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ABSTRACT

Dynamic Models of Religious Conformity and Conversion: Theory and Calibrations

by Oz Shy*

This paper develops behavioral and deterministic overlapping generations models to explain and simulate changes in the proportion of secular and religious people. Under the behavioral approach, the role of the church is to generate an externality associated with the investment in enhancing the conformity rate among young believers. Under the deterministic approach, changes in the number of nonbelievers are explained by different birth rates among secular and religious parents as well as the relative proportion of nonconformists among the young in each group. This model is then used to calibrate for (non)conformity rates among secular and religious people.

Keywords: *Conversion, Religious conformity, Role of the Church, Nonconformity, Nonreligious people, Religious Affiliation, Parents' education, Believers, Nonbelievers*

JEL Classification: Z12

ZUSAMMENFASSUNG

Dynamische Modelle religiöser Konformität und Konversion: Theorie und Simulationen

Diese Arbeit entwickelt deterministische und Verhaltensmodelle mit überlappenden Generationen, welche die Veränderungen des Zahlenverhältnisses von nicht religiösen zu religiösen Menschen erklären und simulieren. Im Verhaltensansatz wird aufgezeigt, dass der Kirche die Aufgabe zukommt, einen externen Effekt zu erzeugen, der dafür sorgt, dass junge Gläubige mit der Glaubenseinstellung ihrer Eltern konform gehen. Der deterministische Ansatz erklärt die Veränderungen in der Anzahl Nichtgläubiger einerseits mit den unterschiedlichen Geburtenraten unter nichtgläubigen Eltern im Vergleich zu religiösen Eltern und andererseits durch den relativen Anteil von Nichtkonformen unter der jungen Generation in jeder Gruppe. Dieses Modell wird verwandt, um (Nicht-)Konformitätsraten – nach denen junge Menschen ihren Eltern im Glauben folgen oder nicht - innerhalb der Gruppen weltlicher sowie religiöser Menschen zu berechnen.

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1. Introduction

1.1 Motivation

Sociologists are divided among themselves as to whether people have become more religious or less religious over the past 200 years (the so called "secularization paradigm"). On one hand the observed resurgence of evangelical Christianity in the United States, the rise of Islamic fundamentalism in the Middle East, and the rapid growth of Protestantism in Latin America may create an impression that parts of the world are drifting away from secular beliefs. On the other hand, as we further discuss below, one should be very careful in interpreting the above observations since they do not conflict with other observations showing a clear rise in those who consider themselves as nonreligious (secular people in what follows).

The secularization paradigm postulates a decline in the social power of religion. Earlier and much stronger interpretations of this paradigm included a view that religions may cease to appeal to the masses with the advance in technologies, communication, and the process of democratization. These views are discussed by Sociology scholars such as Wilson (1966) and Martin (1978) among others. For the purpose of this paper, however, I limit the interpretation of this paradigm to imply only a long-term increase in both the absolute and relative numbers of nonreligious secular people in given societies.[1] Of course, even under this narrow interpretation, the rise in the number of secular people (or simply people who lose their interest in all aspects of religion) may also be be associated with a decline in the extent to which people engage in religious practices.

As noted by Stark and Bainbridge (1985), social scientists have misread the future of religion partly because they erroneously equated religion with a particular set of organizations. The secularization paradigm, which has relied on a "reduction-in-demand" argument, has been challenged since the mid-1980s by "market-oriented" and supply-side theories, see for example Stark

[1] In fact, it should be mentioned right from the start that this paper is not about "secularization" in the broad sense of this term, since the process of secularization may be referred to the process of deepening the separation of church and state. That is, paradoxically under this broad definition, separation of church and state may be supported even by strongly religious people.

and Bainbridge (1987), Finke and Stark (1992), and Stark and Iannaccone (1994). This line of thinking postulates that humankind will always need religion.[2] Thus, if one form of religion declines, another one should take its place. That is, the supply-side argument focuses on the rise and fall of religious institutions and organizations. In this line of thinking, Stark and Iannaccone (1994) argue that supply-side weaknesses, inefficient religious organizations, and highly-regulated economies explain the secularization of many European nations.

It should be pointed out that sociologists still continue to strongly disagree among themselves on the applicability of the secularization paradigm. Not only do they disagree on the theory, but amusedly they also disagree on how to interpret the data. Bruce (2002) challenges the interpretation of the data used by those who oppose the secularization paradigm and supplies a large number of counter facts supporting long-run increases in the number of secular people. On p.43 he writes:

> "...while the proportion of atheists in a population is an interesting secondary indicator (as it is steadily increasing in the West), it is not a primary test. ...I see the popularity of religious belief as a useful index of secularization. I expect the proportion of people who are largely indifferent to religious ideas to increase and the seriously religious to become a small minority."

The goal of the present paper is to model, explain, and simulate changes in the proportion of secular and religious people in a society. Religious affiliations are commonly observed in any society, across all continents, and cut through all nations with all levels of per-capita income. The formation of the various secular groups received much less attention in the literature. This paper attempts to close this gap by explicitly modeling the transition (conversion) of people between the religious and the secular groups. The paper constructs a testable overlapping-generations model in which young can always choose whether adhere to their parents belief (secular versus

[2]Under this approach, the demand for religion stems from essentially the scarcity of rewards, which puts people on the market searching for compensators. Since religion is able to invoke the supernatural, religion is superior to secular philosophies and therapies in the supply of such compensators. Hence, the demand for religion should be high and stable over time.

religious), or whether to switch (convert) to the other group of believers or nonbelievers. The model computes the dynamic paths of the fraction of secular and religious people in a society. The resulting equilibrium paths of secular and religious people in a society are characterized as a function of two parameters sets: The birth rates and the proportion of conformists within each group. Conformists tend to adopt their parents' affiliation (secular versus religious) whereas nonconformists convert against their parents' belief. Thus, a marriage that results in a conversion against a person's parental belief is also captured by nonconformism in our model. In addition, this paper analyzes the foundation of (non)conformism from religious perspectives, and calibrates the model for these parameters.

A secondary goal of this paper is to develop a behavioral approach to conversion by introducing parents who can invest in "proper" education for the purpose of increasing the probability of conformity among their children. I show that the church plays an important role in creating an asymmetry between religious education and secular education, since church education generates an externality that enhances the conformity rate, as compared with privately-financed education.

1.2 Definitions

Secular people form a highly disparate group and not a single religion. Atheists are a small subset of this grouping that actually makes up less than one-tenth of one percent of the population in many countries in which large numbers claim no religious preference, such as the United States. Barrett, Kurian, and Johnson (2001) suggest the following definitions.

Nonreligious: Persons professing no religion, no interest in religion; secularists, materialists, agnostics, but not militantly antireligious or atheists.

Atheists: Militantly anti-religious or anti-Christian agnostics, secularists, or marxists.

Nonreligionists: Term encompassing the two varieties of unbelievers: (a) agnostics or secularists or nonreligious materialists who are not hostile to religion, and (b) atheists or anti-religious militantly opposed or hostile to religion.

In view of these definitions, this paper analyzes the evolution of nonreligionists, since it combines all groups of nonbelievers. For the sake of simplicity, I will be using the terms secular people, nonbelievers, and nonreligious people to mean nonreligionists.

1.3 Data

Table 1 presents aggregate percentage of secular people out of the total population in five continents (averaged from individual countries). Table 1 clearly indicates a rising trend in the proportion of people classified as secular, which was negligibly small at the turn of the 20th Century. As indicated in this table, some Asian countries experience a relative decline in secularization as more people convert to Christianity. Some decline is also observed in Europe, partly because of the increase in the number of member countries, some of which are dominated by Catholic believers. Finally, Africa and Latin America have the lowest percentage of secular people.

Continent	1900	1970	1990	1995	2000	2025
Africa:	0.0	0.2	0.7	0.7	0.7	0.9
Asia:	0.0	25.0	21.0	20.4	19.8	12.6
Europe:	0.5	21.3	18.7	18.2	17.8	14.7
L. America:	0.6	2.5	3.4	3.5	3.6	4.2
N. America:	1.2	4.7	9.0	9.4	9.7	12.9

Table 1: Percentage of secular people (nonreligious and atheists combined).
Source: Data prossessed from the *World Christian Encyclopedia*.

Table 2 displays somewhat more detailed data for a sample of countries. Table 2 reveals that atheists form a small fraction of secular people regardless of whether the fraction of secular people is high or low among the entire population of the country. This is because atheism is considered to be an extreme belief even among nonbelievers. In this sample of countries, the percentage of atheists grows at a much smaller rate than the percentage of nonreligious people who are not atheists. Unlike the data on the five continents displayed in Table 1, here the sampled countries exhibit a fast (generally accelerating) growth in the rate of secular people (atheists and nonreligious combined).

Country	1900		1970		1990		1995		2000		2025	
	A	N	A	N	A	N	A	N	A	N	A	N
Argentina:	0.1	0.1	0.6	0.9	0.7	2.9	0.7	2.2	0.8	2.3	0.8	3.4
Australia:	0.0	0.1	0.7	1.9	0.8	6.4	0.8	6.8	0.8	6.8	1.0	8.6
England:	0.0	1.9	0.5	7.9	1.3	11.3	1.3	11.6	1.4	11.8	1.7	13.5
Germany:	0.1	0.2	2.5	7.1	2.2	16.8	2.2	17.1	2.2	17.2	1.9	17.6
Spain:	0.0	0.0	0.4	1.8	1.1	4.3	1.1	4.4	1.1	4.6	1.5	5.7
Sweden:	0.1	1.0	9.9	14.8	11.9	17.5	11.9	17.5	11.9	17.5	12.1	18.2
U.S.A.:	0.0	1.3	0.1	4.8	0.3	8.4	0.4	8.7	0.4	9.0	0.5	12.3

Table 2: Percentages of atheists (A) and other nonreligious (N) people among the entire population in a sample of countries. *Source*: *World Christian Encyclopedia*

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Some sociologists may explain the increase in the number of secular people relative to the population size by the advance of science and by the introduction of a variety of media that spreads this information (such as, radio, television, magazines, and lately the powerful Internet). The present paper argues that the secularization process is somewhat more complicated as it creates intergenerational conflicts, mainly concerning interreligious marriages. For this reason this paper formulates an overlapping generations model in order to explore the dynamic paths of secularization on one side, and the magnitude of religious affiliation on the other side.

Finally, it is interesting to note that even academic scientists differ significantly in their attitude towards nonreligious and atheist ideas. For example, Stark, Iannaccone, and Finke (1996) report that in the hard sciences around 27% have no religion and 11% oppose to religion. In contrast, 36% of those in social sciences have no religion and 13% oppose to religion.

1.4 Additional literature

We have already discussed some related literature on conversions. Additional literature includes Iannaccone (1998), who provides a general literature survey on the economics of religion. Shy (2001, Ch.11) sketches some static examples on the directions of conversions between two religions. Montgomery (1996) is perhaps the closest to the present research. In his dynamic model, conformity is generated by "religious capital" which makes children become socialized into their parents' religion as they become familiar with the belief, doctrine, rituals, tradition, and fellow

members. Nonconformity in his model is generated by a mismatch between a believer's income earning and the level of strictness of a particular denomination, where the assumed utility function implies a substitution effect between income and strictness. Thus, high income people will seek less strict (or more secular) denominations. The interesting feature in Montgomery's model is that individuals may leave their parents' denomination either because it is too strict or too lax, depending on their social class as manifested by their income. Depending on income distribution, Montgomery's model can predict the rise and fall of new denominations and sects, as well as secular denominations, that can be endogenously determined within the model.

The economics literature on social influence and conformism includes Weiss and Fershtman (1998) who survey the ideas and results from sociology and economics, recognizing that economic decisions are often shaped by social concerns and influences. There is a vast theoretical literature on the effects of conformity and social pressure on consumption demand and prices. This literature includes Bagwell and Bernheim (1996), Bernheim (1994), and much earlier publications such as Leibenstein (1950) and Veblen (1899). In particular, some papers such as Hackner and Nyberg (1996), Corneo and Jeanne (1997), and Grilo, Shy and Thisse (2001), analyze negative social externalities commonly addressed to as vanity, snobbism, or simply nonconformity.

On the "theological" side, there are some empirical papers investigating why and which type of people tend to switch religions. Loveland (2003) shows that formally joining a church while growing up acts to stabilize preferences for a denomination. Other papers testing the determinants of switching religions include Sherkat (1991) and Hadaway, Kirk, and Marler (1993) (see also their references). However, these findings are less related to the present investigation since religious *switching* is a much weaker concept than *conversion*. That is, a change from a Baptist denomination to a Methodist denomination is a switch just as a switch from a Protestant denomination into the Roman Catholic faith is a switch. In contrast, a change from the Catholic faith, or more relevantly to the present paper, a change from an agnostic belief into Judaism would better be termed as *conversion*. Unfortunately I am not aware of similar statistical studies exploring the exact determinants of conversions in general, and the conversion between a secular belief to (and from) a religious affiliation in particular.

Finally, our model relies on differences in birth rates between secular and religious people as one (but not the only one) factor influencing the paths of secular and religious population groups. The cross effects between religious affiliations and fertility rates are noted in Lehrer (1996). These factors are important in addition to other demographic variables such as marriage, number of children, and work habits which are surveyed in Lehrer (2004). In fact, higher fertility rates among some religious groups relative to secular people may be explained by the fact that some religions provide psychological and social rewards to couples who have many children, in the form of approval, social status, and blessings.

1.5 Organization

The present study is organized as follows. Section 2 develops the benchmark infinite-horizon overlapping-generations environment designed for the purpose of analyzing two-way conversion patterns between secular and religious affiliations. Section 3 focuses on the behavioral approach by introducing the church and parents who are willing to invest in "proper" education for the purpose of increasing the conformity rate of their children. Section 4 computes and characterizes dynamic equilibria of the deterministic model. Section 5 simulates equilibrium secularization and religious paths, and also calibrates the model for some specific observations to obtain estimates for the magnitude of religious nonconformity. Section 6 develops two alternative models of religious nonconformity by characterizing several utility functions that generate the nonconformity patterns leading to the conversions described in the basic model. Section 7 offers some concluding comments.

2. A Model of Conformity and Conversion

Consider an overlapping generations model of individuals who can choose to affiliate themselves with one and only one of two communities labeled S and R. Community R consists of individuals who are affiliated and practice a religious faith. Community S consists of individuals who consider themselves as nonreligious secular people. Therefore, by *conversion* we refer to a young person

who is born secular and then becomes religious, and the vice versa.

All individuals live for two periods. At the end of their first period individuals choose whether to affiliate themselves with a religious faith or with the secular people.[3] In each period t, there are s_t^{t-1} and r_t^{t-1} generation $g = t-1$ *old* secular and religious people, respectively. Thus, superscripts denote generations whereas subscripts denote time periods. In period $t = 1$, there are initial $s^0 = s_1^0$ and $r^0 = r_1^0$ generation $g = 0$ secular and religious people who are old at $t = 1$.

Let $\beta_S > 0$ and $\beta_R > 0$ denote the *birth rates* of secular and religious people, respectively. Birth rates are defined as the number of offsprings per each old person. Clearly, the believer and nonbeliever population groups are nondecreasing if $\beta_S, \beta_R \geq 1$, and declining if $\beta_S, \beta_R < 1$. We assume that individuals are born as either conformists or nonconformists where conformism is to be defined below. Formally, let γ_S^t and γ_R^t, where $0 < \gamma_S^t, \gamma_R^t < 1$, denote the fraction of the young who are born as *conformists* to secular and religious people, respectively, in period t. Therefore, the fractions $(1-\gamma_S^t)$ and $(1-\gamma_R^t)$ of all newly born secular and religious people are born as *nonconformists*. Note that the conformity rates could be variables that are influenced by the church, see Section 3 for the behavioral approach. Alternatively, γ_S^t and γ_R^t can be treated as exogenously-given parameters that eventually must be estimated, see the deterministic approach in Sections 4 and the calibration in Section 5.

The above discussion implies that the numbers of *young* religious and secular generation $g = t$ conformists, labeled as c, and nonconformists, labeled n, as functions of the old of generation $g = t-1$, are given by

$$ {}^c r_t^t = \beta_R \, \gamma_R^t \, r_t^{t-1} \qquad\qquad {}^n r_t^t = \beta_R (1-\gamma_R^t) r_t^{t-1}, \tag{1a} $$

$$ {}^c s_t^t = \beta_S \, \gamma_S^t \, s_t^{t-1} \qquad\qquad {}^n s_t^t = \beta_S (1-\gamma_S^t) s_t^{t-1} \tag{1b} $$

for $t = 1, 2, \ldots$. Clearly, ${}^c r_t^t + {}^n r_t^t = r_t^t$ and ${}^c s_t^t + {}^n s_t^t = s_t^t$ meaning that the young of each generation belonging to each community are divided exactly into the conformists and nonconformists subgroups according to (1a) and (1b).

[3] Iannaccone (1998) reports on research confirming our assumption that conversion decisions are made by young individuals and that conversions among older people should be very rare.

We define *conversion* as a decision by a young individual to switch between groups. Clearly, two conversions are possible: A young individual who is born to religious parents can convert to become secular, and a young person who is born to secular parents can convert and join a religious faith. We therefore make the following assumption.

ASSUMPTION 1. *In each period, all young conformists adopt the same affiliation as their parents', whereas all nonconformists convert and affiliate themselves against their parents' belief.*

Assumption 1 identifies those who convert by those who do not conform with their parents' belief. This raises the question whether and how parents can reduce their offsprings' conversion rates by simply reducing the rate of nonconformity, or the probability that their offsprings become nonconformists. The roles of parents and the church in influencing conformity rates γ_R^t and γ_S^t are analyzed in Section 3 below.

The populations consisting of conformists and nonconformists described by (1a) and (1b) and Assumption 1 imply that the secular and religious populations of generation $g = t$ who are *old* in period $t+1$, as functions of the generation $t-1$ religious and secular groups, are given by

$$r_{t+1}^t = \beta_R \gamma_R^t r_t^{t-1} + \beta_S (1-\gamma_S^t) s_t^{t-1} \tag{2a}$$

$$s_{t+1}^t = \beta_R (1-\gamma_R^t) r_t^{t-1} + \beta_S \gamma_S^t s_t^{t-1}, \tag{2b}$$

for each period $t = 1, 2, \ldots$. Therefore, (2a) reveals that each new generation of religious people consists of the fraction γ_R^t of the previous generation of believers, and a fraction $(1-\gamma_S^t)$ of the secular people of the previous generation, who converted to become religious when young. Clearly, all these figures must be multiplied by the relevant birth rates, β_R or β_S. Equation (2b) reveals that each new generation of secular people consists of the fraction $(1-\gamma_R^t)$ of religious people who converted to become secular when young, and the fraction γ_S^t of those who adhere to their parents' secular belief.

3. The Behavioral Approach: The Role of the Church

This section introduces into the model parents who are concerned with the possibility that their children will convert against their own belief. Moreover, we assume that parents can influence the conformity rates of their children by letting the conformity rates (or probabilities) γ_R^t and γ_S^t depend on parents' investment in "proper" education. For religious parents, this investment includes enrollment of their children to Sunday schools, denomination-oriented private schools, repeated church attendance, and holiday celebrations.[4] Investment in secular education is harder to describe, and may not even exist in significant levels as it is intended to prevent children from becoming religious. Such antireligious education may paradoxically include some religious education in order to make the children aware of the different approaches.

3.1 Parents, "proper" education, and the Church

From the above discussion, we can infer that there are some asymmetries between religious education and secular education concerning the consequences of this education on children's conformity rates. That is, religious education tends to be more organized and more community supported than secular education. In fact, secular education seems to prevail more at the family level compared with religious education which is church-supported.[5] Let ${}^{R}e_t^{t-1}$ and ${}^{S}e_t^{t-1}$ denote the period t expenditure of a generation $t-1$ parent on religious or secular education of their children, respectively. Also, let the probability that a young would become a conformist γ depend on parents' education expenditure and satisfy $\gamma(0) = 0$, $\gamma(e) \to 1$ as $e \to +\infty$, $\gamma' > 0$, and $\gamma'' < 0$. That is, if parents don't invest in their children, their children will surely become nonconformists (and hence will convert). However, even by spending a large amount on "proper" education, parents cannot guarantee 100% conformity by their children. For the remainder of

[4] Business week, May 23, 2005, reports that the Evangelist Lakewood enterprise, that brought in $55 million in one year, plans a Sunday school for 5,000 children in downtown Houston. The main campus of Groeschel's Life Church in Edmond, Okla., with a weekly Sunday school attendance of 2,500, includes a "Toon Town" of 3D buildings, a 16-foot high slide, and an animatronic police chief who recites rules.

[5] Secular education should not be confused with publically-funded general education. Here, by secular education I mean education intended to prevent children from becoming religious.

this section, we make the following assumption concerning the effect of education spending on the rates of conformity.

ASSUMPTION 2. *(a) Conformity-enhancing education of children of religious parents is provided by the church via contributions from parents. Formally, the period t probability that a young who is born to a religious person would become a conformist is $\gamma_R^t = \gamma(r_t^{t-1} \cdot {}^R e_t^{t-1})$.*

(b) Conformity-enhancing education of children of secular parents is individually financed by each parent separately. Formally, the period t probability that a young who is born to a secular person would become a conformist is $\gamma_S^t = \gamma({}^S e_t^{t-1})$.

Assumption 2(a) highlights the role played by the church as a generator of an externality associated with the "investment in conformity" by religious parents. This externality, and also the resulting free rider effect, are reflected by the assumption that the conformity rate is affected by *aggregate* expenditure of religious parents as given by product $r_t^{t-1} \cdot {}^R e_t^{t-1}$. This is in contrast with (b) where only the individual parent's expenditure ${}^S e_t^{t-1}$ matters for the conformity rate of children of secular parents. Assumption 2(a) portrays a church that collects a contribution/fee of ${}^R e_t^{t-1}$ from each adult member. These contributions from all religious parents are then combined to finance church services targeted for convincing young people to remain religious.

Important Remark: Some people may object to Assumption 2 by arguing that it is the public school system that actually generates an investment externality in secular conformity, and not the investment in religious conformity which is privately financed. I don't wish to argue with this claim since readers who believe that Assumption 2 should be reversed can simply relabel R as secular (instead of religious), and S as religious (instead of secular), and the entire model goes through. Finally, I must point out that in some countries, where separation of church and state are not fully observed, Assumption 2 should be made even stronger as religious studies are forced by the public school system, which is financed by all taxpayers.

We now formally define the preferences of parents. Note that there is no need to define the preferences of young people as they simply follow the conversion rules described by Assumption 1.

The period t utility functions of generation $t-1$ religious and secular parents are given by

$$
\begin{aligned}
{}^{R}U_t^{t-1} &\stackrel{\text{def}}{=} \alpha\gamma_R^t - {}^{R}e_t^{t-1} = \alpha\gamma(r_t^{t-1}\cdot {}^{R}e_t^{t-1}) - {}^{R}e_t^{t-1} && \text{(3a)}\\
{}^{S}U_t^{t-1} &\stackrel{\text{def}}{=} \alpha\gamma_S^t - {}^{S}e_t^{t-1} = \alpha\gamma({}^{S}e_t^{t-1}) - {}^{S}e_t^{t-1}, && \text{(3b)}
\end{aligned}
$$

where r_t^{t-1} is the number of religious parents given by (2a), and $\alpha > 1$ is a parameter that measures the importance of children's conformity rate. Thus, the utility function of each adult religious and an adult secular parent is the probability of their children becoming conformists less than the expenditure on "proper" education intended to influence the corresponding conformity probability. The church chooses a common expenditure level ${}^{R}e_t^{t-1}$ to maximize (3a). A secular parent chooses expenditure level ${}^{S}e_t^{t-1}$ to maximize (3b). By the strict concavity of the function γ, the first order conditions yield

$$
\begin{aligned}
\gamma'(r_t^{t-1}\cdot {}^{R}e_t^{t-1}) &= \frac{1}{\alpha\, r_t^{t-1}} && \text{(4a)}\\
\gamma'({}^{S}e_t^{t-1}) &= \frac{1}{\alpha}. && \text{(4b)}
\end{aligned}
$$

The utility maximization conditions (4a) and (4b) and the concavity of the function γ together imply that $\gamma_R^t > \gamma_S^t$ meaning that the rate of conformism among children of religious parents is higher than that of children of secular parents. This result follows from the externality assumption, Assumption 2(a). However, this result does not necessarily imply that religious parents spend more on education than secular parents since (4a) implies that sign(de/dr) =sign$[-r\gamma''/(\gamma' + r\gamma'')]$, which depends on the precise specification of the function γ.

Finally, after extracting the equilibrium parents' education expenses ${}^{R}e_t^{t-1}(r_t^{t-1})$ and ${}^{S}e_t^{t-1}$, from the first-order conditions (4a) and (4b), we can obtain the equilibrium conformity rates γ_R^t and γ_S^t. Substituting these into (2a) and (2b) yields the dynamic equilibrium paths of the number religious and secular people.

3.2 An example

Let the conformity function γ take the form of $\gamma(e) \stackrel{\text{def}}{=} 1 - 1/(e+1)$. Clearly, $\gamma(0) = 0$, $\gamma(e) \to 1$ as $e \to +\infty$, $\gamma' > 0$, and $\gamma'' < 0$. In view of Assumption 2, the conformity rates among religious

and secular young as functions of their parents' expenditure are given by

$$\gamma_R^t({}^R e_t^{t-1}, r_t^{t-1}) = 1 - \frac{1}{r_t^{t-1} \cdot {}^R e_t^{t-1}} \quad \text{and} \quad \gamma_S^t({}^S e_t^{t-1}) = 1 - \frac{1}{{}^S e_t^{t-1}}. \tag{5}$$

Substituting (5) into (3a) and (3b), the church and each secular parent of generation $t-1$ choose their period t education expenditures ${}^R e_t^{t-1}$ and ${}^S e_t^{t-1}$ respectively, to solve

$$\max_{{}^R e_t^{t-1}} {}^R U_t^{t-1} = \alpha - \frac{\alpha}{r_t^{t-1} \cdot {}^R e_t^{t-1}} - {}^R e_t^{t-1} \tag{6a}$$

$$\max_{{}^S e_t^{t-1}} {}^S U_t^{t-1} = \alpha - \frac{\alpha}{{}^S e_t^{t-1}} - {}^S e_t^{t-1}. \tag{6b}$$

The unique utility-maximizing expenditure levels are

$${}^R e_t^{t-1} = \frac{\sqrt{r_t^{t-1}}\sqrt{\alpha} - 1}{r_t^{t-1}}, \quad \text{and} \quad {}^S e_t^{t-1} = \sqrt{\alpha} - 1. \tag{7}$$

A natural question to ask at this stage is whether religious parents spend more or less on "conformity" education compared to secular parents. Comparing the two expenditures given by (7) yields the following result.

Result 1. *Given that religious conformity education is run by the church, period t religious parents spend less on conformity education relative to secular parents if and only if the period t number of religious parents is sufficiently large. Formally,*

$${}^R e_t^{t-1} \leq {}^S e_t^{t-1} \quad \textit{if and only if} \quad r_t^{t-1} \geq \frac{1}{\sqrt{(\alpha-1)^2}}.$$

Thus, strong externality effects prevailing in large churches induce the church to reduce the expenditure on conformity of children of religious parents relative to secular parents. The reverse occurs when the number of religious parents is small, in which case religious parents spend more than secular parents on maintaining conformity.

Substituting the equilibrium education expenditure levels (7) into (5), the equilibrium rates of conformity are then given by

$$\gamma_R^t(r_t^{t-1}) = 1 - \frac{1}{\sqrt{r_t^{t-1}}\sqrt{\alpha}} \quad \text{and} \quad \gamma_S^t = 1 - \frac{1}{\sqrt{\alpha}}. \tag{8}$$

Clearly, the conformity rate among children of religious parents exceeds that of children of secular parents as long as the period t number of religious parents satisfies $r_t^{t-1} \geq 1$.

Table 3 provides an example how endogenously-determined education levels can be computed. I chose simple numbers just for the sake of illustration. For example, ${}^{S}e_t^{t-1} = \sqrt{\alpha} - 1 = 1$ is

t	r_t^{t-1}	s_t^{t-1}	${}^{R}e_t^{t-1}$	${}^{S}e_t^{t-1}$	$\gamma_R^t(r_t^{t-1})$	γ_S^t
1	50	50	0.26	1.00	0.93	0.50
2	71	29	0.22	1.00	0.94	0.50
3	82	18	0.22	1.00	0.94	0.50
4	86	14	0.20	1.00	0.95	0.50
6	90	10	0.20	1.00	0.95	0.50
9	90	10	0.20	1.00	0.95	0.50

Table 3: Hypothetical evolution of religious and secular groups and endogenously-determined investments in "conformity" education. Simulations assume $\beta_R = \beta_S = 1$ and $\alpha = 4$.

the private expenditure by a secular parent. Hence, the conformity rate among secular young is constant $\gamma_S^t = 1 - 1/\sqrt{\alpha} = 0.5$. In contrast, the conformity education by religious parents given by (7) declines from 0.26 to 0.2 thereby reflecting an externality effect that is increasing with the number of religious parents who contribute to the church. Clearly, the increase in aggregate expenditure by religious parents increases the conformity rate among religious young, from 0.93 to 0.95.

The simple example given by Table 3 demonstrates a fast convergence from an initial ratio of 50% religious people climbing up to 90% within four generations. This example is based on Assumption 2 which models the church as a generator of a conformity education externality. As explained in a comment right below Assumption 2, changing the role of the education spending externality can produce an equilibrium where secular people become the majority.

4. The Deterministic Approach: Dynamic Equilibria

The analysis of Section 3 has demonstrated how the conformity rates γ_S and γ_R can be endogenously-determined within the overlapping-generations framework analyzed in this paper (see also Sec-

tion 6 below). For the purpose of calibration, however, this section and also Section 5 treat the conformity rates γ_S and γ_R as given parameters. Therefore, we now return to the basic overlapping generations model developed in Section 2. The basic model generates unique equilibrium affiliation paths, which will be shown to depend mainly on the population birth rates, β_S and β_R, as well as the conformity and nonconformity parameters, γ_S and γ_R. In what follows, Subsection 4.1 derives the basic intuition for a symmetric case under equal birth and conformity rates (but still maintains different initial affiliation levels so that r^0 need not be equal to s^0). Subsection 4.2 characterizes equilibrium affiliation paths under complete asymmetry.

4.1 Dynamic equilibrium under equal conformity and birth rates

In this subsection we analyze the simplest case where religious and secular people have identical birth rates, and their young offsprings share a common proportion of conformists and nonconformists. Formally, in this subsection we assume that $\beta_S = \beta_R = \beta$, and that $\gamma_S = \gamma_R = \gamma$.

Applying repeated substitution and backward induction on (2a) and (2b) yield the period $t+1$ total numbers of generation $g = t$ believers and secular people during their second period. Thus, for $t = 1, 2, \ldots,$

$$r_{t+1}^t = \frac{\beta^t(r^0 - s^0)(2\gamma - 1)^t + \beta^t(r^0 + s^0)}{2} \tag{9a}$$

$$s_{t+1}^t = \frac{\beta^t(s^0 - r^0)(2\gamma - 1)^t + \beta^t(r^0 + s^0)}{2}. \tag{9b}$$

Hence, the numbers of religious and secular old people is a linear combination of the initial difference in group sizes, $|r^0 - s^0|$ and the aggregate population size $r^0 + s^0$, both multiplied by the common period t birth factor β^t. However, the first terms in (9a) and (9b) decline very fast since $(2\gamma - 1)^t \longrightarrow 0$ as t increases. Figure 1 displays how the populations of religious and nonreligious people evolve over time for case where most people are born as conformists ($\gamma > 1/2$). Figure 1 illustrates that the religious and secular population groups converge to equal sizes in the long run regardless of the initial difference between the population groups, $r^0 - s^0$, and regardless of whether the total population is increasing or declining over time. Since conformists constitute a majority ($\gamma > 1/2$), the majority of people in each subsequent generation continue to

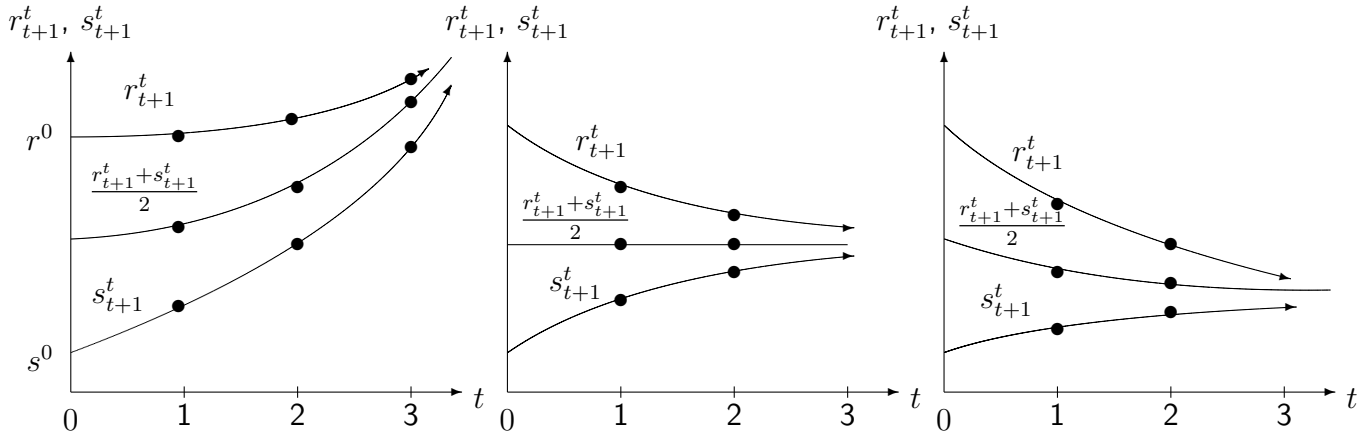

Figure 1: Evolution of religious and secular populations over time under $\gamma > 1/2$ and $r^0 > s^0$. *Left*: $\beta > 1$, *Middle*: $\beta = 1$, *Right*: $\beta < 1$.

adhere to their parents' belief. Therefore, the group that starts out as the largest group (religious people in the case plotted in Figure 1) remains the largest over time, but the difference between the group sizes converges very fast towards zero.

Figure 2 plots the polar case relative to Figure 1 assuming that conformists constitute the minority in the society ($\gamma < 1/2$). Figure 2 illustrates that when nonconformists constitute

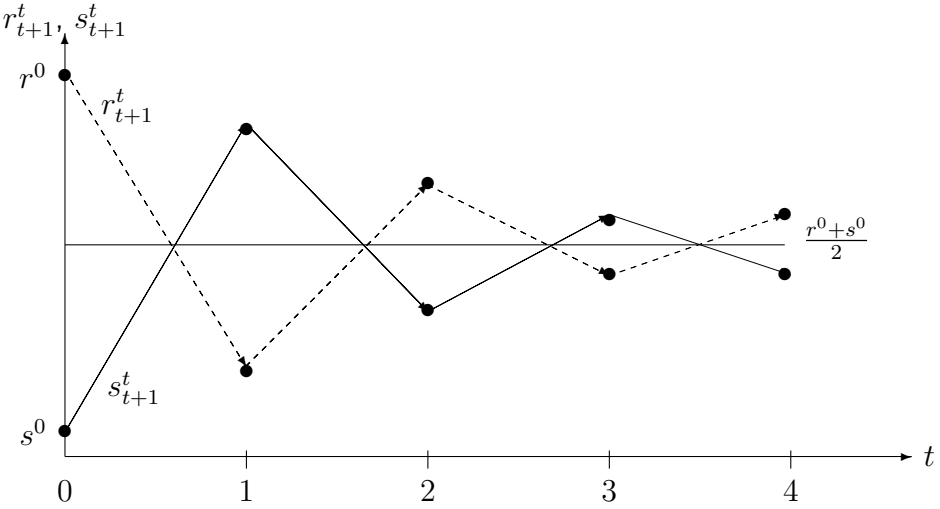

Figure 2: Evolution of religious and secular population over time under $\gamma < 1/2$, $r^0 > s^0$, and constant population $\beta_S = \beta_R = 1$.

the majority in a society, the large number of conversions in each period shifts the majority population of believers into the majority of secular people and vice versa as time progresses. These oscillations are dampened over time as the size of each group converges to half of the population size. Figure 2 is drawn under constant aggregate population ($\beta = 1$) for convenience only, but the reader should bear in mind that these oscillations can be plotted around the upward- and downward-sloping curves drawn in Figure 1(left) and 1(right), respectively.

We summarize our results for the symmetry case as follows.

Result 2. *Under Assumption 1, and under complete symmetry, $\beta_S = \beta_R = \beta$ and $\gamma_S = \gamma_R = \gamma$,*

(a) For any initial distribution of people between the two groups, s^0 and r^0, the population sizes of secular and religious people converge to half of the total population size. That is, $s^t_{t+1} \approx r^t_{t+1} \approx \beta^t(s^0 + r^0)/2$ for sufficiently large t.

(b) If conformists constitute the majority in a society, the religious population will exceed the secular population if and only if the initial religious population is larger than the initial secular population. Formally, if $\gamma > 1/2$, then $r^t_{t+1} \geq s^t_{t+1}$ if and only if $r^0 \geq s^0$. In contrast,

(c) If nonconformists constitute the majority ($\gamma < 1/2$), then the relative population sizes oscillate where if the religious population constitutes a majority in one period, secular people constitute a majority in a subsequent period, and the other way around.

Parts (b) and (c) follow directly by subtracting (9b) from (9a) to obtain $r^t_{t+1} - s^t_{t+1} = \beta^t(r^0 - s^0)(2\gamma - 1)^t$. Therefore, for $\gamma < 1/2$, the sign of this difference depends on whether t takes even or odd values.

Result 2 predicts that societies will be equally divided between religious and nonreligious people. That is, the believer and nonbeliever groups will converge to be of equal size and equal share in the total population in the long run. Clearly, since this prediction is unlikely to be observed in reality, we can state the following corollary.

Corollary 3. *The number of religious and secular people in the long run can differ only if either the two groups exhibit different birth rates, or different proportions of conformists and nonconformists.*

In view of Corollary 3, the following subsections explore dynamic equilibria under unequal birth rates and unequal proportions of conformists and nonconformists among the religious and the secular groups.

4.2 Dynamic asymmetric equilibria: The general case

In this subsection, we further extend the model by allowing for unequal birth rates ($\beta_S \neq \beta_R$) and unequal proportions of conformists and nonconformists among the young in each group ($\gamma_S \neq \gamma_R$). Since explicit solutions like the one given by (9a) and (9b) are hard to obtain for the general asymmetric case, we characterize the secular and religious evolution paths directly from the recursive laws of motion given by (2a) and (2b). This system of equations implies that the ratio of generation $g = t$ old religious people to the total old generation $g = t$ population is given by

$$f(t) \stackrel{\text{def}}{=} \frac{r_{t+1}^t}{r_{t+1}^t + s_{t+1}^t} = \frac{\beta_R \gamma_R r_t^{t-1} + \beta_S (1-\gamma_S) s_t^{t-1}}{\beta_R r_t^{t-1} + \beta_S s_t^{t-1}}, \quad t = 1, 2, \ldots \tag{10}$$

The function f is a contraction that converges to the steady-state equilibrium to be solved from $f(t+1) = f(t)$ for all $t = 1, 2, 3, \ldots$. Thus, (10) implies that the steady-state ratio of secular to religious people is

$$\frac{s}{r} = \frac{2\beta_R(1-\gamma_R)}{\sqrt{\beta_R^2\gamma_R^2 + 2\beta_R\beta_S[\gamma_R(\gamma_S-2) - 2(\gamma_S-1)] + \beta_S^2\gamma_S^2} + \beta_R\gamma_R - \beta_S\gamma_S}. \tag{11}$$

It can be easily verified from (11) that $s = r$ for any parameter values satisfying $\beta_S = \beta_R$ and $\gamma_S = \gamma_R$, which is consistent with our derivations in Subsection 4.1. The ratio obtained in (11) leads us to the following result.

Result 4. *For any given birth rates β_S and β_R, and any given proportions of conformists and nonconformists among young people, γ_S and γ_R, the long-run ratio of secular to religious people is* **independent** *of the initial distribution of secular and religious people, s^0 and r^0.*

Result 4 provides the key for understanding how the composition of secular and religious people may completely change over time since it highlights that in the long run only the relative birth rates and the proportion of nonconformists will matter.

In order to emphasize the role played by the different birth-rates, substituting $\beta_S = \beta_R$ into (11) yields

$$\frac{s}{r}\Big|_{\beta_S=\beta_R} = \frac{1-\gamma_R}{1-\gamma_S}. \tag{12}$$

This proves the following result.

Result 5. *Under any birth rates satisfying $\beta_S = \beta_R$,*

(a) The long-run ratio of secular to religious people depends **only** *on the proportion of conformists to nonconformists among the young within each group.*

(b) The long-term number of religious people exceeds the number of secular people if and only if young religious people tend to be more conformists relative to young secular people. Formally, $r \geq s$ if and only if $\gamma_R \geq \gamma_S$.

5. Simulations and Calibration

This section brings the model closer to reality by first testing the predictions of the model for hypothetical birth and conformity rates in Subsection 5.1. Then, Subsection 5.2 calibrates for the conformity and nonconformity rates in the two communities using real-life data on birth rates and the proportions of secular and religious people in the United States.

5.1 Some numerical simulations: The general case

The dynamic equilibrium characterized in the previous section can be numerically simulated by applying the laws of motion described by (2a) and (2b). All these simulations confirm fast convergence to the steady-stage evolution path characterized by (11). Table 4 displays a variety of numerical simulations and the fast convergence to the steady-state path given in (11).

t	r^t_{t+1}	s^t_{t+1}	$r^t_{t+1}+s^t_{t+1}$	$\frac{r^t_{t+1}}{r^t_{t+1}+s^t_{t+1}}$	$\frac{s^t_{t+1}}{r^t_{t+1}+s^t_{t+1}}$	$\frac{r^t_{t+1}}{s^t_{t+1}}$	$\frac{r}{s}$ eq.(11)
0	400	100	500	0.8000	0.2000	4.0000	
Symmetry case:			$\beta_R = \beta_S = 1.1$ and		$\gamma_R = \gamma_S = 0.8$		
1	374	176	550	0.6800	0.3200	2.1250	1.0000
2	368	273	605	0.6080	0.3920	1.5510	1.0000
3	376	290	666	0.6080	0.3920	1.5510	1.0000
5	421	384	805	0.5233	0.4767	1.0979	1.0000
8	541	530	1072	0.5050	0.4950	1.0204	1.0000
Unequal birth rates:			$\beta_R = 1.1 < 1.4 = \beta_S$ and		$\gamma_R = 0.8 = \gamma_S$		
1	380	200	580	0.6552	0.3448	1.9000	0.7076
2	390	308	698	0.5593	0.4407	1.2692	0.7076
3	430	430	860	0.5000	0.5000	1.0000	0.7076
5	600	755	1356	0.4427	0.5573	0.7945	0.7076
8	1166	1613	2779	0.4197	0.5803	0.7231	0.7076
Unequal conformists:			$\beta_R = 1.1 = \beta_S$ and		$\gamma_R = 0.6 < 0.9 = \gamma_S$		
1	275	275	550	0.5000	0.5000	1.000	0.2500
2	212	393	605	0.3500	0.3500	0.5385	0.2500
3	183	482	666	0.2750	0.7250	0.3793	0.2500
5	176	629	805	0.2188	0.7813	0.2800	0.2500
8	217	855	1072	0.2023	0.7977	0.2537	0.2500

Table 4: Hypothetical evolution of religious and secular groups.

Table 4 portrays a society that starts out with $r^0_1 = 400$ religious and $s^0_1 = 100$ secular people who are old in period $t = 1$. Thus, with no loss of generality these simulations are confined to an initial ratio of 4:1. The column on the right is the steady-state ratio of religious old people to secular old people computed directly from (11). The column next to column on the right displays the simulated ratio of religious to secular old people for generations $t = 1, 2, 3, 5, 8$. This column clearly demonstrates a fast convergence to its stead-state level computed in (11).

The top part of Table 4 simulates the symmetric case analyzed in Subsection 4.1 and Figure 1. This part confirms Result 2 by demonstrating the fast convergence to the steady-state 1:1 ratio of religious to secular people, regardless of the initial ratio (4:1 in the present example).

The middle part of Table 4 simulates unequal birth rates, where I deliberately assumed that $\beta_R < \beta_S$ to demonstrate that unequal birth rates are sufficient to explain long-term differences

between the two population groups. This example demonstrates that the largest group (religious people) can become a minority if its birth rate is below the birth rate of the other group (secular people).

The bottom part of Table 4 simulates unequal proportion of conformists and nonconformists between the groups. This part confirms Result 5 demonstrating that differences in size distribution among the groups can be explained solely by the emergence of different proportions of conformists and nonconformists in different congregations, religious and secular groups. Section 3 has already demonstrated the role of the church (or public education) in creating these differences. The choice of $\gamma_R < \gamma_S$ was simply to demonstrate again that initial size distribution (ratio of 4:1) can be reversed into a 1:4 ratio of religious to secular people if we assume that children who are born to religious parents tend to be less conformists than children to secular people (in this example).

5.2 Calibration for (non)conformity rates

Our model predicts the secular and religious affiliation paths based on four parameters: The birth rates, β_R and β_S, and the proportion of conformists, γ_R and γ_S. From a practical point of view, the birth rates are clearly observable and therefore can be obtained, whereas the conformity rates are much harder to find. This is partly because the conformity and nonconformity behavior can be viewed as utility-based choices that can be observed only via formal surveys. For this reason, in this subsection we demonstrate how to calibrate for the secular and religious conformity and nonconformity parameters using real-life data on birth rates and the actual number of secular and religious people in the United States.

Mosher, Williams, and Johnson (1992) carefully analyze how fertility rates in the United States are affected by the particular religious and nonreligious affiliation of mothers. The data is processed from the 1982 and 1988 National Surveys of Family Growth conducted by the National Center of Health Statistics, where mothers stated whether there are Protestant, Catholic, Jewish, something else, or none which was interpreted as no religious affiliation. The surveyed women (ages 15–44) not only stated how many children they have, but also had to estimate the number of children they expect to have during their lifetime. The findings clearly indicate that different

religions and secular people have very different birth rates: 2.4 children per Catholic woman, 2.2 for a Protestant, and 2.02 for a Jewish women. The total expected births of nonreligious mothers was 1.81 per mother, which constituted the lowest in this survey.

For the present calibration, since most religious people are classified as protestants, the number of births per religious woman will be taken to be 2.22, whereas the number of children per nonreligious woman is taken to be 1.81. Therefore, assuming that women constitute 50% of the population, the number of religious and secular offsprings per adult are taken to be $\beta_R = 2.22/2 = 1.11$ and $\beta_S = 1.81/2 = 0.905$. Next, Table 2 implies that during the year 2000 the ratio of secular (nonreligious and atheists combined) to religious people was $s/r = (0.4+0.9)/(1-0.4-0.9) = 47/453$. Assuming that the affiliation levels during the year 2000 are around their steady-state levels, we substitute for β_S, β_R, and s/r into (11), and then solve for γ_R to obtain

$$\gamma_R = \frac{45156569}{50283000} + \frac{8507}{100566}\,\gamma_S \approx 0.898 + 0.0846\,\gamma_S. \tag{13}$$

The relationship (13) provides the calibrated real value of the fraction of conformists among religious people as a function of this fraction among secular people, which is also plotted in Figure 3. Figure 3 indicates that the fraction of conformists is likely to be higher among religious people relative to secular people, as one may expect. Moreover, even though Figure 3 and (13) are merely functions, we can see that any possible calibrated value of γ_R must fall inside a small interval, as stated by the following result.

Result 6. *According to present calibration, more than 90% of children who are born to religious people are classified as conformists and therefore are unlikely to become secular.*

6. Two Alternative Models of Religious Nonconformity

Section 3 has already demonstrated how the conformity rates can be exogenously determined by modeling parents' investment in "proper" conformity-enhancing education. In this section, I propose some alternative formulations by specifying different preferences towards secular and religious denominations (Subsection 6.1), and preferences over the network sizes associated with each type of beliefs (Subsection 6.2).

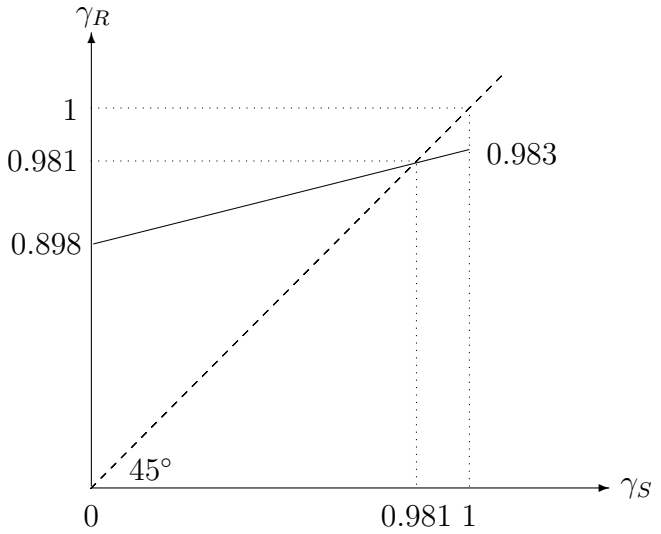

Figure 3: Calibrated relationship between fraction of conformists born to religious and secular parents, given by (13). *Note*: Vertical axis is not drawn to scale for the sake of illustration only.

6.1 Religious strictness and conversion cost

Suppose that the densities of newborns to secular and religious parents are such that all newborns are distributed on the closed interval $[0, 1]$. Following Montgomery (1996), each newborn is indexed by $0 \leq \sigma \leq 1$ to indicate her preference for the level of strictness imposed by her affiliation. Under this interpretation, an individual indexed by σ closer to 1 prefers to practice a strict religion whereas those indexed close to 0 prefer the least strict religion. For our purposes $\sigma = 1$ will represent the strongest preference for a religious affiliation, whereas $\sigma = 0$ the strongest preference for secular life.

We assume that any individual can convert only at the end of her first period. Clearly, the decision to convert is based on forward looking to the individual's second-period utility. Then, we can assume that the second-period utility functions of individuals indexed by σ and who are born to secular and religious parents are given by

$$U_S \overset{\text{def}}{=} \begin{cases} (1-\sigma)v_S & \text{Does not convert} \\ \sigma v_R - c_R & \text{Converts to } R \end{cases} \quad \text{and} \quad U_R \overset{\text{def}}{=} \begin{cases} \sigma v_R & \text{Does not convert} \\ (1-\sigma)v_S - c_S & \text{Converts to } S \end{cases}. \tag{14}$$

Thus, the parameters v_S and v_R are the basic utilities derived from secular and religious affiliation, respectively; and c_S and c_R denote the cost of conversion to become secular or religious, respectively. Clearly we must assume that $0 \leq \max\{c_S, c_R\} < \min\{v_S, v_R\}$ in order to induce some conversion in both directions. It should be noted that conversion costs (resemble switching costs commonly assumed in Industrial Organization) are very important for our study since conversion generally involves disputes and often disconnection from parents, other family members, relocation, and in some instances high learning costs (such as conversion to Judaism). All these are summarized by the parameters c_S and c_R. For the sake of illustration only, let $c_S = c_R = c$.

Consider first an individual indexed by σ who is born to secular parents. The utility function stated in (14) implies that this individual will find it beneficial to convert and become religious if

$$\sigma v_R - c > (1-\sigma)v_S, \quad \text{hence if} \quad \sigma > \sigma_{SR} \overset{\text{def}}{=} \frac{v_S + c}{v_S + v_R}. \tag{15}$$

Similarly, an individual indexed by σ who is born to religious parents will choose to convert and become secular if

$$(1-\sigma)v_S - c > \sigma v_R, \quad \text{hence if} \quad \sigma < \sigma_{RS} \overset{\text{def}}{=} \frac{v_S - c}{v_S + v_R}. \tag{16}$$

Figure 4 illustrates the range of individuals who convert and who do not convert against their parents' belief. The space $[0, 1]$ represents the heterogeneity of all newborns to religious and secular parents. Clearly, (15), (16), and Figure 4 imply that

Result 7. *(a) Newborns to secular parents who are endowed with a strong preference for religious strictness, (formally, those indexed by $\sigma > \sigma_{SR}$) convert to become religious.*

(b) Newborns to religious parents who are endowed with a strong preference against religious strictness, (formally, those indexed by $\sigma < \sigma_{RS}$) convert to become secular.

(c) All newborns who have a moderate preference for religious strictness (formally, those indexed by $\sigma_{SR} \leq \sigma \leq \sigma_{RS}$) adhere to their parents' belief regardless of whether they are born to secular parents or to religious parents.

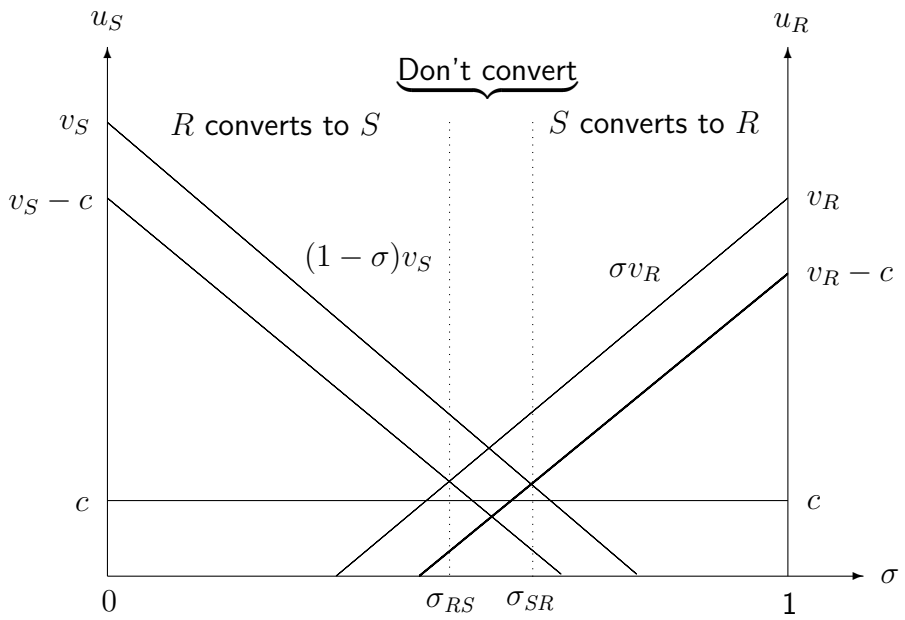

Figure 4: Conversions patterns and directions.

Result 7 confirms similar results obtained by Montgomery (1996) in an entirely different setup. Both models predict that only people with a strong preference for and against religious strictness end up converting, whereas all the newborns with a moderate preference adhere to their parents' belief.

Perhaps the most interesting feature of the model presented in this section is that it is one-hundred percent consistent with our benchmark model and therefore provides some additional micro foundations for the conformity and nonconformity behavior from religious and secular perspectives. This feature is summarized by the following result.

Result 8. *The conversion patterns generated by the consumer preferences defined in (14) support the simple conversion rules given by Assumption 1. Formally,*

(a) Setting $\gamma_S = \sigma_{SR}$ yields the fraction of newborns to secular parents who are conformists and therefore adhere to their parents' secular belief, and

(b) Setting $\gamma_R = 1 - \sigma_{RS}$ yields the fraction of newborns to religious parents who are also conformists and therefore adhere to their parents' religious belief.

6.2 Network-based conversion rules

Under network-based preferences, individuals derive utility or disutility from the size of the community associated with each belief. Social influences of this kind have been discussed in economics ever since Veblen (1899). The model developed in this subsection can be interpreted as before, secular versus religious population groups, or as a model of *two competing religions* called S and R, see a discussion on possible interpretations in Section 7 below. As before, two-period lived individuals are born to parents affiliated with either S or R. At the end of their first period, individuals choose whether to adhere to their parents' religion in their second period, or whether to convert to the other religion and practice it during their second period.

Clearly, a "network-based" conversion decision must take into consideration that the children will also be affiliated with the new religion at their first period of life. The decision to convert also must take into consideration how other believers of the same generation choose their affiliation during their second period as well as how many children they will have. By construction, individuals are born into a certain religion and do not switch until the end of their first period. Therefore, for conversion decision purposes, we need to define only an individual's second-period utility function. Formally, the period $t+1$ utility of a conformist and a nonconformist of generation $g=t$ born to any type of parents are given by

$$U^t_{t+1}(k) \stackrel{\text{def}}{=} \begin{cases} \mu_k\left([1+\beta_S]s^t_{t+1}\right) & \text{affliated with } S \text{ in period } t+1 \\ \mu_k\left([1+\beta_R]r^t_{t+1}\right) & \text{affliated with } R \text{ in period } t+1, \end{cases} \tag{17}$$

where $k=c$ if the individual is born as a conformist, and $k=n$ if born as a nonconformist. The function $\mu_k(\cdot)$ measures an individual's utility from the size of the community affiliated with the religion of her choice. The community size consists of the old at $t+1$ plus the young who are born according to the birth rates β_S and β_R. Our analysis will rely on the following simplifying assumptions.

ASSUMPTION 3. *(a) All individuals have perfect foresight for predicting the number of believers affiliated with each religion. In addition, individuals believe that their own choice does not affect these numbers.*

(b) Conformists prefer larger communities whereas nonconformists prefer smaller communities. Formally, the function μ_c is increasing and μ_n is decreasing with community sizes.

(c) A fraction γ_S of the children born to S-affiliated and a fraction γ_R to R-affiliated parents are conformists. All others are born as nonconformists.

Part (a) states that all believers consider themselves as negligible relative to the entire population in the sense that their individual choice does not affect the network sizes. Assumption 3(b) simplifies our analysis by focusing on two extreme types of conformists and nonconformists. Conformists prefer to join the most popular religion (largest network) whereas nonconformists exhibit vanity or snob type behavior, leading them to choose the least popular religion (smallest network of believers). It should be pointed out that the meanings of conformists and nonconformists are very different from the previous models presented in this paper. Here, individuals do not have a preference over whether to convert or a preference for a specific religion. Instead, *individuals care only about the size of the communities* affiliated with each religion. Clearly, this assumption on preferences needs to be further motivated, therefore the reader is referred to the last paragraph of the concluding section, Section 7, for further discussions on the assumed network preferences.

As with most network-based models, the equilibrium paths are not unique and are driven by self-fulfilling expectations. That is, if on an equilibrium path all individuals expect religion S to be more popular than religion R in some period $t+1$, then at the end of period t all conformists will adhere/convert to S whereas all nonconformists will adhere/convert to R. Formally stated, if

$$(1+\beta_S)s_{t+1}^t \geq (1+\beta_R)r_{t+1}^t \quad \text{then} \quad \begin{cases} s_{t+1}^t &= \gamma_S\, s_t^{t-1} + \gamma_R\, r_t^{t-1} \\ r_{t+1}^t &= (1-\gamma_S)s_t^{t-1} + (1-\gamma_R)r_t^{t-1}. \end{cases} \tag{18}$$

In contrast, if all individuals believe that religion R will dominate in period $t+1$, then at the end of period t all conformists will adhere/covert to R whereas all nonconformists will adhere/convert to S. Formally, if

$$(1+\beta_R)r_{t+1}^t \geq (1+\beta_S)s_{t+1}^t \quad \text{then} \quad \begin{cases} s_{t+1}^t &= (1-\gamma_S)s_t^{t-1} + (1-\gamma_R)r_t^{t-1} \\ r_{t+1}^t &= \gamma_S\, s_t^{t-1} + \gamma_R\, r_t^{t-1}. \end{cases} \tag{19}$$

The multiplicity of equilibria stems from the fact that (18) and (19) are not mutually exclusive. A unique equilibrium can exist only for large differences in birth rates under which the

religion with the relatively high birth rate dominates forever. Otherwise, when both (18) and (19) hold, in each period there are two possible allocations of believers between the two religions which could generate a large number of equilibrium paths. Table 5 displays several such equilibria. Equilibrium #1 in Table 5 corresponds to a common self-fulfilling expectation among all believers

#	Exp.	Religion	0	1	2	3	4	5	6	7	8	9
Symmetry case:						$\beta_R = \beta_S = 1.1$		and	$\gamma_R = \gamma_S = 0.8$			
1	CON	s^t_{t+1}	100	440	484	532	586	644	709	779	857	943
1	NON	r^t_{t+1}	400	110	121	133	146	161	177	195	214	236
2	NON	s^t_{t+1}	100	110	121	133	146	161	177	195	214	236
2	CON	r^t_{t+1}	400	440	484	532	586	644	709	779	857	943
3	MIX	s^t_{t+1}	100	440	121	532	146	644	177	779	214	943
3	MIX	r^t_{t+1}	400	110	484	133	586	161	709	195	857	236
Small difference in birth rates:						$\beta_S = 1.4 > 1.1 = \beta_R$		and	$\gamma_R = \gamma_S = 0.8$			
4	CON	s^t_{t+1}	100	560	750	1006	1347	1806	2419	3242	4344	5821
4	NON	r^t_{t+1}	400	110	147	198	265	355	475	637	853	1143
5	NON	s^t_{t+1}	100	140	162	188	219	253	294	341	396	459
5	CON	r^t_{t+1}	400	440	510	592	687	797	924	1072	1244	1443
6	MIX	s^t_{t+1}	100	560	188	870	292	1353	453	2103	705	3269
6	MIX	r^t_{t+1}	400	110	590	171	916	266	1425	413	2214	642
Large difference in birth rates:						$\beta_S = 1.2 > 0.3 = \beta_R$		and	$\gamma_R = \gamma_S = 0.8$			
7	CON	s^t_{t+1}	100	480	490	499	509	520	530	541	551	562
7	NON	r^t_{t+1}	400	30	31	31	32	32	33	34	34	35

Table 5: Equilibrium religious affiliations for generations 1–9 under network-based preferences, assuming that $s^0 = 100$ and $r^0 = 400$. *Expectation formation*: CON: All conformists adhere/conver to. NON: All nonconformists adhere/convert to. MIX: Expectations change (flip) each period.

that religion S is always the dominating religion, despite the head start of religion R. Equilibrium #2 is computed under the polar expectations where religion S dominates. Equilibrium #3 demonstrates a flip of expectations among generations, where people belonging to odd generations expect S to be the largest religion whereas those belonging to even generations expect R to dominate. Clearly, there is a large number of equilibria associated with different types of changing expectations.

The equilibria 1–3 correspond to identical birth and conformity rates among the two religions. For this reason, the aggregate population size does not vary among these equilibria. This suggest

that Table 5 omits the trivial class of equilibria where both religions are adhered to by exactly 50% of the total population so that $s^t_{t+1} = r^t_{t+1}$ for all $t = 1, 2, \ldots$. Of course, this type of equilibria can be ruled out on the basis of being Pareto dominated by unevenly-distributed allocations of believers where conformists adhere to the largest denomination while nonconformists to the smallest one.

The equilibria 4–6 correspond to equilibria 1–3 but are computed for unequal birth rates, where we assume that an S-affiliated parent has more children than an R-affiliated parent. The self-fulfilling expectation about the dominance of each religion are the same as in equilibria 1–3. The aggregate population size, however, varies among the equilibria due to the difference in the number of offsprings between the religions. Equilibrium #7 demonstrates that when the difference in birth rates is significant (in this example, R parents bring less offsprings than the previous generation) the equilibrium becomes unique where all the conformists adhere or convert to S. Finally, the case which is presented in Table 4 where different religions generate different conformity and nonconformity rates is omitted from Table 5. Simulations confirm as with the different birth rates case, that all equilibria exist for small differences, but become unique as the difference between γ_S and γ_R is enlarged.

7. Concluding Comments

This paper analyzes the dynamics behind the "demand" for secular and religious affiliations. For this reason, this paper develops and presents models of religious retention across generations, allowing for dynamic switching between secular and religious affiliations. The conversion patterns are shown to depend on differences in birth rates, and more importantly, different attitudes towards conformism and nonconformism.

Section 3 endogenizes the (non)conformity rates by introducing parents who are concerned with the probability that their children will convert against their own belief. In doing so, the role of the church becomes to generate a positive externality in church education that promotes conformity. Section 3 can be extended to endogenize also the fertility rates as influenced by

the teaching of the church. For example, some churches preach against birth control, and some encourage large families. If we assume that the teaching of a religion is endogenous with the religion's status in society, then such factors as being a minority could affect the group's doctrine on fertility, and in turn affecting the birth rate.

The models presented in this paper can be used to simulate two types of communities. (a) The transition between secular and religious groups. Under this interpretation, conversion means that a young who is born secular becomes religious, and vice versa. (b) The transition between two different religions. Under this interpretation, there are no secular people, and all individuals must be affiliated with one religion. Under the second interpretation, we can also model the transition between two streams or subreligions within the same religion. For example, conversions between Orthodox and Reform streams of Judaism, between Catholics and Protestants, and the Sunni and Shiites streams of Islam.

The data provided in the introductory section clearly displays an increase in the percentage of secular people, where now atheists are around 2.5% of the worldwide population and other nonreligious constitute about 12.7% worldwide, for 236 countries (see also the 2001 Britannica Book of the Year). Table 1 predicts some increase in these rates for North and Latin America, but a decline for Europe and Asia. This clearly indicates that there is a complete uncertainty whether the ongoing secularization trends will continue. Indeed, well-enforced governmental guarantees of religious freedom might have contributed to the increase of both the level of participation among the religious while at the same time increasing the number of people willing to admit that they are secular.

Finally, I would like to end this paper with a short motivation for the "network" approach examined in Subsection 6.2. In fact my interest in religion economics, Shy (2001, Ch.11), started from asking the question why conversion to Judaism (at least they way it is done in Israel), is much more difficult or time consuming than conversion to other much larger religions, where only taking a communion or being baptized are needed? In fact, if Judaism is on a decline, then network economics (or simple marketing intuition) tells us that Jews should "lower the standards" with respect to requirements for conversion to Judaism (say, as Reform Jews practice to some

degree). The only, perhaps unsatisfactory, explanation that I found so far is the negative network effect, also called vanity effect, where some believers prefer to be affiliated with smaller religions or cults, than with the world's dominating religions. This can be accomplished by toughening the requirements from outsiders who want to convert. Of course, smaller groups also have the advantage of generating "public goods" in the form of trust among members, by threatening to expel deviants from the community.

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