e)$ or $(b_1 + \kappa, b_2 + \kappa, \tilde{h}_e - \kappa)$ leads to the same model outcomes.

$\tilde{h}_1 = 0$. Third, the religion-specific contributions to human capital are only identified up to a constant:[18] I also normalize those for Christian mothers and fathers, $h_{12} = h_{22} = 0$. These normalizations leave 32 free parameters to estimate. Next, I compute the maximum likelihood estimator of these parameters with the log-likelihood expression (26). As in section 3, the covariance matrix is obtained via the BHHH estimator.

5.2 Results

Table 7 presents the estimation results. The fit can be compared to the null model with an intercept only for each religion–education type ($N \times E - 1 = 14$ free parameters), which has a deviance of 64 510. This comparison yields a pseudo-R^2 of 0.30.

I now turn to the estimated parameters. First, the estimates for the cultural adoption constants k_n are broadly consistent with the corresponding estimates in the reduced-form analysis. By default, individuals are most likely to select the No religion affiliation, followed by Christian, Other, Muslim and, finally, Jewish. As discussed in section 3, these results somewhat reflect the specificities of religious affiliations: for instance, while adopting the No religion trait requires little investment in religious capital, becoming Jewish without a Jewish parent is very rare.

Second, the relative values of religious capital for mothers and fathers, ν_{1n} and ν_{2n}, exhibit wide differences across gender and religions. Overall, the estimates suggest that mothers have stronger preferences for religion versus education than fathers do, except among Nones. They also suggest that Muslims and Jews value religious capital the most relative to education-oriented human capital, followed by Others, Nones, and finally Christians. Note that the estimates for Jewish mothers and fathers are very large but remain very imprecisely estimated. These large standard errors are a consequence of data being scarce for Jewish parents, particularly in the context of heterogamous households, which are used to identify the difference in preferences between mothers and fathers.

Third, the estimates of productivity in religious socialization, a and a_0, suggest that vertical socialization operates on a larger order of magnitude than oblique socialization, confirming the important roles of parents in the socialization process.

Moving to the estimates related to human capital formation, the measures of added productivity from parental human capital $\tilde{h}_e$ are, reassuringly, increasing in the associated educational attainment e. The added productivity obtained from holding a Secondary diploma is approximately the same as that from holding a Tertiary diploma. This result confirms that higher-educated parents are more productive when spending time to transmit human capital to their children. This feature of the estimates is, of course, driven by the fact that higher-educated parents have higher-educated children in the data. The

[18]The parameters (h_{1n}, h_{2n}) and $(h_{1n} + \kappa, h_{2n} - \kappa)$ lead to the same human capital outcomes for any constant κ, so we need to anchor one of these parameters. Furthermore, the parameters $(h_{2n}, \bar{h}_e)$ and $(h_{2n} - \kappa, \bar{h}_e + \kappa)$ also lead to the same human capital outcomes, so one of them also needs to be fixed constant.

Table 7: Structural model of religious socialization and human capital formation, Estimates

	Estimates
	model (26)
Religious socialization	
Cultural adoption constants k_n, by religion n	
None	2.08 (0.13)
Christian	0 (baseline)
Muslim	−1.91 (0.22)
Jewish	−3.19 (0.32)
Other	−1.29 (0.21)
Value of religious capital for mothers ν_{1n}, by religion n	
None	0.08 (0.04)
Christian	0.68 (0.10)
Muslim	2.13 (0.46)
Jewish	36.22 (55.60)
Other	1.59 (0.33)
Value of religious capital for fathers ν_{2n}, by religion n	
None	0.14 (0.05)
Christian	0.09 (0.05)
Muslim	1.98 (0.35)
Jewish	17.07 (10.15)
Other	0.00 (0.24)
Vertical religious socialization time productivity, a	11.74 (2.90)
Oblique religious socialization time productivity, a_0	1.60 (0.33)
Human capital formation	
Contributions to human capital from mothers h_{1n}, by religion n	
None	−0.45 (0.08)
Christian	0 (baseline)
Muslim	1.85 (0.28)
Jewish	4.82 (1.19)
Other	1.16 (0.19)
Contributions to human capital from fathers h_{2n}, by religion n	
None	−0.48 (0.07)
Christian	0 (baseline)
Muslim	0.88 (0.22)
Jewish	5.01 (0.74)
Other	−0.81 (0.16)
Human capital formation time productivity, b	14.68 (3.99)
Added productivity $\tilde{h}_e$, by education level e	
Primary	0 (baseline)
Secondary	1.85 (0.44)
Tertiary	3.75 (0.88)
Human capital threshold $\bar{h}_1$: Primary → Secondary	6.90 (0.95)
Human capital threshold $\bar{h}_2$: Secondary → Tertiary	11.07 (0.95)
Other	
Total time budget of mothers, T_1	0.66 (0.15)
Total time budget of fathers, T_2	0.68 (0.16)
Time trend, λ	0.01 (0.00)
Observations	18 155
Sampling weights	Yes
Deviance ($-2\ln L$)	45 247
Pseudo-R^2	0.30

Note: Standard errors in parentheses.

baseline time productivity in human capital formation, b, is similar in magnitude but greater than the time productivity of vertical socialization, a.

Regarding the religion-specific parental contributions to human capital, I find that relative to Christians, Jewish mothers and fathers contribute the most to the human capital formation of children, confirming the documented strong emphasis on human capital among Jews (Botticini and Eckstein 2007, 2012). Muslims also contribute more than Christians by default, and therefore, their lower educational rates must be attributable to the trade-off between investments in religion versus education. None parents contribute less than Christians. Finally, among Other parents, Other mothers contribute more than Christian ones, while Other fathers contribute less.

5.3 Interpretation of the estimates

With Cobb–Douglas preferences, the parameter ν_i can be interpreted in this way: parent i is indifferent between the child's religious capital K_{n_i} increasing by 1%, and the child's human capital H increasing by ν_i%. However, since both H and K_{n_i} are latent variables with no obvious measure scale, this interpretation is not immediately helpful in understanding parents' trade-offs in terms of religious transmission and education. Instead, another way to understand this trade-off is to ask a question such as: what loss in their children's educational attainment are parents accepting in exchange for a 1% increase in the chance that they will transmit their religious affiliation? With this question we finally tackle the motivating question of the paper, that is, the cost that parents pay to transmit their religion.

Note that a parent's transmission probability (the probability that the child will share his or her religious affiliation) depends not only on that parent's gender and religion but also on their education level, on the spouse's characteristics, and on the religions' population shares which are relevant for the child's socialization. All these factors will play a role in determining how costly religious transmission is for a given parent. To keep the illustration simple, I therefore focus on parents in homogamous households, and I take as a baseline the population shares for each religion in the year 2008, corresponding to the year of the survey. Furthermore, I consider households in which both parents share the same education level. Finally, since preference parameters for Jewish parents are very imprecisely estimated, I do not include them in this analysis.

Figure 18 shows, for homogamous households in which both parents have a Secondary education, what this trade-off looks like. The cost of religious transmission is measured in terms of foregone probability that the child obtains a Tertiary education, through a marginal rate of transformation. At their predicted transmission profile (the white dots on the graph), Christian parents, for instance, are renouncing a 0.41 percentage point (p.p.) chance that their child will attain a Tertiary education, in order to increase by 1 p.p. the chance that they will transmit their religious affiliation. This number is to 0.33 for Nones, rising to 0.64 for Others, and to 3.91 for Muslims. Thus, Muslims are paying

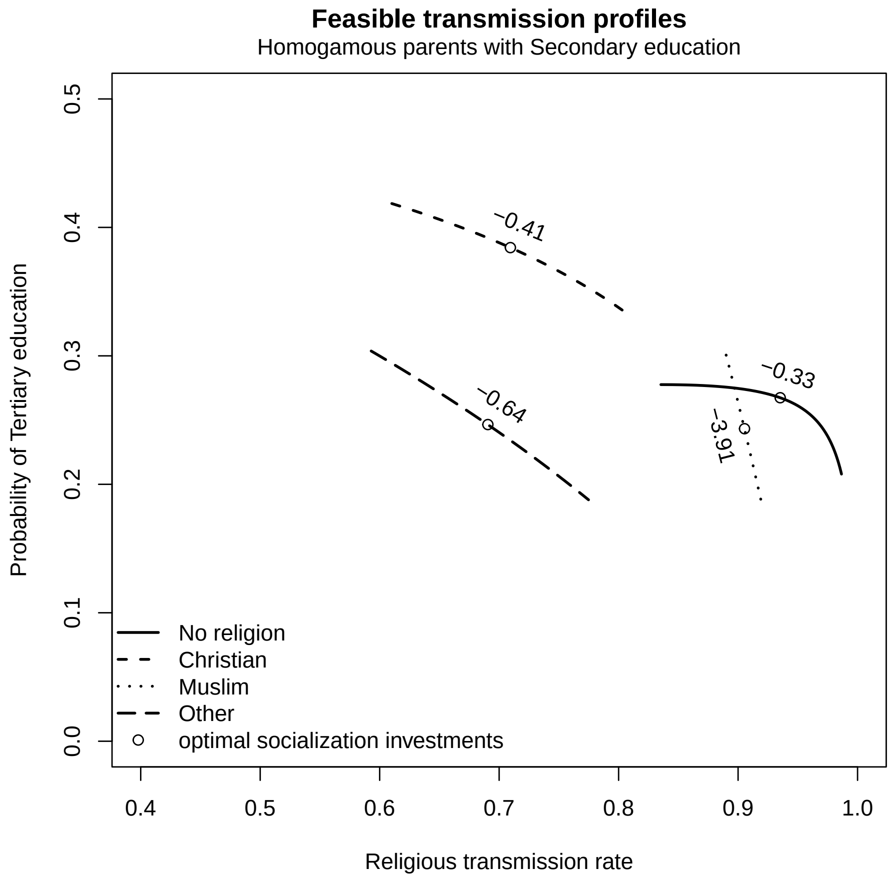

Figure 18: Trade-off between the religious transmission rate and the probability of the child attaining a Tertiary education. The lines depict the feasible transmission profiles (technology frontier) for households with Secondary-educated parents in religiously homogamous households. The white dots correspond to the profiles chosen by parents as predicted by the model. The marginal rate of transformation at this chosen profile is reported for each household type. (I do not report the corresponding results for Jewish households given the imprecision of the estimates.)

a marginal price approximately 10 times greater than Christians in terms of their child's educational attainment to ensure the transmission of their religious affiliation.

In Table 8 I summarize this information on marginal rates of transformation for different levels of parental education. As suggested by the evidence on Secondary-educated parents, I find that Muslim parents of all educational levels face higher costs than other denominations overall. Keeping the example of Muslims and Christians for illustration, the ratio of their marginal rates of transformation varies between 8 and 13. This strongly suggests that Muslims do indeed pay a significantly larger price than other denominations to transmit their religious affiliation. The difference between other affiliations is not as striking, although I find that Others pay a steeper cost than Christians, who themselves have a cost comparable to Nones.

Parents' education	Parents' religion					
	None	Christian	Muslim	Jewish	Other	Musl./Chri. ratio
	Marginal rate of transformation					
Primary or less	0.16	0.25	2.09	–	0.30	8.4
Secondary	0.33	0.41	3.91	–	0.64	9.5
Tertiary or more	0.38	0.35	4.59	–	0.78	13.1

Table 8: Cost of religious transmission, in terms of child's probability of Tertiary education.

5.4 Log-likelihood decomposition

Even though the estimated parameters from Table 7 provide a rough idea of the magnitude of the different mechanisms at play in the model, a more detailed analysis is needed to understand their respective importance. Here I delve deeper into this issue with a log-likelihood decomposition, which allows me to rank the three mechanisms at play in the model by order of importance in terms of explanatory power. These three mechanisms are (1) heterogeneous parental preferences across gender and religious affiliations, (2) the role of parental human capital in the substitution effect, and (3) oblique socialization. In order to measure the respective explanatory power of these three mechanisms, I consider three corresponding restrictions on the model parameters. Such restrictions allow me to shut down the three mechanisms separately and, as a result, to measure their respective ability to explain the variation in the data. The mechanisms and associated restrictions are the following.

Parental preferences. What if parents had homogeneous preferences? I restrict all preference parameters to take the same value, $\nu_{1n} = \nu_{2n} = \nu$ for all n and for some constant ν. For ν, I choose the value of which is associated with the maximum log-likelihood under this constraint and while keeping other parameter estimates constant.

Parental human capital. What if parental human capital did not affect time productivity in the child's human capital formation? In this case I set the added time productivity due to parental human capital, $\tilde{h}_1$ and $\tilde{h}_2$, to 0.

Oblique socialization. What if oblique socialization played no role in the transmission process? In order to cancel this effect I set the oblique socialization parameter a_0 to 0.

I then use the log-likelihood from equation (26), which I denote here using the lowercase ℓ, to obtain a measure of explanatory power for each of these mechanisms. Specifically, I consider as a baseline the difference between the log-likelihood evaluated at the actual estimator $\hat{\boldsymbol{\beta}}$ (the one reported in Table 7), and the log-likelihood of the null model:

$\ell(\hat{\boldsymbol{\beta}}) - \ell_0$.[19] We saw that the structural model performs better than the null model at explaining the data, such that this difference is positive. Then, for each mechanism I modify the vector of estimated parameters $\hat{\boldsymbol{\beta}}$ by applying the associated parameter restriction, yielding a new vector of parameters $\hat{\boldsymbol{\beta}}_{\text{restr}}$. I can then compute the difference $\ell(\hat{\boldsymbol{\beta}}_{\text{restr}}) - \ell_0$ and compare it to the baseline difference $\ell(\hat{\boldsymbol{\beta}}) - \ell_0$ (this baseline is necessarily greater by definition of the maximum likelihood estimator). If $\ell(\hat{\boldsymbol{\beta}}_{\text{restr}}) - \ell_0$ is close to $\ell(\hat{\boldsymbol{\beta}}) - \ell_0$ it means that the mechanism which was shut down has little explanatory power. Conversely, if the two are far from each other, it means that the mechanism which was shut down actually matters a lot to explain variation in the data. Having noted this, a possible statistic to measure the explanatory power of the different mechanisms is therefore

$$1 - \frac{\ell(\hat{\boldsymbol{\beta}}_{\text{restr}}) - \ell_0}{\ell(\hat{\boldsymbol{\beta}}) - \ell_0}. \tag{27}$$

A higher value of this statistic means a larger explanatory power for the associated mechanism.

The values of this statistic for the three mechanisms considered are presented in Figure 19. I find that the dominant mechanism in terms of explanatory power is parental preferences, with a decrease of 42% in log-likelihood when shutting it down. Parental human capital comes second, with a decrease of 27% in log-likelihood when ignoring its effect. Finally, oblique socialization seems to play a minimal role, with a decrease of only 2% in log-likelihood when shutting it down. This may however be due in part to the rough measure of oblique socialization used in the model, namely population shares at the national level.

[19]Recall that the null model is defined by an intercept only for each religion–education type of the child.

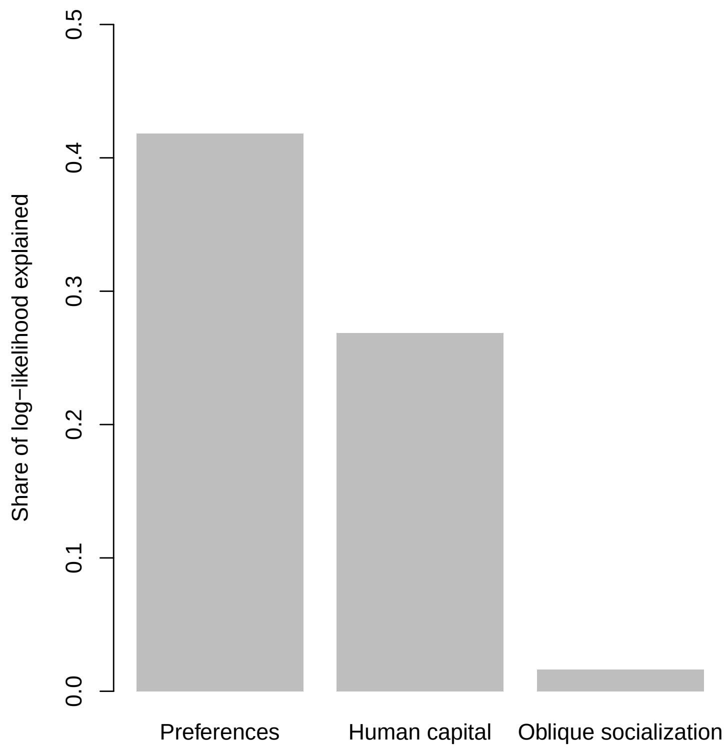

Figure 19: Three mechanisms ranked in terms of explanatory power.

6 Conclusion

While there is historical evidence of investments in religious transmission to children coming at the expense of their human capital outcomes, research has not really truly addressed this issue in a contemporary context. This gap remains despite strong anecdotical evidence that such trade-offs take place, especially among religious minorities – in the US for instance, among the Amish, Jehovah's Witnesses, or Hasidic Jews. In this paper, I have used data on religious affiliation in contemporary France to study this trade-off. I first documented how parents from different affiliations contribute to religious transmission to their children, finding that mothers transmit more than fathers, religious minorities transmit more than majorities, and higher-educated parents transmit less than lower-educated parents. To explain these stylized facts, I built a structural model that illustrates the trade-offs between investments in religious versus human capital. The estimates of the structural model suggest, for instance, that Muslims pay a cost that can be more than 10 times greater than that paid by Christians to transmit their religion, in terms of the educational attainment of their children.

More work remains to understand how this trade-off occurs across different contexts, such as other countries, different religious affiliations not well represented in the French context, and even for other cultural traits such as language or ethnicity. Additional data on religion and how parents allocate their time could also could also help refine the estimates obtained from the new methodology developed here. In particular, the model would benefit greatly from local measures of religions' population shares to better understand the religious environment in which individuals grow up; intensive measures of individuals' religion, such as the intensity of their religious practices, to better gauge their involvement with their declared religious affiliation; or measures of parental investments in the culture or formal education of their children to better understand how parents substitute their investments in various dimensions. Overall, this work lays out an interesting research program for better understanding the costs that parents pay to transmit their culture.

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Appendix

A Descriptive statistics for the TeO survey

A.1 General descriptives

Table A1: General descriptive statistics of the TeO survey.

	Mean	StdDev	Min	Max	Obs.
Age	36	11.5	17	60	21,761
Female (%)	52.8				21,761
Education (%)					21,761
Primary or less	8.0				–
Secondary	63.6				–
Tertiary or more	28.4				–
Religion (%)					21,443
No religion	29.3				–
Christian	39.2				–
Muslim	26.6				–
Jewish	0.8				–
Other	4.1				–
Partner					
Has partner (%)	72.5				21,761
Same-sex partner[1] (%)	0.7				13,242
Raised by... (%, several may apply)					21,761
Both parents	86.1				
Mother only	14.9				
Father only	2.3				
Mother's education (%)					20,239
Primary or less	59.3				–
Secondary	30.4				–
Tertiary or more	10.2				–
Father's education (%)					19,239
Primary or less	54.2				–
Secondary	31.2				–
Tertiary or more	14.7				–
Parents' religion					
Homogamous parents (same religion, %)	89.3				20,671
Shares religion with at least one parent (%)	84.9				20,988

Notes: [1] Information only available if the partner lives in the same house.

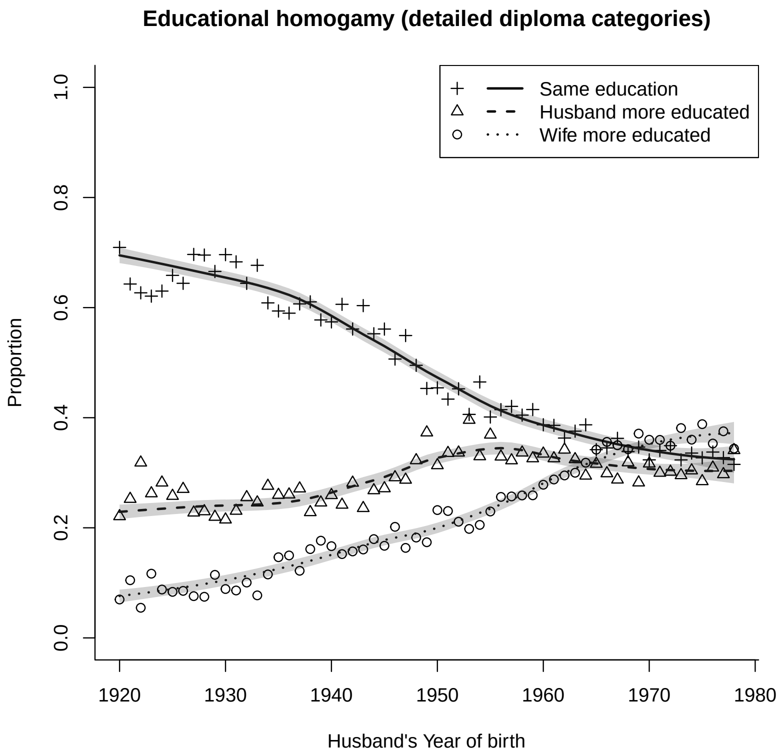

Figure A1: Educational homogamy with detailed diploma categories.

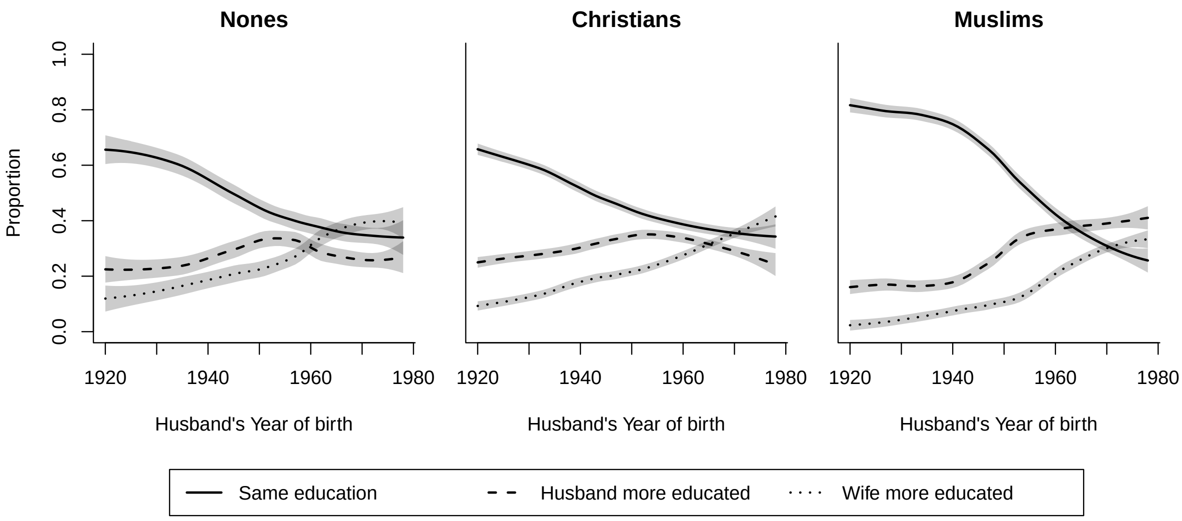

Figure A2: Educational homogamy with detailed diploma categories, same-religion couples.

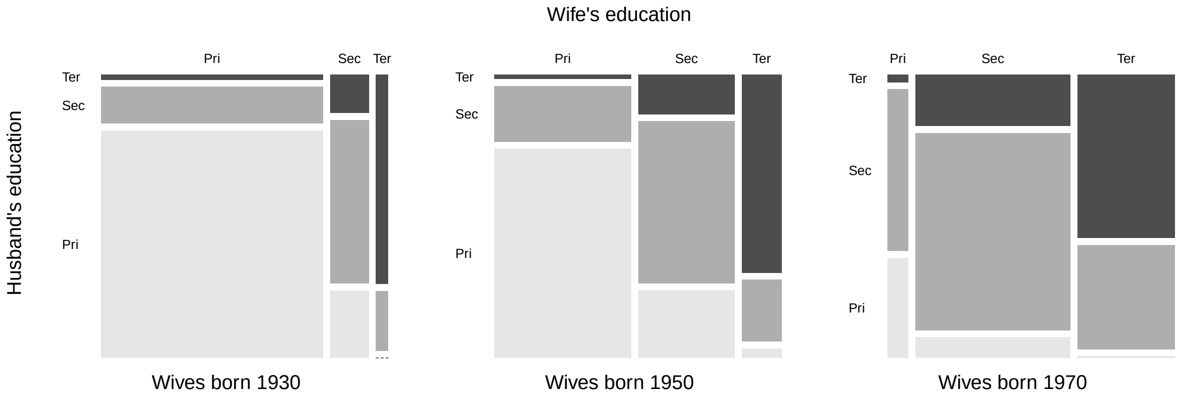

Figure A3: Educational assortment in couples with a wife born in 1930, 1950, and 1970.

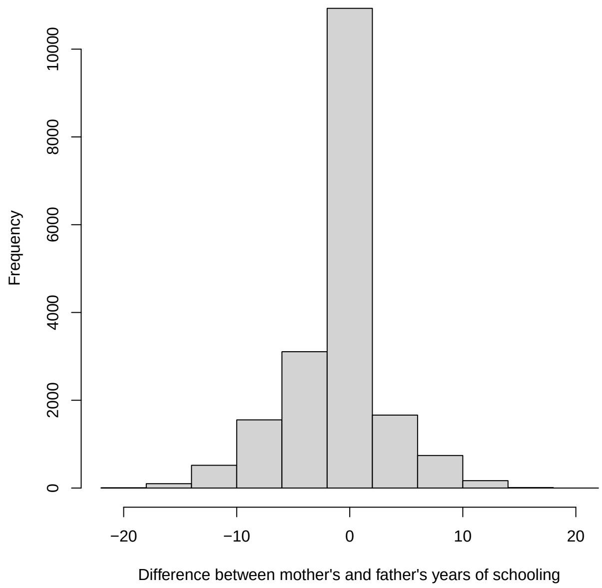

Figure A4: Distribution of the difference in years of schooling between mothers and fathers.

A.3 Religion

See Figures A5, A6, A7; and Table A2.

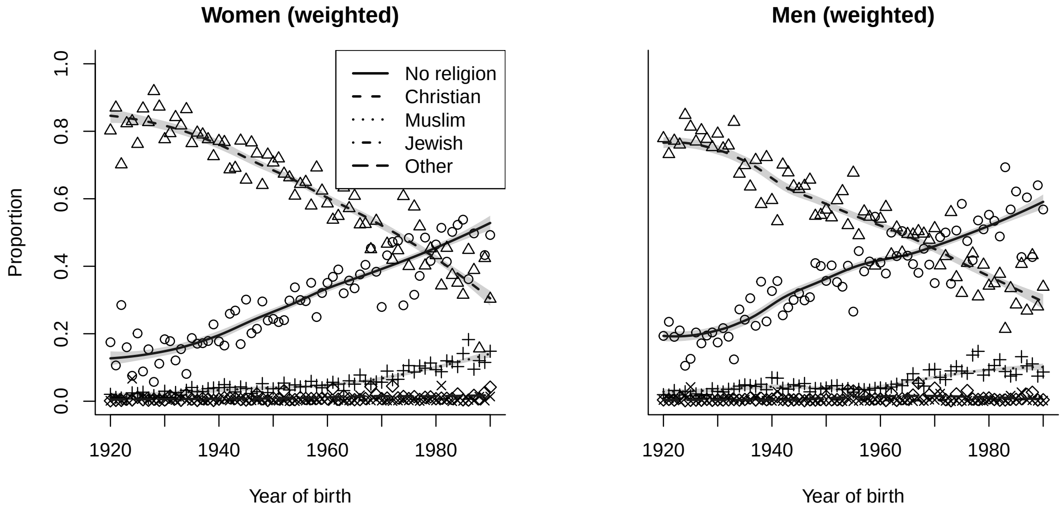

Figure A5: Religious affiliation, Women and Men (using sampling weights).

Table A2: Religious affiliations and homogamy.

Mother's religion	Father's religion					Total	Homogamy
	None	Christian	Muslim	Jewish	Other		
None	2448	221	105	8	28	2810	0.87
Christian	1071	9044	240	32	89	10476	0.86
Muslim	118	42	5905	0	3	6068	0.97
Jewish	9	25	4	149	1	188	0.79
Other	110	76	19	1	923	1129	0.82
Total	3756	9408	6273	190	1044	20671	
Homogamy	0.65	0.96	0.94	0.78	0.88		

Note: For each line, homogamy is computed as the ratio of mothers in a homogamous union divided by the total number of mothers in that line (idem for fathers in each column). Homogamy rates can thus differ within a single religion between mothers and fathers because of they have different distributions regarding religion.

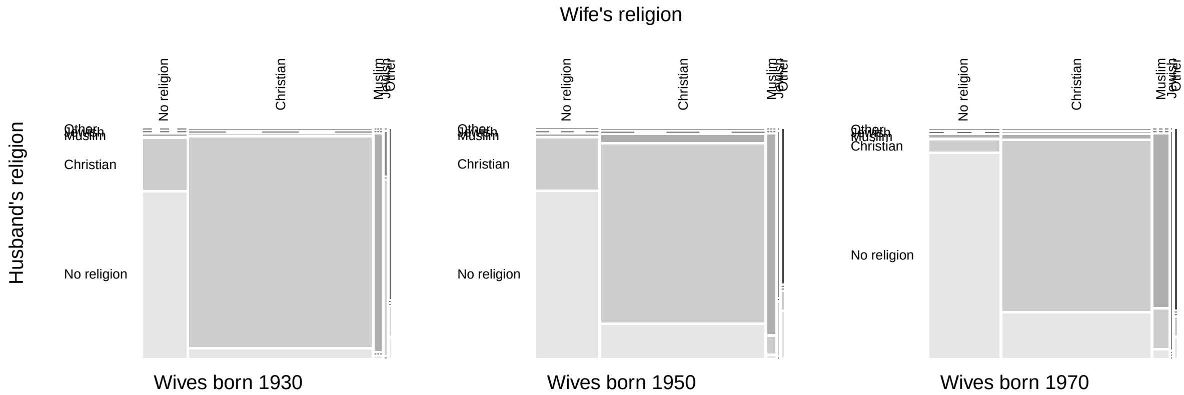

Figure A6: Religious assortment in couples with a wife born in 1930, 1950, and 1970 (using sampling weights).

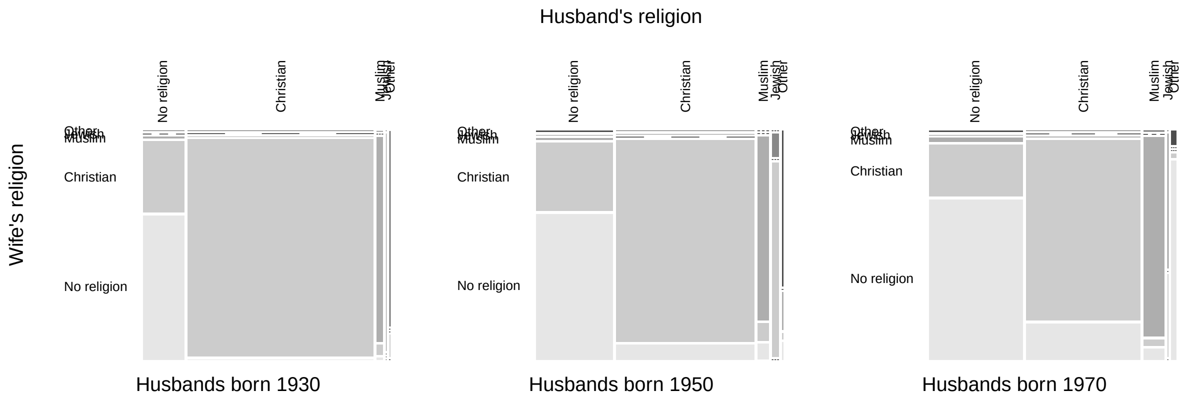

Figure A7: Religious assortment in couples with a husband born in 1930, 1950, and 1970 (using sampling weights).

A.4 Transmission of education

See Tables A3 and A4 for additional regressions.

Let's further investigate the interaction between the mother's and father's education levels, e_m and e_f, in determining the education of the child e_c. To do this, let's simplify the education variable even more than above by defining e_i as

$$e_i = \mathbf{1}_{\{i \text{ has (at least) a Secondary diploma}\}}.$$

Call $\mu_{h_m h_f} = \mathbb{P}(e_c = 1 \mid e_m, e_f)$ the probability that a child has (at least) a Secondary diploma, conditional on her mother and father having education levels e_m and e_f respectively. A simple measure of the interaction effect between the parents' education levels is then

$$\mu_{11} - \mu_{10} - \mu_{01} + \mu_{00}. \tag{28}$$

(For instance, in the linear probability model $\mu_{h_m h_f} = \alpha + \beta_m e_m + \beta_f e_f + \gamma e_m e_f$, we have $\mu_{11} - \mu_{10} - \mu_{01} + \mu_{00} = \gamma$.) I estimate the expression (28) on the whole sample first. The estimator

Table A3: Transmission of education (Ordered Logit).

	Child's education			
	(Ord. logit)	(Ord. logit)	(Ord. logit)	(Ord. logit)
Mother's education				
Secondary	0.64 (0.02)	1.04 (0.03)	0.97 (0.03)	0.98 (0.03)
Tertiary	1.00 (0.03)	2.60 (0.10)	2.57 (0.10)	2.57 (0.10)
Father's education				
Secondary	0.63 (0.02)	0.99 (0.03)	0.96 (0.03)	0.96 (0.03)
Tertiary	1.56 (0.03)	1.74 (0.05)	1.72 (0.05)	1.72 (0.05)
Mother's × Father's education				
Secondary × Secondary		−0.76 (0.04)	−0.68 (0.04)	−0.67 (0.04)
Secondary × Tertiary		−0.40 (0.06)	−0.36 (0.07)	−0.36 (0.07)
Tertiary × Secondary		−2.03 (0.11)	−2.10 (0.11)	−2.10 (0.11)
Tertiary × Tertiary		−1.76 (0.12)	−1.75 (0.12)	−1.76 (0.12)
Mother's religion				
Christian			0.25 (0.02)	0.24 (0.03)
Muslim			0.03 (0.28)	0.02 (0.49)
Jewish			−0.02 (0.16)	1.47 (1.18)
Other			0.63 (0.16)	0.59 (0.43)
Father's religion				
Christian			0.28 (0.02)	0.28 (0.05)
Muslim			−0.11 (0.28)	0.03 (0.66)
Jewish			1.23 (0.16)	1.05 (0.31)
Other			−0.74 (0.21)	−1.03 (1.49)
Mother's × Father's religion				
Christian × Christian				0.00 (0.06)
Christian × Muslim				−0.19 (0.78)
Christian × Jewish				0.35 (0.43)
Christian × Other				1.98 (2.04)
Muslim × Christian				−0.13 (1.41)
Muslim × Muslim				−0.13 (0.82)
Muslim × Jewish				no data
Muslim × Other				1.52 (15.83)
Jewish × Christian				−1.76 (1.21)
Jewish × Muslim				−1.36 (5.92)
Jewish × Jewish				−1.35 (1.23)
Jewish × Other				no data
Other × Christian				0.55 (0.48)
Other × Muslim				−1.15 (2.00)
Other × Jewish				no data
Other × Other				0.21 (1.55)
Child's year of birth /100	0.30 (0.06)	0.40 (0.06)	1.07 (0.07)	1.08 (0.07)
Cut-off: Primary → Secondary	3.56 (1.24)	5.58 (1.25)	19.03 (1.28)	19.10 (1.28)
Cut-off: Secondary → Tertiary	7.70 (1.24)	9.76 (1.25)	23.25 (1.28)	23.33 (1.28)
Observations	18 793	18 793	18 222	18 222
Sampling weights	Yes	Yes	Yes	Yes
Residual Deviance	27098	26947	25901	25888

Note: Standard errors in parentheses.
Reference category for mother/father education is "Primary."
Reference category for mother/father religion is "No religion."

Table A4: Transmission of education (OLS).

	Child's education		
	(OLS)	(OLS)	(OLS)
Mother's education	0.13^{***}	0.21^{***}	0.20^{***}
	(0.01)	(0.02)	(0.02)
Father's education	0.18^{***}	0.25^{***}	0.24^{***}
	(0.01)	(0.01)	(0.02)
Mother's × Father's education		-0.04^{***}	-0.04^{***}
		(0.01)	(0.01)
Mother's religion…			
Christian			0.06^{***}
			(0.01)
Muslim			0.01
			(0.05)
Jewish			−0.01
			(0.07)
Other			0.15^{**}
			(0.05)
Father's religion…			
Christian			0.06^{***}
			(0.01)
Muslim			−0.02
			(0.04)
Jewish			0.30^{***}
			(0.07)
Other			-0.18^{**}
			(0.06)
Child's year of birth /100	0.11^{**}	0.08^{*}	0.23^{***}
	(0.03)	(0.03)	(0.03)
Observations	18793	18793	18222
Sampling weights	Yes	Yes	Yes
Adjusted R^2	0.14	0.15	0.16

Note: Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Reference category for wife/husband religion fixed effects is "No religion."

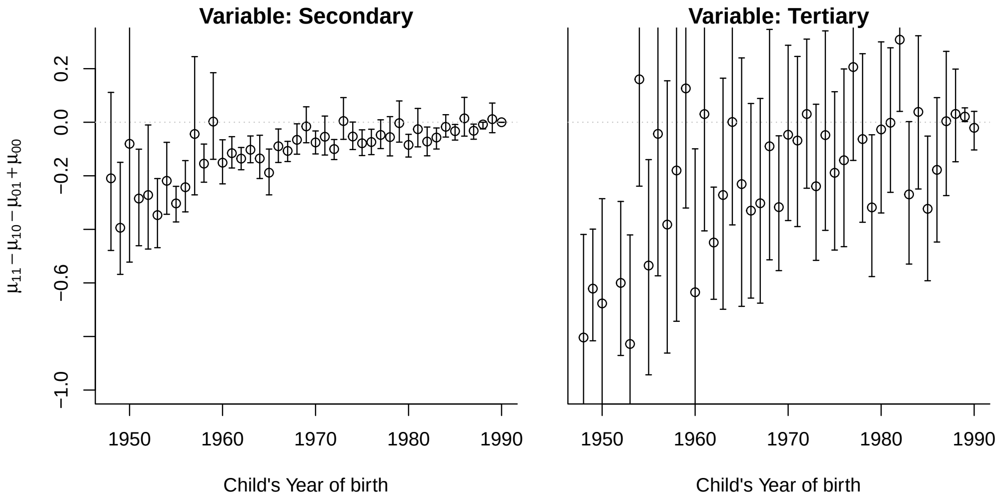

Figure A8: Interaction effects of parents' education levels for the child's education. 95% confidence intervals for $\mu_{11} - \mu_{10} - \mu_{01} + \mu_{00}$ are reported for each cohort. Left panel uses Secondary diplomas to define the binary education variable e_i, right panel uses Tertiary diplomas.

$\hat{\mu}_{e_m e_f}$ of $\mu_{e_m e_f}$ is the sample mean of e_c on the subsample of respondents with a mother e_m and a father e_f. The point estimate for (28) is then simply $\hat{\mu}_{11} - \hat{\mu}_{10} - \hat{\mu}_{01} + \hat{\mu}_{00}$. The confidence interval is obtained by simulation, knowing that each $\hat{\mu}_{e_m e_f}$ follows a binomial distribution. I obtain the point estimate -0.120, with $[-0.132, -0.108]$ for the 95% confidence interval. This estimate can be interpreted as follows: the gain from having an additional Secondary-educated parent is 12 p.p. less for children who already have one Secondary-educated parent, compared to children who have none. This result indicates that interaction effects are negative. Next I perform the same exercise within cohorts. The results are shown in Figure A8. Again, estimates for (28) are negative, even within cohorts.

As a last control, I perform the same exercise but instead define e_i as

$$e_i = \mathbf{1}_{\{i \text{ has a Tertiary diploma}\}}.$$

Estimation of (28) on the full sample yields the point estimate -0.122 with 95% confidence interval $[-0.178, -0.066]$. Estimation within cohorts is again reported in Figure A8. Most point estimates remain negative, although many cannot be statistically distinguished from 0.

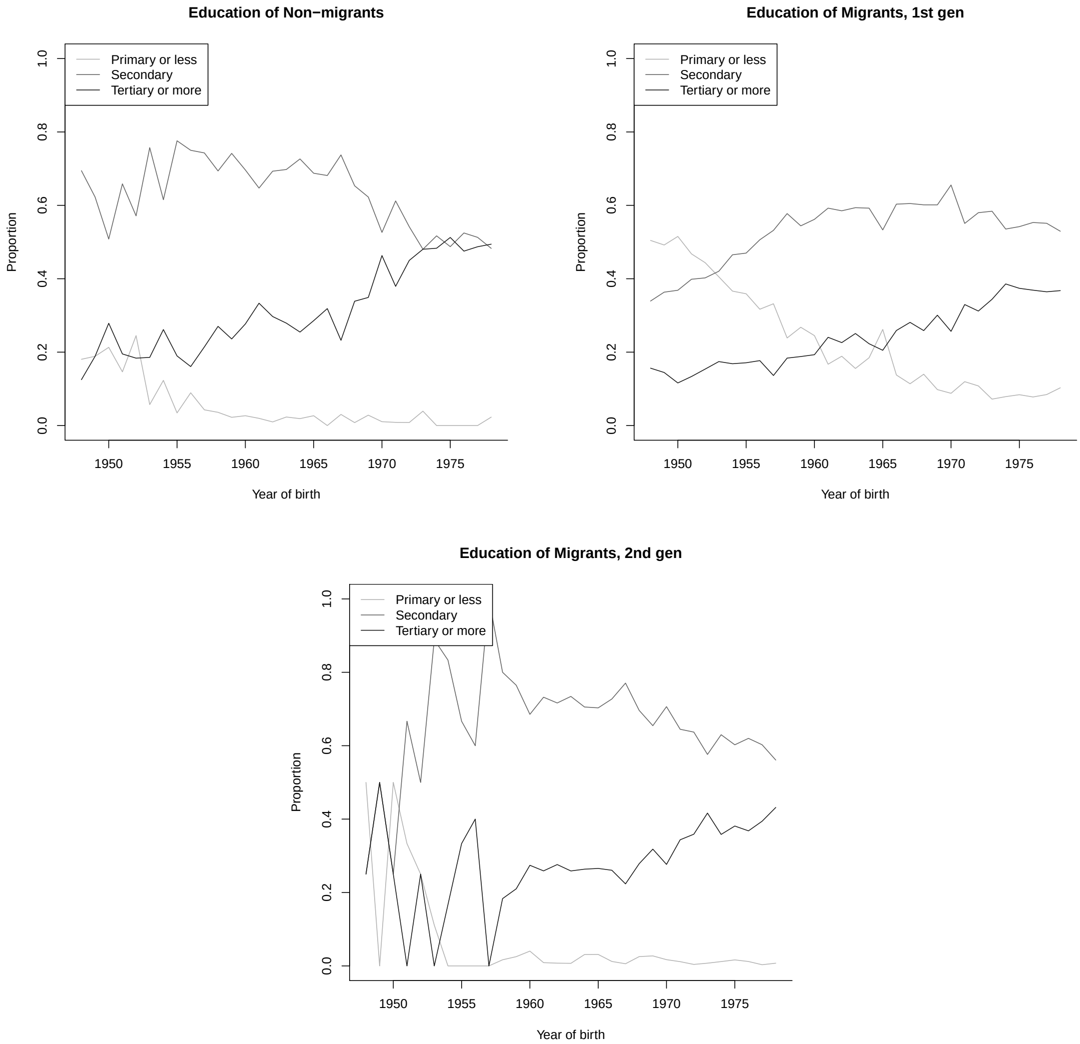

Figure A9: Education by Migration status.

Homogamy advantage. When focusing on households without a None parent, homogamous households perform significantly better than heterogamous households in passing on religious traits (Figure A10).

This advantage is also confirmed when considering transmission rates for any combination of parental religious affiliations (Figure A11).

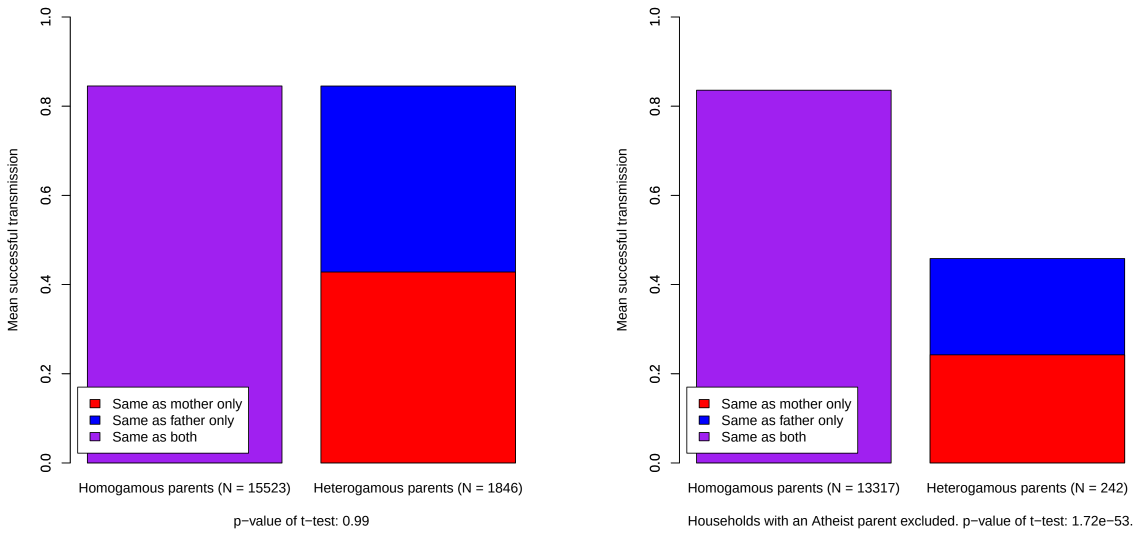

Figure A10: Transmission rates for homogamous and heterogamous households. The right-hand graph omits the respondents who declared having a 'No religion' parent.

Gender asymmetry. Another documented fact is that mothers pass on their cultural trait at a higher rate than fathers do. This difference is somewhat visible in Figure A11, where mothers' transmission rates (in red) seem overall more prominent than fathers' (in blue). However, no clear pattern emerges from the aggregated evidence. This is because the distribution of religious traits is different for mothers and fathers in the sample: in particular, there are more None fathers than mothers, which biases transmission success in the favor of fathers given the trend towards No religion mentioned above. For this reason, we must examine how mothers and fathers perform when they are in comparable situations. I systematically investigate this mother–father asymmetry in Figure A12 by comparing the respective religious transmission rates of mothers and fathers in symmetric household configurations. Specifically, for any religious traits a and b, I compute the difference between the transmission rate of mothers in households ab (i.e. when the mother has religion a and the father religion b) and the transmission rate of fathers in households ba (i.e. when the father has religion a and the mother religion b). I find that an argument can indeed be made for the larger role of mothers in religious transmission: in five cases this difference in transmission rates is significant at the 95% level in favor of mothers (None vs. Christian, None vs. Muslim, Christian vs. None, Jewish vs. Christian, Other vs. Christian). The Jewish vs. Christian case is notable, as it reflects that Jewish affiliation is passed down from the mother and not the father. In contrast, there is no significant advantage for fathers at the 95% level. If

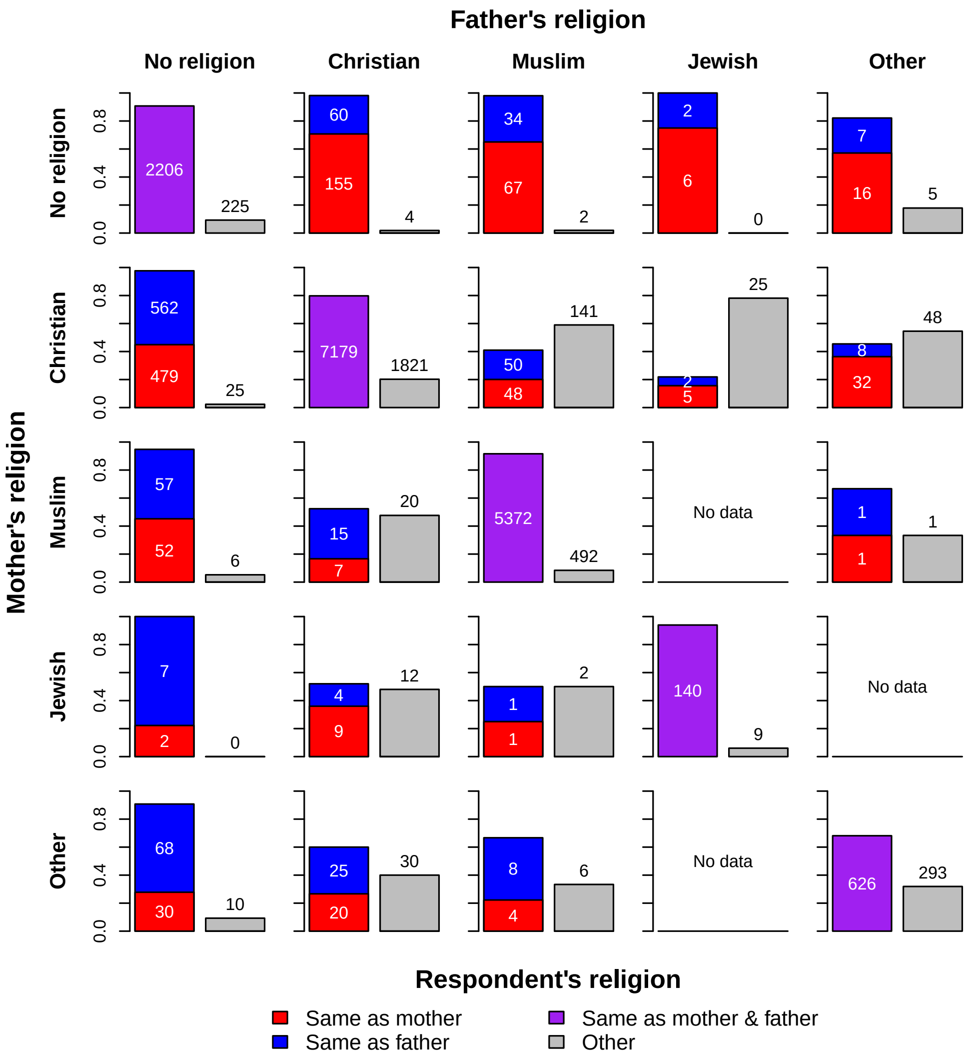

Figure A11: Transmission rates for all combinations of the parents' religions (number of observations reported for each bar).

we broaden the confidence interval to the 90% level, mothers gain a significant advantage in the Muslim vs. None case, while fathers gain a significant advantage in the Christian vs. Muslim case (perhaps reflecting the fact that Muslim affiliation is primarily passed down from the father).

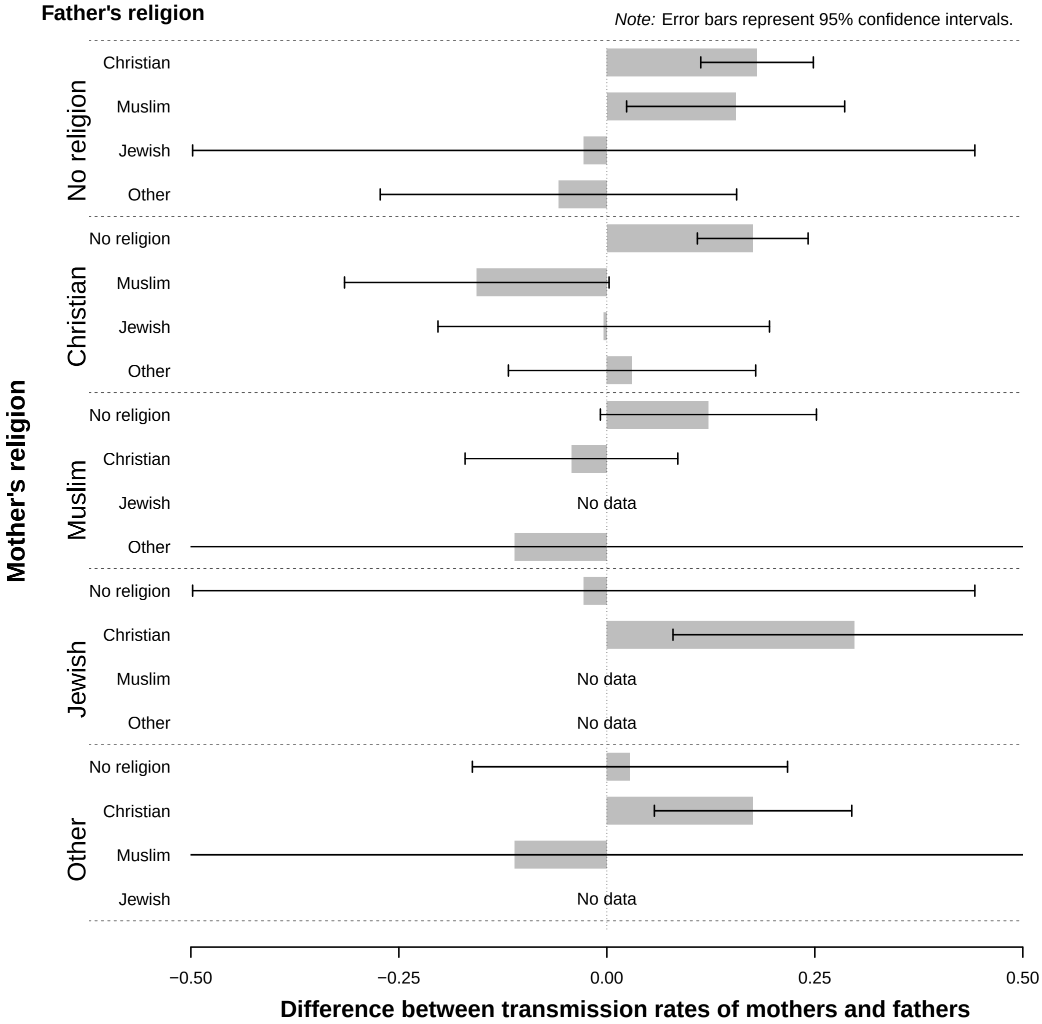

Figure A12: Mothers' advantage in religious transmission. Plotted are the differences between the transmission rate of mothers in households ab and the transmission rate of fathers in households ba for any religions $a \neq b$.

B Reduced-form models of transmission

B.1 Reconstructing population shares

Finding which population shares to use is not straightforward. Ideally, one should use a time series of religious shares in France over the period considered. Unfortunately, this information is not consistently available for every year. Instead, I resort to using the TeO survey data to reconstruct these population shares. I assume that for a given birth cohort y, the population that contributes to oblique socialization for that cohort consists of all individuals born between $y-1$ and $y-60$ who were residents of metropolitan France no later than $y+18$. Population shares for each trait n are computed accordingly in that subsample (which includes respondents' parents) by using sampling weights. The limit of $y-60$ means that individuals born more than 60 years before a given cohort do not affect that cohort's oblique socialization. This limit is chosen somewhat arbitrarily to account for deaths among older individuals, given that dates of death are not available. Furthermore, behind the decision to count only residents at $y+18$ is the implicit assumption that religious affiliation is decided by age 18. The resulting population shares involved in oblique socialization for every birth cohort are shown in Figure 15. As a point of comparison, in the same figure I also show the corresponding estimates from the 2005 World Values Survey based on 996 respondents. (The 2005 population shares correspond to those involved in the oblique socialization of cohort $2005-18=1992$). The estimates for the shares of Nones and Christians differ, with approximately 12 p.p. more Nones in the World Values Survey than in the reconstructed shares. However, these shares are consistent with estimates from other studies.

B.2 Derivation of testable restrictions

Following equation (3), the independence of irrelevant alternatives assumption of the conditional logit model takes the following form:

$$\begin{aligned}\ln\left(\frac{\pi_{in}}{\pi_{i\ell}}\right) = \ln K_{in} - \ln K_{i\ell} = k_n + m_n \mathbf{1}_{\{i\text{'s mother is } n\}} + f_n \mathbf{1}_{\{i\text{'s father is } n\}} + \alpha\, q_{y_i n} \\ - k_\ell - m_\ell \mathbf{1}_{\{i\text{'s mother is } \ell\}} - f_\ell \mathbf{1}_{\{i\text{'s father is } \ell\}} - \alpha\, q_{y_i \ell}\end{aligned}$$

where I have made explicit that q_{in} depends on i only through her year of birth y_i.

Call $\pi_{in\,|\,yab}$ the probability that i adopts trait n conditional on belonging to birth cohort y, and having a mother a and a father b. Then for any two traits a and b and two birth cohorts y

and $\tilde{y}$, we have:

$$\ln\left(\frac{\pi_{ia\,|\,yaa}}{\pi_{ib\,|\,yaa}}\right) = k_a + m_a + f_a + \alpha\, q_{ya} - k_b - \alpha\, q_{yb} \tag{29}$$

$$\ln\left(\frac{\pi_{ia\,|\,yab}}{\pi_{ib\,|\,yab}}\right) = k_a + m_a + \alpha\, q_{ya} - k_b - f_b - \alpha\, q_{yb} \tag{30}$$

$$\ln\left(\frac{\pi_{ia\,|\,\tilde{y}ba}}{\pi_{ib\,|\,\tilde{y}ba}}\right) = k_a + f_a + \alpha\, q_{\tilde{y}a} - k_b - m_b - \alpha\, q_{\tilde{y}b} \tag{31}$$

$$\ln\left(\frac{\pi_{ia\,|\,\tilde{y}bb}}{\pi_{ib\,|\,\tilde{y}bb}}\right) = k_a + \alpha\, q_{\tilde{y}a} - k_b - m_b - f_b - \alpha\, q_{\tilde{y}b}. \tag{32}$$

It follows that

$$\ln\left(\frac{\pi_{ia\,|\,yaa}}{\pi_{ib\,|\,yaa}}\right) - \ln\left(\frac{\pi_{ia\,|\,yab}}{\pi_{ib\,|\,yab}}\right) - \ln\left(\frac{\pi_{ia\,|\,\tilde{y}ba}}{\pi_{ib\,|\,\tilde{y}ba}}\right) + \ln\left(\frac{\pi_{ia\,|\,\tilde{y}bb}}{\pi_{ib\,|\,\tilde{y}bb}}\right) = 0. \tag{33}$$

Note that we cannot take a reference trait n_0 as pivot, in the sense that if equation (33) is true for the traits an_0 and bn_0, it does not imply that it is true for the traits ab. This is because this equation involves different subpopulations depending on the choice of the two traits:

- if we consider the property (33) for the traits a and n_0, then the subpopulation involved consists of all individuals with parents aa, an_0, n_0a, or n_0n_0;
- for the traits b and n_0, it is the individuals with parents bb, bn_0, n_0b, or n_0n_0;
- for the traits a and b, it is the individuals with parents aa, ab, ba, or bb.

Since the first two points do not involve individuals with parents ab or ba, there is no way that any combination of the two associated equations would yield results on this subpopulation and, consequently, no way that they could imply (33) for traits a and b.

We can however take a birth cohort y_0 as a pivot. That is, equation (33) is true for all a, b, y, and $\tilde{y}$, if and only if it is true for all a, b, and y, but taking $\tilde{y} = y_0$ fixed. In practice, however, this approach is not useful as I do not have enough observations to perform the test for every cohort. Instead, I consider the approximate test

$$\ln\left(\frac{\pi_{ia\,|\,aa}}{\pi_{ib\,|\,aa}}\right) - \ln\left(\frac{\pi_{ia\,|\,ab}}{\pi_{ib\,|\,ab}}\right) - \ln\left(\frac{\pi_{ia\,|\,ba}}{\pi_{ib\,|\,ba}}\right) + \ln\left(\frac{\pi_{ia\,|\,bb}}{\pi_{ib\,|\,bb}}\right) = 0 \tag{34}$$

where $\pi_{in\,|\,ab}$ is the probability that i will adopt n conditional on having a mother a and a father b (but no longer conditioning on birth cohorts). This simplification relies on almost-constant population shares over the period considered. Test results are presented in Figure B1, with 100,000 parametric bootstrap simulations to obtain confidence intervals. The $\pi_{in\,|\,ab}$ are computed considering sampling weights. There are 10 tests to perform, 2 of which cannot be computed because of a lack of observations. Among 8 computable tests, 5 do not reject the restriction at the 5% level, and 3 do.

As a next step, I test these hypotheses simultaneously through both global and multiple testing procedures. First, I compute the individual p-value for each test corresponding to a trait combination ab. This computation is not straightforward since it is not *a priori* clear which distribution the left-hand term of equation (34) follows under the null. Here I rely on a result from Katz et al. (1978), who show that a log-ratio of binomial distributions is approximately

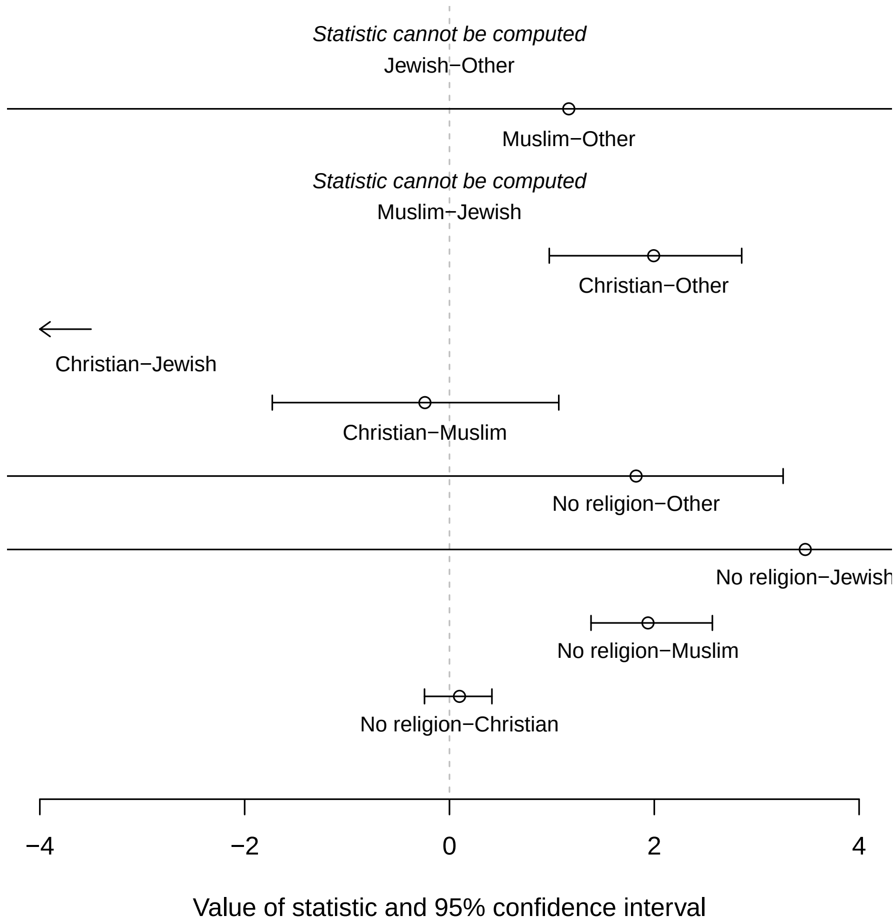

Figure B1: Statistical tests of equation (34) for all trait combinations ab.

normally distributed. Since the $\pi_{in\,|\,ab}$ follow binomial distributions, each logarithm term in (34) is approximately normally distributed, and therefore, the left-hand side of equation (34) is approximately normally distributed (as a sum of normal distributions). I compute the p-value for the test ab by checking how the empirical estimate of the statistic compares to the normal distribution with mean zero and standard deviation equal to that recovered by parametric bootstrap (although it is not clear whether the null (34) would also modify the standard deviation of the distribution). There are 8 such computable p-values (corresponding to the 8 computable tests).

Once p-values are computed, I can follow Bonferroni's method for global testing. Among 8 tests, 3 have a p-value below .05/8 (the 3 tests that reject the null individually), so Bonferroni's method leads to rejection (34). I can also follow the procedure of Benjamini and Hochberg (1995) for multiple testing, to control for the false discovery rate (FDR). In Figure B2 I plot the p-values corresponding to each test, ordered from smallest to largest, along with the threshold line of slope $j\gamma/S$, with S the total number of tests, j the index variable, and $\gamma = 5\%$ the level of the multiple test. This procedure leads to rejecting the same 3 tests that were rejected above.

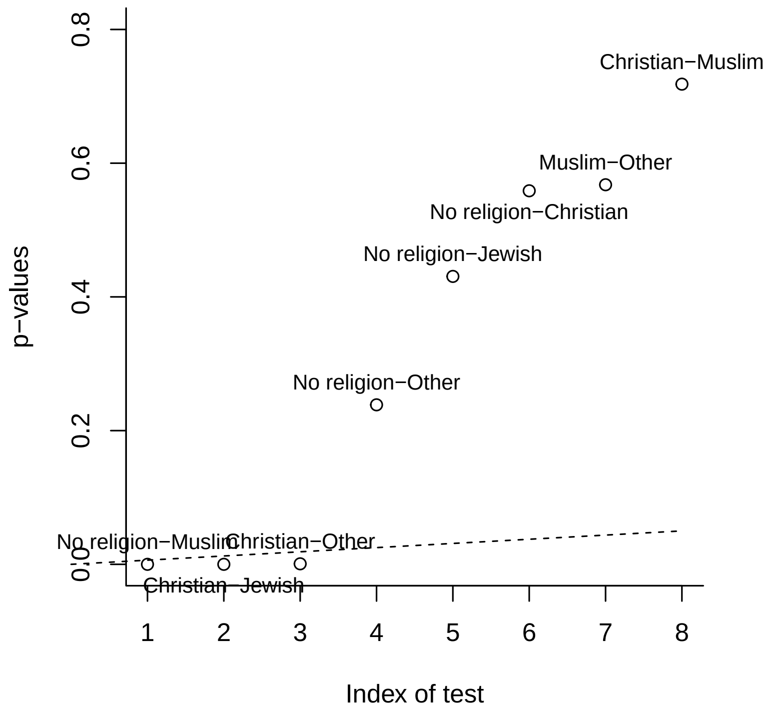

Figure B2: Benjamini–Hochberg procedure for multiple testing. p-values under the dashed line imply rejection of the corresponding test.

B.3 Observed vs. simulated transmission rates by religion and education categories

See Figure B3.

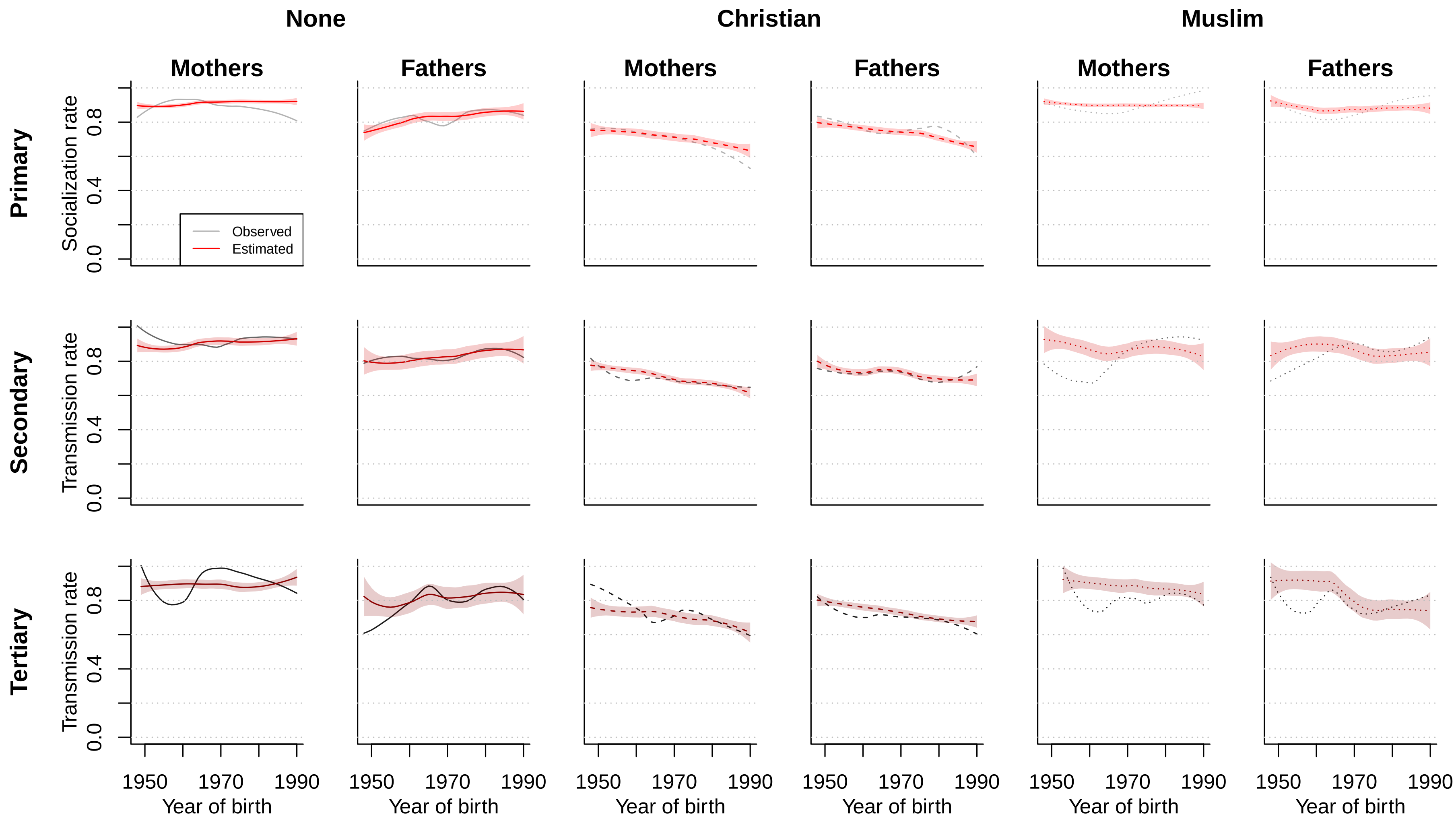

Figure B3: Conditional logit transmission, smoothed observed vs. simulated transmission rates (by Religion & Education).

C Household formation and population dynamics

Household formation. The next step is to embed the collective household model into a matching framework, in which men and women match on the two characteristics {religion, education}. In the classical framework, women and men meet on a bilateral, frictionless marriage market. Households are formed endogenously based on the indirect utility provided by the match to each of the spouses. The associated equilibrium concept is stability: a matching is stable if and only if no two individuals would rather match together than stay in their current match.

The matching models usually fall into one of three categories: transferable utility (TU), imperfectly transferable utility (ITU), and nontransferable utility (NTU) (Chiappori 2017). Here, the homogamous household problem has the NTU property (under the assumption that the individual value of culture is homogeneous within a given culture), while the heterogamous household problem has the ITU property. The NTU case is well documented (Roth and Sotomayor 1990). Recent works provide both theoretical and empirical results for the ITU case (Galichon et al. 2019, Galichon and Salanié 2022).

The first step to analyze matching in the ITU framework is to describe the Pareto frontier of the household by expressing the utility of parent 1 as a decreasing function of the utility of parent 2,

$$u_1 = \Phi(\theta_1, \theta_2, u_2)$$

where $\theta_i = (n_i, h_i) \in \Theta$ is the bidimensional type of parent i, and Φ is decreasing in u_2. A match is then characterized by a measure ψ over Θ^2 and utility functions $u_1(\theta_1)$ and $u_2(\theta_2)$ such that

$$u_1(\theta_1) = \Phi(\theta_1, \theta_2, u_2(\theta_2)) \qquad \forall(\theta_1, \theta_2) \in \operatorname{supp} \psi.$$

Stability requires

$$u_1(\theta_1) \geq \Phi(\theta_1, \theta_2, u_2(\theta_2)) \qquad \forall(\theta_1, \theta_2) \in \Theta^2$$

which implies

$$u_1(\theta_1) = \max_{\vartheta_2} \; \Phi(\theta_1, \vartheta_2, u_2(\vartheta_2))$$

and similarly for $u_2(\theta_2)$. One can then use first-order conditions to analyze the matching problem.

In my case, even though the function Φ exists, I cannot find a closed-form expression for it. Instead, I can parametrize the Pareto frontier by the power μ,

$$\begin{aligned} u_1 &= \Phi_1(\theta_1, \theta_2, \mu) \\ u_2 &= \Phi_2(\theta_1, \theta_2, \mu), \end{aligned}$$

where Φ_1 is increasing and Φ_2 is decreasing in μ. A match must then be characterized by a measure ψ over Θ^2, utility functions $u_1(\theta_1)$ and $u_2(\theta_2)$, and a power function $\mu(\theta_1, \theta_2)$ such that

$$\begin{aligned} u_1(\theta_1) &= \Phi_1(\theta_1, \theta_2, \mu(\theta_1, \theta_2)) \\ u_2(\theta_2) &= \Phi_2(\theta_1, \theta_2, \mu(\theta_1, \theta_2)) \end{aligned}$$

for all $(\theta_1, \theta_2) \in \operatorname{supp} \psi$. Stability requires

$$u_1(\theta_1) \geq \Phi_1(\theta_1, \theta_2, \mu(\theta_1, \theta_2))$$
$$u_2(\theta_2) \geq \Phi_2(\theta_1, \theta_2, \mu(\theta_1, \theta_2))$$

for all $(\theta_1, \theta_2) \in \Theta^2$, implying

$$u_1(\theta_1) = \max_{\vartheta_2} \Phi_1(\theta_1, \vartheta_2, \mu(\theta_1, \vartheta_2))$$
$$u_2(\theta_2) = \max_{\vartheta_1} \Phi_2(\vartheta_1, \theta_2, \mu(\vartheta_1, \theta_2)).$$

First-order conditions with respect to h_2 and h_1 write

$$\frac{\partial \Phi_1}{\partial h_2}(\theta_1, \theta_2, \mu(\theta_1, \theta_2)) + \frac{\partial \mu}{\partial h_2}(\theta_1, \theta_2) \times \frac{\partial \Phi_1}{\partial \mu}(\theta_1, \theta_2, \mu(\theta_1, \theta_2)) = 0$$
$$\frac{\partial \Phi_2}{\partial h_1}(\theta_1, \theta_2, \mu(\theta_1, \theta_2)) + \frac{\partial \mu}{\partial h_1}(\theta_1, \theta_2) \times \frac{\partial \Phi_2}{\partial \mu}(\theta_1, \theta_2, \mu(\theta_1, \theta_2)) = 0$$

which is a partial differential equation for μ.

The following issues arise compared to the usual framework:

- There is no explicit form for the function Φ that allows to describe the Pareto frontier with u_1 as a function of u_2. Consequently, I must rely on parametrizing the Pareto frontier by the Pareto weight μ, thus introducing a new function into the equilibrium. A consequence is that μ must be recovered through a system of partial differential equations rather than a standard differential equation for recovering utilities.
- The type of individuals is bidimensional, with the first dimension being discrete. Thus, the solution cannot be characterized entirely by first-order conditions.

The empirical analysis might, however, be easier. The bidimensional type is now (n, e), which takes a finite number $N \times E$ of values. Index these types by I for women and J for men. The goal is to find the Pareto weights μ^{IJ} that best explain the empirical matching patterns, according to the individuals' discrete choices. Denoting women by $i \in I$ and men by $j \in J$, these discrete choice problems are

$$u_i = \max_j \left\{ \Phi_1(I, J, \mu^{IJ}) + \alpha_i^J \right\}$$
$$u_j = \max_i \left\{ \Phi_2(I, J, \mu^{IJ}) + \beta_j^I \right\}$$

where α_i^J and β_j^I are random shocks that depend exclusively on the partner's type, as in the Choo and Siow (2006) framework. These translate into a probability for each individual i or j of marrying a partner of type J or I. In this case, estimation must be performed simultaneously on marriage patterns and transmission patterns to jointly estimate the Pareto weights μ^{IJ} and the parameters of the utilities and production functions that I estimated previously.

Population dynamics. The last contribution of this paper will be to study the population dynamics implied by the model. This can be conducted either empirically or theoretically. Empirically: once the model's primitive parameters are estimated, one can iterate the model to simulate the evolution of the population along the two dimensions of interest (religion and education). This simply requires to solve for the ITU matching equilibrium, for which a solution was proposed by Galichon and Salanié (2022). From the matching equilibrium, we can infer the joint distribution of religious traits and educational levels in the next generation through the collective household model. It might be possible to perform the same exercise theoretically for sufficiently simple distributions of traits.

The dynamic implications could be interesting. For instance, if the cultural minority starts with lower average human capital than the majority (as is for instance the case with immigrants in many countries), the need to safeguard their culture could occur at the expense of their human capital development, such that the human capital gap between cultural minority and majority could widen with time. (Or, at the least, this mechanism could delay the catch-up of the minority with the majority compared to the baseline case wherein people do not care about cultural transmission.) Intuitively, this process could lead to a higher-educated, little-socialized cultural majority on the one side and a lower-educated, highly socialized cultural minority on the other side.

D Analysis of deviance residuals

In order to examine the validity of the hypothesis of independent errors in section 5.1, here I analyze the residuals of the estimated structural model. In qualitative response models such as multinomial logit or ordered logit (which are the two models that I use), there are several options for computing residuals. Notable examples include response residuals, Pearson residuals, generalized residuals, or deviance residuals. Deviance residuals, in particular, are obtained by measuring the contribution of each individual observation to the total deviance of the estimated model. In models with multiple choice they are the easiest to handle because they are one-dimensional – whereas in the case of Pearson or generalized residuals, there are as many residuals as there are possible responses. For this reason, i choose deviance residuals for this analysis.

From equation (26), we can rewrite the deviance of the model as

$$-2\ln L = \sum_i w_i\,(d_i^{\text{rel}} + d_i^{\text{edu}}) \tag{35}$$

where

$$d_i^{\text{rel}} = -2\sum_{n=1}^{N} \mathbf{1}_{\{i \text{ is } n\}} \ln(\pi_{in}) \qquad \text{and} \qquad d_i^{\text{edu}} = -2\sum_{e=1}^{E} \mathbf{1}_{\{i \text{ is } e\}} \ln(\phi_{ie}) \tag{36}$$

are the contributions of the individual observation i to the deviance, in terms of religious affiliation (d_i^{rel}) and educational attainment (d_i^{edu}) respectively. Deviance residuals r_i^{rel} and r_i^{edu} are then defined as

$$r_i^{\text{rel}} = (-1)^{\mathbf{1}\{n_i \neq \arg\max_n K_{in}\}}\sqrt{d_i^{\text{rel}}} \tag{37}$$

$$r_i^{\text{edu}} = (-1)^{\mathbf{1}\{\ln H_i > \bar{h}_{e_i}\}}\sqrt{d_i^{\text{edu}}}. \tag{38}$$

To understand the signs, recall that n_i is the observed religion of i and K_{in} her predicted level of religious capital in religion n. The condition $n_i \neq \arg\max_n K_{in}$ is then satisfied when the religious affiliation predicted by the model for i is different than the actual one. Thus, r_i^{rel} is positive if the model correctly predicted the religious affiliation of individual i, and negative otherwise. This sign is consistent with the definition of response residuals for binomial logit models, for instance.

For the education residuals, recall that e_i is the observed education level of i, and $\bar{h}_{e_i}$ is the ordered logit threshold between having education level e_i and $e_i + 1$. Furthermore, $\ln H_i$ is the predicted level of (log-)human capital for i. Thus, r_i^{edu} is positive if the model predicted an education level identical or below the observed one, and negative otherwise. This is consistent with the common understanding of residuals (e.g. in traditional linear models), in which residuals are negative if the model "overshoots," and positive if it "undershoots."

I compute these deviance residuals, and present them in Figure D1. The plot represents the education residuals r_i^{edu} as a function of the religion residuals r_i^{rel}, as well as the best linear prediction. Note that there are no residuals r_i^{rel} between -1 and 0 (roughly). This is a mechanical consequence of the multinomial logit model: if an affiliation n is not predicted by the model (negative residuals), it means that its associated choice probability must be below 1/2 (otherwise it would be the most likely outcome, i.e. the predicted outcome). As a consequence, in this case

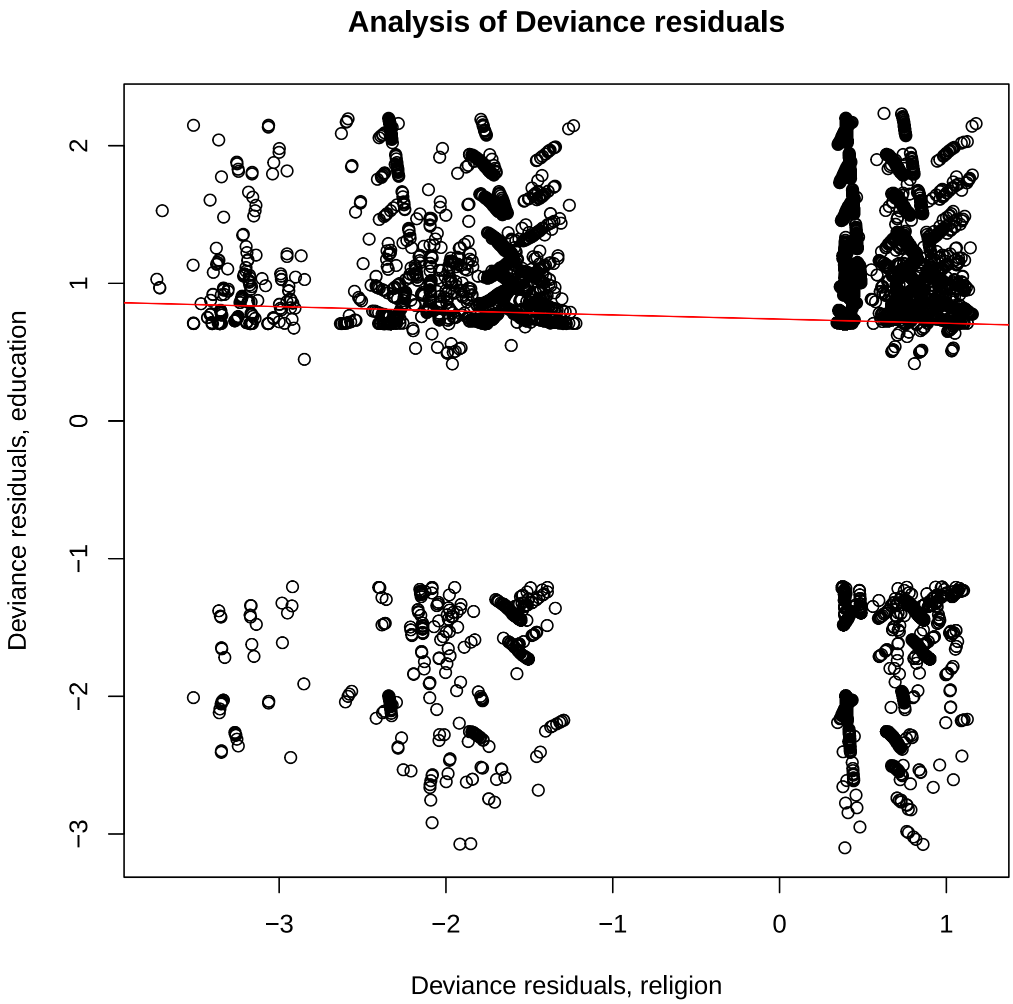

Figure D1: Deviance residuals on religion r_i^{red} and education r_i^{edu}, along with linear prediction (in red).

the deviance contribution d_i^{rel} must be more than $-2\ln(1/2) = 2\ln 2$. Finally, the residual must be less than $-\sqrt{2\ln 2} \simeq 1.18$; this is consistent with the observed values for r_i^{rel}. For a similar reason, there are no residuals r_i^{edu} between -1 and 0 (again, roughly), leading to an "empty cross" pattern.

The linear fit suggests a very weak negative correlation between the religious affiliation residuals r_i^{rel} and the educational attainment residuals r_i^{edu}. This suggests that the assumption on the independence of errors is reasonable.

E Educational homogamy: local log odds ratios analysis

In this section I follow the methodology of Siow (2015) to study educational homogamy using local log odds ratios. As pointed out by Siow, simply computing correlations of spouses' education levels remains a weak test of homogamy since we don't know how high the correlation should be to infer that the data indeed exhibits homogamy. A stronger tests consists in verifying that all local log odds ratios are positive.

To begin with, Table E1 provides the sample distribution of marriages according to the spouses' education levels. The repartition of marriages is thus represented by a 3×3 matrix $(n_{ij})_{1 \le i,j \le 3}$, for a total number of observations N. The local log odds ratios are defined for $i, j \le 2$ as

$$\ln \left(\frac{n_{ij}\, n_{i+1,j+1}}{n_{i,j+1}\, n_{i+1,j}} \right) \tag{39}$$

which constitutes a measure of local homogamy in the submatrix $\left(\begin{smallmatrix} n_{ij} & n_{i,j+1} \\ n_{i+1,j} & n_{i+1,j+1} \end{smallmatrix} \right)$. In particular if random matching is occurring, one should expect all these log odds ratios to be equal to 0.

Siow (2015) shows that supermodularity of the marital surplus implies that all local log odds ratios should be positive, i.e. that the matrix $(n_{ij})_{1 \le i,j \le 3}$ should be totally positive of order 2, or TP2 for short. I test this TP2 criterion statistically by following the method prescribed by Garre et al. (2002), which Siow (2015) also follows. First define three different hypotheses: H_0 corresponds to the restricted model where all local log odds ratios are equal to 0; H_1 the model where they are positive; and H_2 the unrestricted model. Hypothesis H_0 also means that the matrix $(n_{ij})_{1 \le i,j \le 3}$ is totally null of order 2, which I call TN2 for short. Call L_0, L_1, and L_2 the models' respective likelihoods: for instance,

$$L_1 = \max_{\nu_{ij}} \sum_{ij} n_{ij} \ln(\nu_{ij}) \tag{40}$$

subject to the constraints

$$\ln \left(\frac{\nu_{ij}\ \nu_{i+1,j+1}}{\nu_{i,j+1}\ \nu_{i+1,j}} \right) \ge 0 \qquad (\forall i, j \le 2) \tag{41}$$

and

$$\sum_{ij} \nu_{ij} = N. \tag{42}$$

The likelihood L_0 is obtained by using an equality constraint in (41), and L_2 by removing

Mother's education	Father's education			Total
	Primary or less	Secondary	More than secondary	
Primary or less	8998	1968	298	11264
Secondary	1136	3428	1023	5587
More than secondary	97	428	1417	1942
Total	10231	5824	2738	18793

Table E1: Parental education and homogamy.

Mother's education	Father's education: Pri	Sec	Sec+	Total		Local log odds ratios: Pri, Sec	Sec, Sec+
	TP2 probabilities					TP2 log odds	
Pri	0.479	0.105	0.016	0.600	Pri, Sec	2.624	0.678
	(0.004)	(0.002)	(0.001)			(0.039)	(0.068)
Sec	0.060	0.182	0.054	0.296	Sec, Sec+	0.380	2.406
	(0.002)	(0.003)	(0.002)			(0.119)	(0.061)
Sec+	0.005	0.023	0.075	0.103			
	(0.001)	(0.001)	(0.002)		LR_{01} statistic: 10 352		
Total	0.544	0.310	0.145	1	p-value: 0		
	TN2 probabilities						
Pri	0.326	0.186	0.087	0.599			
	(0.003)	(0.002)	(0.002)				
Sec	0.162	0.092	0.043	0.297			
	(0.002)	(0.001)	(0.001)				
Sec+	0.056	0.032	0.015	0.103			
	(0.001)	(0.001)	(0.000)				
Total	0.544	0.310	0.145	1			

Note: Standard errors in parentheses (parametric bootstrap, 100 replications).

Table E2: Estimated probabilities and local log odds ratios – full sample.

constraint (41) entirely. The statistics of interest are log-likelihood ratio (LR) test statistics,

$$\text{LR}_{01} = 2(L_1 - L_0) \qquad \text{and} \qquad \text{LR}_{12} = 2(L_2 - L_1). \tag{43}$$

The statistic LR_{12} indicates to what extent TP2 fits the data, and LR_{01} tests whether positive local log odds ratios are a better fit than if they are null. When samples obey TP2, I test H_1 versus H_0. When they do not, I test H_1 versus H_2. I report estimates of the probabilities $p_{ij} = \frac{\nu_{ij}}{N}$ for a marriage observation to fall in the ij category. The p-values and standard errors are obtained by parametric bootstrap with 100 replications.

Analysis on the full sample. Table E2 presents the estimated probabilities and the associated local log odds ratios for the full sample. The local log odds ratios are all positive, so the data obeys TP2. For this reason, the estimates from the unrestricted problem are the same as the TP2 estimates, which is why I only report the latter. In this case, the relevant hypothesis test is H_1 versus H_0: is there evidence for positive local log odds ratios, rather than them being all zeros? The associated test statistic is LR_{01}.

The value of the LR_{01} test statistic is very large in this case, at 10 352. Accordingly, the p-value is extremely small – in fact, it cannot be differentiated from 0 at the precision level which I use. This provides strong evidence to reject the null hypothesis H_0 that local log odds ratios are all zeros, in favor of H_1 and TP2. In turn, this provides strong evidence of homogamy and of the supermodularity of the marital surplus in the full sample.

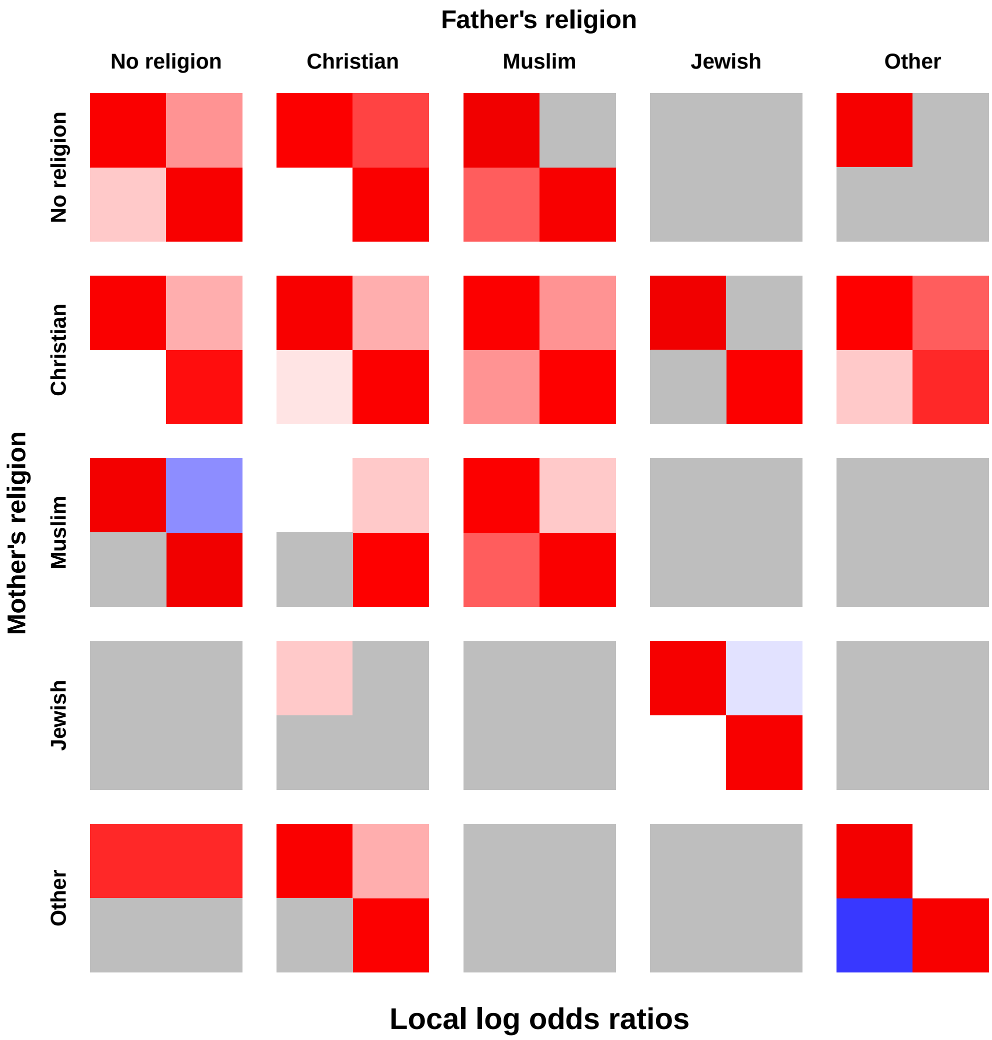

Figure E1: Local log odds ratios conditional on spouses' religious affiliation. Red indicates positive values, and blue negative ones. Lighter shades indicate values closer to 0. Gray indicates missing values.

Analysis conditional on spouses' religious affiliations. Figure E1 presents the empirical local log odds ratios conditional on spouses' religious affiliation using a color chart. Red indicates positive values, and blue negative ones (gray indicates missing data). A glimpse at the figure shows that most of the local log odds ratios which can be computed are positive. I test TP2 for each configuration of the spouses' religious affiliation, using the same method as for the full sample.

Mother: No religion Father: No religion						
	Father's education				Local log odds ratios	
Mother's education	Pri	Sec	Sec+		Pri, Sec	Sec, Sec+
	Unrestricted probabilities				Unrestricted log odds	
Pri	0.342	0.094	0.009	Pri, Sec	2.425	0.860
	(0.011)	(0.007)	(0.002)		(0.134)	(0.300)
Sec	0.085	0.264	0.059	Sec, Sec+	0.531	2.657
	(0.006)	(0.010)	(0.006)		(0.322)	(0.162)
Sec+	0.006	0.034	0.107			
	(0.002)	(0.004)	(0.007)			
	TP2 probabilities				TP2 log odds	
Pri	0.342	0.094	0.009	Pri, Sec	2.425	0.860
	(0.011)	(0.007)	(0.002)		(0.119)	(0.301)
Sec	0.085	0.264	0.059	Sec, Sec+	0.531	2.657
	(0.006)	(0.009)	(0.005)		(0.318)	(0.161)
Sec+	0.006	0.034	0.107			
	(0.002)	(0.004)	(0.006)			
	TN2 probabilities			$N = 2033$		
Pri	0.193	0.175	0.078	LR_{12} statistic: 0		
	(0.007)	(0.005)	(0.004)	p-value: 1		
Sec	0.176	0.160	0.071	LR_{01} statistic: 1 211		
	(0.005)	(0.005)	(0.004)	p-value: 0		
Sec+	0.064	0.058	0.026			
	(0.004)	(0.004)	(0.002)			

Note: Standard errors in parentheses (parametric bootstrap, 100 replications).

Table E3: Estimated probabilities and local log odds ratios – No religion, No religion.

Mother: No religion Father: Christian						
	Father's education				Local log odds ratios	
Mother's education	Pri	Sec	Sec+		Pri, Sec	Sec, Sec+
	Unrestricted probabilities				Unrestricted log odds	
Pri	0.175	0.079	0.005	Pri, Sec	2.212	1.427
	(0.026)	(0.021)	(0.005)		(0.462)	(38.636)
Sec	0.069	0.286	0.079	Sec, Sec+	0.042	2.454
	(0.020)	(0.028)	(0.017)		(7.964)	(0.404)
Sec+	0.016	0.069	0.222			
	(0.010)	(0.018)	(0.027)			
	TP2 probabilities				TP2 log odds	
Pri	0.175	0.079	0.005	Pri, Sec	2.212	1.427
	(0.031)	(0.021)	(0.005)		(0.496)	(23.882)
Sec	0.069	0.286	0.079	Sec, Sec+	0.042	2.454
	(0.019)	(0.033)	(0.017)		(13.175)	(0.389)
Sec+	0.016	0.069	0.222			
	(0.007)	(0.019)	(0.030)			
	TN2 probabilities			$N = 189$		
Pri	0.067	0.112	0.080	LR_{12} statistic: 0		
	(0.011)	(0.015)	(0.013)	p-value: 1		
Sec	0.112	0.188	0.133	LR_{01} statistic: 109		
	(0.015)	(0.022)	(0.017)	p-value: 0		
Sec+	0.080	0.133	0.094			
	(0.012)	(0.019)	(0.015)			

Note: Standard errors in parentheses (parametric bootstrap, 100 replications).

Table E4: Estimated probabilities and local log odds ratios – No religion, Christian.

Mother: No religion Father: Muslim						
	Father's education				Local log odds ratios	
Mother's education	Pri	Sec	Sec+		Pri, Sec	Sec, Sec+
	Unrestricted probabilities				Unrestricted log odds	
Pri	0.375	0.011	0.000	Pri, Sec	3.561	+Inf
	(0.057)	(0.012)	(0.000)		(20.911)	(20.160)
Sec	0.170	0.182	0.045	Sec, Sec+	1.322	2.639
	(0.038)	(0.042)	(0.022)		(22.206)	(9.429)
Sec+	0.011	0.045	0.159			
	(0.012)	(0.024)	(0.043)			
	TP2 probabilities				TP2 log odds	
Pri	0.375	0.011	0.000	Pri, Sec	3.561	26.579
	(0.049)	(0.013)	(0.000)		(13.546)	(5.671)
Sec	0.170	0.182	0.045	Sec, Sec+	1.322	2.639
	(0.043)	(0.045)	(0.021)		(14.614)	(0.914)
Sec+	0.011	0.045	0.159			
	(0.011)	(0.022)	(0.043)			
	TN2 probabilities			$N = 88$		
Pri	0.215	0.092	0.079	LR_{12} statistic: 0		
	(0.036)	(0.022)	(0.022)	p-value: 1		
Sec	0.221	0.095	0.081	LR_{01} statistic: 71		
	(0.042)	(0.023)	(0.019)	p-value: 0		
Sec+	0.120	0.052	0.044			
	(0.027)	(0.017)	(0.013)			

Note: Standard errors in parentheses (parametric bootstrap, 100 replications).

Table E5: Estimated probabilities and local log odds ratios – No religion, Muslim.

Mother: No religion Father: Jewish						
	Father's education				Local log odds ratios	
Mother's education	Pri	Sec	Sec+		Pri, Sec	Sec, Sec+
	Unrestricted probabilities				Unrestricted log odds	
Pri	0.250	0.000	0.000	Pri, Sec	–	–
	(0.163)	(0.000)	(0.000)		(9.925)	(11.615)
Sec	0.375	0.000	0.125	Sec, Sec+	–	–
	(0.190)	(0.000)	(0.115)		(4.953)	(14.785)
Sec+	0.000	0.000	0.250			
	(0.000)	(0.000)	(0.162)			
	TP2 probabilities				TP2 log odds	
Pri	0.250	0.000	0.000	Pri, Sec	7.410	13.921
	(0.132)	(0.000)	(0.000)		(3.095)	(5.022)
Sec	0.375	0.000	0.125	Sec, Sec+	15.385	8.021
	(0.161)	(0.000)	(0.123)		(4.501)	(8.117)
Sec+	0.000	0.000	0.250			
	(0.000)	(0.000)	(0.144)			
	TN2 probabilities			$N = 8$		
Pri	0.156	0.000	0.094	LR_{12} statistic: 0		
	(0.105)	(0.000)	(0.079)	p-value: 0.750		
Sec	0.312	0.000	0.187	LR_{01} statistic: 6.086		
	(0.139)	(0.000)	(0.103)	p-value: 0.010		
Sec+	0.156	0.000	0.094			
	(0.114)	(0.000)	(0.074)			

Note: Standard errors in parentheses (parametric bootstrap, 100 replications).

Table E6: Estimated probabilities and local log odds ratios – No religion, Jewish.

	Mother: No religion	Father: Other				
	Father's education				Local log odds ratios	
Mother's education	Pri	Sec	Sec+		Pri, Sec	Sec, Sec+
	Unrestricted probabilities				Unrestricted log odds	
Pri	0.250	0.000	0.000	Pri, Sec	–	–
	(0.163)	(0.000)	(0.000)		(9.925)	(11.615)
Sec	0.375	0.000	0.125	Sec, Sec+	–	–
	(0.190)	(0.000)	(0.115)		(4.953)	(14.785)
Sec+	0.000	0.000	0.250			
	(0.000)	(0.000)	(0.162)			
	TP2 probabilities				TP2 log odds	
Pri	0.250	0.000	0.000	Pri, Sec	7.410	13.921
	(0.132)	(0.000)	(0.000)		(3.095)	(5.022)
Sec	0.375	0.000	0.125	Sec, Sec+	15.385	8.021
	(0.161)	(0.000)	(0.123)		(4.501)	(8.117)
Sec+	0.000	0.000	0.250			
	(0.000)	(0.000)	(0.144)			
	TN2 probabilities			$N = 24$		
Pri	0.156	0.000	0.094	LR_{12} statistic: 0		
	(0.105)	(0.000)	(0.079)	p-value: 1		
Sec	0.312	0.000	0.187	LR_{01} statistic: 25.125		
	(0.139)	(0.000)	(0.103)	p-value: 0		
Sec+	0.156	0.000	0.094			
	(0.114)	(0.000)	(0.074)			

Note: Standard errors in parentheses (parametric bootstrap, 100 replications).

Table E7: Estimated probabilities and local log odds ratios – No religion, Other.