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Believing and Practicing: How Religion Shapes Human Capital and Growth

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Abstract

We develop a dynamic model in which individuals allocate time between work and religious activities, and parents invest in their children's human capital and religious belief. The model delivers, in a unified framework, the two empirical regularities documented by Barro and McCleary (2003) and McCleary and Barro (2019): controlling for religious activities, stronger belief raises economic growth because it raises human capital investment; controlling for belief, more time spent on religious activities lowers growth by crowding out labor supply. While the labor-supply margin is individually optimal, the human-capital margin is not: parents do not internalize that greater human-capital investment crowds out future religious transmission through the socialization channel, leading to inefficiently high human capital in equilibrium under strong socialization externality. We extend this baseline framework in three directions. First, introducing a complementarity between religious belief and human capital—capturing the Protestant-ethic channel of Weber (1930)—we show that the efficiency of equilibrium depends non-monotonically on the strength of this complementarity. Second, allowing for cultural conflict between two religious groups à la Bisin and Verdier (2000), we show that cultural intolerance depresses human capital investment and, if human capital raises labor productivity, reduces economic growth. Third, embedding the model in a system of cities, we show that larger, more productive cities endogenously attract workers who invest more in human capital and spend less time on religious activities, generating a negative cross-city relationship between city size and religiosity that is consistent with the empirical evidence in McCleary and Barro (2019).

JEL Classification: O40, Z12, J24, R11.

Keywords: religion, human capital, cultural transmission, economic growth, cities.

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1 Introduction

Religion is one of the most pervasive forces shaping individual behavior and aggregate economic outcomes. Across countries and over time, the intensity of religious belief and the time devoted to religious activities display large and persistent variation, and this variation is systematically correlated with growth, education, and urbanization. Yet the channels through which religion affects the economy—and the extent to which private religious choices are individually or socially optimal—remain poorly understood.

Religions combine two economically distinct dimensions. On the one hand, religious beliefs and norms may foster discipline, patience, social cohesion, and investment-oriented behavior. On the other hand, religious practices are time-intensive activities that compete with labor and secular education. Understanding how these two dimensions jointly shape economic development is the central objective of this paper.

The empirical puzzle. Two empirical regularities, documented by Barro and McCleary (2003) and McCleary and Barro (2019) using cross-country data, provide the organizing motivation for this paper.

- **Stylized Fact 1 (Belief and growth).** Controlling for the level of religious *activities*, religious *belief* is positively associated with economic growth.
- **Stylized Fact 2 (Activities and growth).** Controlling for religious *belief*, time spent on religious *activities* is negatively associated with economic growth.

These two facts jointly imply that religious belief and activities have opposite effects on growth, and that omitting either one from a regression on growth leads to biased inference. Intuitively, religious belief may embody values—such as deferred gratification, honesty, or a work ethic—that enhance productivity, while time spent in church or mosque crowds out productive labor. But existing theory has not provided a unified micro-founded framework that generates both facts simultaneously from optimizing behavior, characterizes the welfare properties of the resulting equilibrium, and extends the analysis to cultural conflict and urban geography.[1]

[1] These two facts find support beyond cross-country regressions. Campante and Yanagizawa-Drott (2015) provide quasi-experimental evidence that Ramadan fasting reduces GDP growth in Muslim-majority countries, consistent with the labor-supply channel of Stylized Fact 2. For Stylized Fact 1, Becker and Woessmann (2009) document substantially higher literacy in Protestant regions, consistent with the belief-to-human-capital channel.

What we do. We build a dynamic model in continuous time with overlapping generations. Each cohort allocates a unit time endowment between labor and religious activities. When a generational transition occurs (modeled as a Poisson event), a parent instantaneously chooses how much to invest in her child's human capital and religious belief. The child's religious belief is determined by the parent's investment and by socialization—absorption of the economy-wide average belief level. This socialization channel is the source of the key externality: by investing in her child's human capital rather than religious transmission, a parent lowers average belief in future generations without internalizing this cost.

The model delivers four main results.

Result 1 (Two stylized facts). In equilibrium, holding labor supply fixed, a higher average belief reduces the marginal need for direct belief transmission via the socialization channel, freeing parental resources toward human capital investment, and this in turn raises the economy's growth rate. Holding belief fixed, more time spent on religious activities lowers labor supply and reduces growth. The model therefore reproduces both stylized facts within a single, internally consistent framework.

Result 2 (Inefficiency). The equilibrium labor-supply decision is socially optimal because individuals fully internalize the return to work. The human-capital investment decision is not. By investing in human capital rather than religious transmission, a parent lowers average belief in future generations and, since belief is partially transmitted through socialization, this effect propagates across generations. As a result, and under the empirically plausible condition that the socialization externality dominates, equilibrium human-capital investment is inefficiently high relative to the social optimum.

Result 3 (Complementarity and the Protestant Ethic). When we introduce a complementarity between religious belief and human capital investment—capturing Weber's (1930) Protestant-ethic hypothesis—the direction of the inefficiency depends non-monotonically on the strength of complementarity. For large complementarities, the balanced-growth property of the model drives human capital and belief toward equal levels, which diverges from the social optimum in the direction of too much human capital. For small complementarities, the externality channel dominates and human capital can be under- or over-provided depending on the parent's preference over child's belief and human capital.

Result 4 (Religious conflict and cities). When two cultural groups compete for transmission—as in Bisin and Verdier (2000)—cultural intolerance reduces human capital investment and reduces growth. In a multi-city extension, larger and more productive cities endogenously select workers who devote more time to labor and invest more in human capital, generating the negative relationship between city size and religiosity documented in McCleary and Barro (2019).

Related Literature. Our paper bridges three literatures that have largely developed in parallel.

The first is the literature on religion and growth. The most comprehensive recent synthesis of the religion-and-growth literature is Becker et al. (2024), who organize the evidence around four channels of a macroeconomic production function: physical capital (thrift and financial development), human capital (religious and secular education), labor supply (work effort, fertility, and demographic change), and total factor productivity (technological change, institutions, and conflict). Their survey documents a rich body of reduced-form evidence on each channel but leaves two important questions unanswered. First, it provides no micro-founded model in which belief and religious activities are simultaneously determined by optimizing agents alongside human capital investment, and therefore cannot explain why belief and activities have *opposite* effects on growth. Second, it does not ask whether the equilibrium level of religious investment is socially optimal. We address both gaps. Our model shows that the two stylized facts of Barro and McCleary (2003) and McCleary and Barro (2019)—which Becker et al. (2024) take as motivating evidence—emerge naturally from a single optimization problem, and that the socialization externality inherent in cultural transmission causes the equilibrium human-capital level to be inefficient. Becker and Woessmann (2009) find evidence that Protestant regions had substantially higher literacy and human capital accumulation, consistent with the belief-to-human-capital channel in our model, while Campante and Yanagizawa-Drott (2015) provide quasi-experimental evidence that longer Ramadan fasting reduces output growth in Muslim-majority countries, consistent with the labor-supply channel.

The second is the cultural transmission literature. Following the seminal papers of Bisin and Verdier (2000, 2001), a large body of work studies how cultural traits are transmitted across generations and how cultural heterogeneity evolves; see Bisin and Verdier (2023, 2025); Bisin et al. (2023) for recent surveys, the latter focusing specifically on religion. Within this literature, Patacchini and Zenou (2016) provide empirical evidence that parental investment and community religiosity are complements in the intergenerational transmission of religion, and Della Lena et al. (2023) model the intergenerational transmission of guilt aversion as a religiously rooted moral emotion that sustains trust and cooperation. We embed cultural transmission in an economic growth model with endogenous human capital, generating a two-way interaction between cultural dynamics and economic outcomes that is absent from the existing cultural economics literature.

The third is the literature on the economics of religion (see Iannaccone, 1998; Iyer, 2016; Carvalho et al., 2019, and the references therein). This literature has emphasized the club-good and commitment-device functions of religious activities (Iannaccone, 1992; Carvalho, 2012), and the role of religious competition and market structure in shaping denominational outcomes. We complement these contributions by studying the economy-wide general-equilibrium implications of individual religious choices for human capital accumulation and growth.[2]

Our paper contributes to these literatures by developing a unified framework in which religious belief, religious activities, and human-capital investment are jointly determined through intergenerational cultural transmission. More broadly, the paper studies how intergenerational cultural transmission creates a trade-off between identity preservation and human-capital accumulation. The paper's central insight is that religious transmission behaves like a cultural public good: parents value it privately, but its aggregate persistence depends on the transmission decisions of all families.

Organization Section 2 presents the baseline model and characterizes the unique stable steady-state equilibrium. Section 3 connects the model to the two empirical stylized facts and studies the efficiency of the equilibrium. Section 4 develops extensions: the complementarity (Protestant-ethic) model (Section 4.1), the veiling and temptation model (Section 4.2), the religious conflict model (Section 4.3), and the multi-city model (Section 4.4). Section 5 concludes. All proofs can be found in the Appendix.

2 The Baseline Model

2.1 Environment

Time is continuous. There is a unit mass of individuals, each endowed with one unit of time. At each instant, an individual allocates her time between labor, $l \in [0, 1]$, and religious activities, $1 - l$. A generational change occurs according to a Poisson process with rate $\varepsilon > 0$: when the event arrives, the individual instantly becomes a parent, makes a one-time investment in her child, and exits the economy, while her offspring enters. Because generational transitions are instantaneous and the law of large numbers holds, the total population size is constant.

[2]Guiso et al. (2003) and Becker and Woessmann (2009) study specific denominations—Catholicism and Protestantism respectively—but abstract from the joint determination of belief and activities. Cinnirella et al. (2026) provide more recent evidence that Protestant and Catholic ethics generate systematically different patterns of public good contribution, with denominational differences transmitted across generations, consistent with the intergenerational transmission mechanism in our model.

Individual utility while active. An active individual's value function satisfies the Bellman equation

$$rU_t = u_t + \varepsilon(V_t - U_t), \tag{1}$$

where $r > 0$ is the discount rate, u_t is the flow utility from working and religious activities, and V_t is the value obtained at the moment of the generational transition. The flow utility is

$$u_t = u(A_t h_t l_t,\ b_t(1 - l_t))\,, \tag{2}$$

where $A_t h_t l_t$ represents the return from working, which is interpreted as the material return—the product of economy-wide labor productivity A_t, the individual's human capital h_t (inherited from her parent), and labor supply l_t—and $b_t(1 - l_t)$ is the return from religious activities, with b_t (also parent-determined) measuring the individual's religious belief level and $1 - l_t$ the time spent on religious activities.

The function $u(\cdot, \cdot)$ is twice continuously differentiable, strictly increasing, and strictly concave in each argument[3] ($u_k > 0$, $u_{kk} < 0$), and satisfies $u_{12} = u_{21} \geqslant 0$. Thus, an individual derives utility from both labor income and religious activities, with diminishing marginal returns, and material and religious returns are not substitutes. Labor productivity A_t may depend on time (exogenous technological progress) and on the economy-wide average human capital $\bar{h}_t$ (endogenous growth), i.e., $A_t = A(t, \bar{h}_t)$, with $A_1 \geqslant 0$, $A_2 \geqslant 0$, and $A_{12} \geqslant 0$.

Parental value function. At the moment of the generational transition, the parent chooses her child's human capital $h_{t'}$ and religious belief $b_{t'}$, obtaining value

$$V_t = v(b_{t'}, h_{t'}), \tag{3}$$

where $v(\cdot, \cdot)$ is twice continuously differentiable, strictly increasing and strictly concave in each argument, and satisfies $v_{12} = v_{21} \geqslant 0$. The parent therefore values both the child's religious belief and the child's human capital with decreasing marginal rates and with no substitution between the two. Immediately after determining $b_{t'}$ and $h_{t'}$, the parent obtains the value $v(b_{t'}, h_{t'})$ and exits the economy.[4]

Belief transmission. The child's religious belief (b'_t) is determined by two forces: the parent's direct religious investment ($1 - h'_t$) and the socialization effect of the economy's average belief ($\bar{b}_t$),

$$b_{t'} = \beta(1 - h_{t'}) + (1 - \beta)\bar{b}_t, \tag{4}$$

[3]A subscript k of a function denotes the partial derivative with respect to the k-th argument.

[4]Alternatively, we can assume a retirement period, which ends according to a Poisson process λ (> 0). Then, if we normalize the unit of utility so that $r + \lambda = 1$, we obtain the same value function as (3).

where $\beta \in (0, 1)$ is the weight of the parent's own investment in shaping the child's religious belief. There are two things to notice about this transmission rule. First, the parent's religious investment in the child is the substitute of human capital investment, $1 - h_{t'}$: time and resources spent on the child's education $(h_{t'})$ reduce the parent's capacity to transmit belief. Second, the socialization term $(1 - \beta)\bar{b}_t$ captures the passive absorption of the prevailing culture: a more religious society transmits stronger belief to all children, independently of parental investment. This socialization channel is the source of the externality analyzed in Section 3.

2.2 Individual optimization

Labor-supply decision. An active individual maximizes u_t with respect to $l_t \in [0, 1]$, taking A_t, h_t, b_t, and $\bar{b}_t$ as given. Differentiating (2) with respect to l_t, we obtain the unique interior optimum:

$$u_1 A_t h_t = u_2 b_t, \tag{5}$$

which equates the marginal utility of labor income to the marginal utility of religious activity. This condition implicitly defines optimal labor supply as $l^* = l(A_t, h_t, b_t)$. The second-order condition holds under the assumed curvature of u.[5]

Human-capital investment decision. At the moment of the generational transition, the parent maximizes V_t with respect to $h_{t'} \in [0, 1]$, taking $\bar{b}_t$ as given. Substituting the transmission rule (4) into (3), the unique interior optimum satisfies[6]

$$\beta v_1 = v_2, \tag{6}$$

which equates the (weighted) marginal value of the child's belief to the marginal value of the child's human capital. This condition defines the optimal human capital investment as a function of the economy-wide average belief: $h^* = h(\bar{b}_t)$.

Since U_t and V_t are continuous functions of l_t and $h_{t'}$, respectively, the Extreme Value

[5]Indeed, the second-order condition is satisfied since

$$u_{11}(A_t h_t)^2 - 2u_{12} b_t A_t h_t + u_{22} b_t^2 < 0.$$

[6]The second-order condition is satisfied since

$$\beta^2 v_{11} - 2\beta v_{12} + v_{22} < 0.$$

Theorem implies that there exist l_t^* and $h_{t'}^*$ such that

$$l_t^* = \arg\max_{l_t \in [0,1]} U_t,$$

$$h_{t'}^* = \arg\max_{h_{t'} \in [0,1]} V_t,$$

where interior solutions are given by $l^*(A_t, h_t, b_t)$ and $h^*(\bar{b}_t)$.

Equations (5) and (6) imply that, once $\bar{b}_t$ is determined, the other endogenous variables, including l_t and h_t, are uniquely determined. Hence, the remaining element of the model to be specified is the dynamics of $\bar{b}_t$.

2.3 Equilibrium Dynamics and Steady State

Effect of average religious belief on human capital. A higher economy-wide belief level relaxes the trade-off between belief transmission and human capital investment: socialization (4) delivers a larger fraction of the child's belief automatically, freeing the parent to invest more in human capital. Formally, differentiating (6) implicitly yields:

$$h'(\bar{b}_t) = \frac{(1-\beta)(\beta v_{11} - v_{12})}{\beta^2 v_{11} - 2\beta v_{12} + v_{22}} > 0. \tag{7}$$

The mechanism is a cultural free-riding effect. When average belief in society is high, parents expect part of their child's religiosity to arise automatically through socialization.

Law of motion. Because the generational transition arrives at Poisson rate ε and the law of large numbers holds, the average religious belief in the economy evolves as[7,8]

$$\dot{\bar{b}}_t = \varepsilon(b_{t'} - \bar{b}_t). \tag{8}$$

From (7), we obtain the equilibrium level of human capital:

[7] During a short period Δ, the probability that an individual faces a generational change at least once is given by $1 - e^{-\varepsilon\Delta}$. Assuming that the law of large numbers holds true, the dynamics of $\bar{b}_t$ is written as

$$\bar{b}_{t+\Delta} = (1 - e^{-\varepsilon\Delta})b_t + e^{-\varepsilon\Delta}\bar{b}_t,$$

which can be rewritten as

$$\frac{\bar{b}_{t+\Delta} - \bar{b}_t}{\Delta} = \frac{1 - e^{-\varepsilon\Delta}}{\Delta}(b_t - \bar{b}_t).$$

Taking a limit of $\Delta \to 0$, we obtain (8).

[8] The dynamics of the average human capital investment level, $\bar{h}_t$, is given by

$$\dot{\bar{h}}_t = \varepsilon(h_{t'} - \bar{h}_t).$$

In equilibrium, $h_{t'}$ is determined by $h(\bar{b}_t)$ so that $\bar{h}_t$ converges to a steady-state if $\bar{b}_t$ converges to a steady-state.

$$h^*_{t'} = \begin{cases} 1 & \text{if } h(\bar{b}_t) \geqslant 1 \\ h(\bar{b}_t) & \text{if } h(\bar{b}_t) \in (0,1) \\ 0 & \text{if } h(\bar{b}_t) \leqslant 0 \end{cases}, \tag{9}$$

where the first and third lines of the right hand side (RHS) of (9) represent the corner solutions whereas the second line represents the interior solution. Plugging (9) into (8), we obtain the full equation of motion for average religious belief:

$$\dot{\bar{b}}_t = \begin{cases} -\varepsilon\beta\bar{b}_t & \text{if } h(0) \geqslant 1 \quad \text{(full human capital)}, \\ \varepsilon\beta\left(1 - \bar{b}_t - h(\bar{b}_t)\right) & \text{if } h(0) < 1 \text{ and } h(1) > 0 \quad \text{(interior solution)}, \\ \varepsilon\beta\left(1 - \bar{b}_t\right) & \text{if } h(1) \leqslant 0 \quad \text{(zero human capital)}. \end{cases} \tag{10}$$

Note that when human capital investment is maximal ($h^* = 1$), parents devote no resources to direct religious transmission, so average belief decays over time ($\dot{\bar{b}}_t = -\varepsilon\beta\bar{b}_t < 0$). Conversely, when $h^* = 0$, full religious transmission drives average belief toward its maximum ($\dot{\bar{b}}_t = \varepsilon\beta(1 - \bar{b}_t) > 0$).

In all three cases, the right-hand side of (10) is strictly decreasing in $\bar{b}_t$: a higher current belief reduces the net inflow of belief into the economy. Moreover, one can verify that the right-hand side is strictly positive at $\bar{b}_t = 0$ and strictly negative at $\bar{b}_t = 1$ in the interior case, guaranteeing by continuity exactly one zero crossing. This monotonicity and boundary behavior jointly ensure the existence of a unique globally stable steady state $\bar{b}^*$.

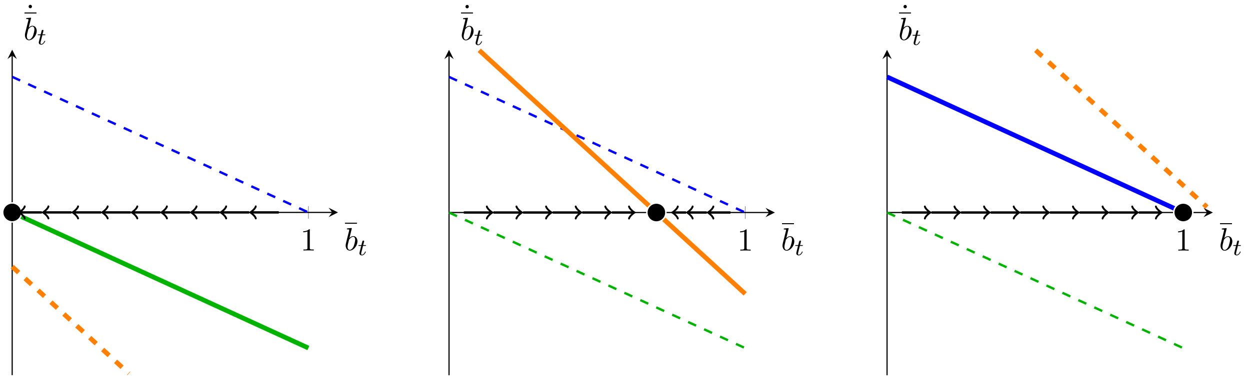
Proposition 1 *The model has a unique stable steady-state equilibrium. Regardless of the initial condition $\bar{b}_0$, the economy converges to a steady state $\bar{b}^*$ at which $\dot{\bar{b}}_t = 0$.*

Figure 1 illustrates the dynamics for each of the three cases. The green curve represents the corner solution $h^*_{t'} = 1$, the orange curve the interior solution $h^*_{t'} = h(\bar{b}_t)$, and the blue curve the corner solution $h^*_{t'} = 0$. In the corner case $h^* = 1$ (panel a), parents invest all resources in human capital and none in direct religious transmission. The child's belief is determined solely by socialization, $b'_t = (1 - \beta)\bar{b}_t$, so average belief decays toward $\bar{b}^* = 0$. In the corner case $h^* = 0$ (panel c), parents invest nothing in human capital and transmit belief directly with full intensity, $b'_t = \beta + (1 - \beta)\bar{b}_t$, so average belief converges to $\bar{b}^* = 1$.

3 Religion, Human Capital, and Growth

3.1 The Two Stylized Facts

To connect the model to the empirical evidence, let $g(t, h_t, l_t)$ denote a general function capturing the economy's growth rate. We assume $g_k > 0$ for all arguments: growth is



(a) corner solution ($h_{t'} = 1$) (b) interior solution ($h_{t'} = h(\bar{b}_t)$) (c) corner solution ($h_{t'} = 0$)

Figure 1: Steady-state equilibrium. Blue: $\dot{\bar{b}}_t = \varepsilon\beta(1 - \bar{b}_t)$; green: $\dot{\bar{b}}_t = -\varepsilon\beta\bar{b}_t$; orange: $\dot{\bar{b}}_t = \varepsilon\beta(1 - \bar{b}_t - h^*(\bar{b}_t))$. The solid line is the active regime. Arrows indicate convergence to the steady state (filled circle).

increasing in time (capturing exogenous progress), in human capital (through productivity spillovers), and in labor supply (through the scale of production).

Barro and McCleary (2003) and McCleary and Barro (2019) provide two significant stylized facts regarding the relationship between religion and economic growth (Becker et al., 2024). We here discuss how our model can relate to these two stylized facts.

Stylized Fact 1 (religious belief raises growth, controlling for religious activities): holding l_t fixed and allowing h_t to adjust through the equilibrium condition (7), an increase in $\bar{b}_t$ raises human capital ($h'(\bar{b}_t) > 0$) and therefore raises the growth rate:

$$\frac{\partial}{\partial \bar{b}_t}\left[g(t, h_t, l_t)\right]\big|_{l_t \text{ fixed}} = g_2\, h'(\bar{b}_t) \;\geqslant\; 0.$$

Stylized Fact 2 (religious activities reduce growth, controlling for belief): holding $\bar{b}_t$ fixed, an increase in time spent on religious activities $(1 - l_t)$ reduces labor supply and lowers growth:

$$\frac{\partial}{\partial (1 - l_t)}\left[g(t, h_t, l_t)\right]\big|_{\bar{b}_t \text{ fixed}} = -g_3 \;\leqslant\; 0.$$

We have the following result:

Proposition 2 *For a fixed level of religious activities, higher religious belief raises human capital investment and therefore enhances economic growth. For a fixed level of religious belief, more time devoted to religious activities reduces labor supply and therefore reduces economic growth.*

Both parts of Proposition 2 find empirical support in the literature. For the first part, Becker and Woessmann (2009) document that Protestant regions—where religious belief was particularly strong—had substantially higher literacy and human capital accumulation. For the second part, Campante and Yanagizawa-Drott (2015) provide quasi-experimental evidence that longer Ramadan fasting significantly reduces output growth in Muslim-majority countries, consistent with the labor-supply channel formalized above.

Moreover, as Barro and McCleary (2003) show empirically, if we allow both l_t and $\bar{b}_t$ to change, the dependence of l_t on $\bar{b}_t$ partly offsets the growth enhancing effect of religious belief and the net effect of an increase in $\bar{b}_t$ on growth is ambiguous because greater religious belief also affects labor supply through (5). Specifically:

$$sgn\left(\frac{\partial l_t}{\partial \bar{b}_t}\right) = sgn\left(\underbrace{(u_{12}A_t h_t - u_{22}\bar{b}_t)(1-l_t)}_{(+)} \underbrace{-u_2}_{(-)}\right). \tag{11}$$

When the average religious belief level increases, the marginal utility of working rises relative to time spent on religious activities through two direct channels: the complementarity between material and religious returns (the u_{12} term) and the diminishing marginal utility of religious activity (the u_{22} term). These two effects are captured by the first two terms in the parentheses on the right-hand side of (11). At the same time, a higher level of religious belief also increases the return to religious activities, thereby discouraging work and reducing time spent on working. This negative effect is represented by the last term in the parentheses on the right-hand side of (11). Since the overall effect of an increase in $\bar{b}_t$ on g_t is given by

$$\frac{\partial g_t(t, h_t, l_t)}{\partial \bar{b}_t} = g_2 h'(\bar{b}_t) + g_3 \frac{\partial l_t}{\partial \bar{b}_t},$$

its sign is ambiguous due to the negative impact of religious beliefs on working time. These opposing forces capture a fundamental tension: religious beliefs can be growth-enhancing through human capital accumulation, yet growth-reducing through substitution toward leisure. This is consistent with the ambiguous cross-sectional evidence in Barro and McCleary (2003) regarding the overall effect of religious belief.

3.2 Efficiency of the Equilibrium

The equilibrium involves two types of decisions: the labor-supply decision of the active individual, and the human-capital investment decision of the parent facing the generational transition. We now investigate the efficiency of equilibrium. Here, we use the sum of expected utility accruing to a representative individual having $\bar{b}_t$ and $\bar{h}_t$ as a welfare criterion:

$$S_t = u_t + \varepsilon V_t \qquad (12)$$
$$= u(A_t \bar{h}_t l_t, \bar{b}_t(1 - l_t)) + \varepsilon v(b_{t'}, h_{t'}).$$

The social planner maximizes

$$\int_0^\infty e^{-rt} S_t dt$$

under the religious belief transmission rule (4) and the laws of motions $\dot{\bar{b}}_t = \varepsilon(b_{t'} - \bar{b}_t)$ and $\dot{\bar{h}}_t = \varepsilon(h_{t'} - \bar{h}_t)$.[9]

Proposition 3 *The equilibrium labor-supply decision is socially optimal. The equilibrium human-capital investment is socially optimal if and only if $\mu_{ht} = \beta\mu_{bt}$, where μ_{ht} and μ_{bt} are the social shadow prices of human capital and religious belief. When $\mu_{ht} < \beta\mu_{bt}$, the equilibrium human-capital level is inefficiently high.*

The efficiency of the labor-supply decision follows because an active individual's choice of l_t affects only her own utility and there is no externality from labor supply. The inefficiency of the human-capital decision arises from the socialization externality in (4), when a parent invests more in her child's human capital (increasing $h_{t'}$), this reduces the child's religious belief ($b_{t'} = \beta(1 - h_{t'}) + (1 - \beta)\bar{b}_t$), which in turn reduces the economy-wide average belief of the next generation and, by equation (7), reduces human capital investment by all future parents as well. The parent does not internalize this negative effect on the average belief.

The direction of the resulting inefficiency—over- or under-provision of human capital—depends on whether the social value of human capital exceeds or falls short of the social value of religious belief (weighted by β, the share of parental investment in belief transmission). Because belief is partially transmitted through socialization, an individual parent does not internalize the effect of her education decision on future aggregate belief. A larger β implies a larger impacts of parent's investment in belief transmission on the future aggregate belief. Therefore, if β is sufficiently large so that $\mu_{ht} < \beta\mu_{bt}$ holds true, the planner places greater weight on preserving the stock of social belief than decentralized parents do, and the equilibrium allocates too much investment to human capital and too little to religious transmission.

Our efficiency result (Proposition 3) adds to Becker et al. (2024)'s discussion of crowding out. Becker et al. note that religious education can crowd out secular education (e.g.,

[9] Proofs are provided in the Appendix.

West and Woessmann, 2010), but treat this as a purely negative effect of religion on human capital.

We show that the crowding-out relationship runs in *both* directions: in equilibrium, parents over-invest in human capital whenever the social value of religious transmission exceeds the social returns to human capital. The direction of the distortion—whether it is secular education that crowds out religious transmission or vice versa—depends on the sign of $\mu_{ht} - \beta\mu_{bt}$, the gap between the social shadow prices of the two types of investment. This provides a nuanced view of the crowding-out mechanism that is absent from the existing survey literature.

3.3 Discussion of assumptions

As a first step in characterizing the relationship between religious transmission and human capital investment, we assume that intergenerational linkage operates in a single direction, from parents to children. This simplification greatly facilitates the characterization of the equilibrium. In particular, an individual's decision regarding working time generates no externality, implying that the equilibrium choice is optimal. By contrast, the parent's decision concerning religious transmission (and human capital investment) affects her child's behavior by altering the returns to working and religious activities, thereby generating an externality. Consequently, the equilibrium level of religious transmission is distorted.

One could, of course, introduce additional intergenerational linkages, which would generate further externalities. For example, suppose that parents care about their children's utility, so that the model incorporates a second direction of intergenerational linkage. This can be formalized by assuming that an individual's utility at the generational transition is given by a weighted sum of V_t and U_t, thereby transforming the model into a dynastic framework. In this case, an individual's decision regarding working time would also generate an externality, as it affects her parent's utility without being internalized in her own decision-making. As a result, the equilibrium allocation of working time would also be distorted.

Although such extensions are of interest, introducing multiple sources of externalities complicates the analysis and obscures a clear characterization of the model. In this paper, we therefore maintain a parsimonious framework in order to isolate and study the relationship between religious transmission and human capital investment across different environments, which we analyze in the next section. Accordingly, we restrict attention to a single direction of intergenerational linkage, from parents to children.

4 Extensions

We now extend our baseline framework in several directions.

4.1 Complementarity between Culture and Economy

Max Weber's (1930) *Protestant Ethic and the Spirit of Capitalism* argues that Protestant belief enhanced economic progress by sanctifying worldly labor and promoting literacy. To capture this mechanism, we introduce a direct complementarity between religious belief and human capital in the utility functions:

$$\begin{aligned} u_t &= A_t h_t l_t + b_t(1 - l_t) + X l_t(1 - l_t), \\ V_t &= V b_{t'} + W h_{t'} + X b_{t'} h_{t'}, \end{aligned} \tag{13}$$

where $X > 0$ parameterizes the complementarity,[10] $V > 0$ is the marginal returns of the child's religious belief, and $W > 0$ is the marginal value of the child's human capital. The term $X b_{t'} h_{t'}$ in the parental value function captures the Protestant-ethic channel: a parent values religious belief and human capital not only separately but also *jointly*, because a child who is both educated and devout is worth more than the sum of the two attributes. Observe that $A_t = e^{\gamma t \bar{h}_t}$ where γ ($\geqslant 0$) is the exogenous technological growth rate. In Proposition A1 in Online Appendix A.1, we show under which conditions there exists the unique stable steady-state equilibrium with interior solutions. We have the following result:

Proposition 4 *A higher complementarity between religious belief and human capital yields a larger human capital investment and a lower religious belief if and only if $\beta V > W$.*

The intuition is that a higher complementarity X makes the two attributes more valuable jointly than separately in the parental value function. If the marginal return to human capital W is lower than the marginal return to religious transmission βV, a higher X induces the parent to invest more in human capital to exploit the complementarity with belief. Conversely, if human capital is already highly valued ($W > \beta V$), a higher X shifts investment toward religious belief instead.

The empirical evidence on the Protestant-ethic channel is indeed mixed, and our framework offers a natural reconciliation. Becker and Woessmann (2009) find strong positive effects of Protestantism on literacy in Prussia, consistent with a large βV in our model.

[10] For Protestants, a higher X can be interpreted as reflecting the Protestant work ethic (Weber, 1930) or their higher levels of literacy (Becker and Woessmann, 2009). For Catholics, it can be interpreted as capturing the influence of the Jesuit order (Caicedo, 2019).

Cantoni (2015) finds no significant effect of Protestant adoption on city growth across 272 German cities, consistent with a small βV. Our model accommodates both findings, with the strength of the Protestant-ethic channel, X, governed by the relative size of the marginal returns.

Efficiency also depends on the degree of complementarity, X. The welfare criterion is given by the sum of expected utilities, S_t, defined in (12). The associated present-value Hamiltonian, H_t, is given by (18), while the first-order and transversality conditions are provided in (19) and (20), respectively. In this setting, the equilibrium condition for time allocated to work remains optimal, whereas the condition for human capital investment yields an inefficiently high level if and only if $\mu_{ht} - \beta\mu_{bt} < 0$, as shown in (21).

To clearly characterize the effects of X on efficiency, we focus on the case where $\gamma = 0$ and $r = 0$ (i.e., no growth and no discounting) and restrict attention to the steady-state optimum.

Proposition 5 *Suppose there is no economic growth and no discounting. The steady-state equilibrium condition for time spent working is optimal, whereas that for human capital investment yields an inefficiently high* $\bar{h}_t$ *if and only if*

$$\frac{2(W - \beta V) + (1-\beta)X - \varepsilon X^2(1-\beta)(W + V + X)}{2(\varepsilon X^2 - 1)} < 0.$$

When X is relatively small compared to W and βV, efficiency is primarily determined by the marginal returns to human capital and cultural transmission, namely W and βV. As X increases, its influence on efficiency becomes more pronounced. Figure 2 illustrates this relationship.

In Figure 2, the thicker line depicts $\mu_{ht} - \beta\mu_{bt}$ for a relatively large W compared to βV, whereas the thinner line corresponds to a relatively small W. In both cases, when X is small, the sign of $W - \beta V$ determines the sign of $\mu_{ht} - \beta\mu_{bt}$. As X increases, its effect becomes more pronounced and may eventually dominate that of $W - \beta V$. As discussed above, a higher X induces a more balanced allocation between cultural transmission and human capital investment. In the limit as $X \to \infty$, the religious belief level converges to $\beta/(1+\beta)$, while the human capital level converges to $1/(1+\beta)$.[11] However, for sufficiently large X, cultural transmission and human capital investment are weighted equally in the value function, implying that the optimal allocation requires $\bar{b}_t = \bar{h}_t = 1/2$. Consequently, $\mu_h - \beta\mu_b$ eventually becomes negative, implying that equilibrium human-capital investment becomes inefficiently high relative to the social optimum when complementarity is sufficiently strong.

[11] Indeed, $\lim_{X\to\infty} \bar{b}_t = \beta/(1+\beta)$ and $\lim_{X\to\infty} \bar{h}_t = 1/(1+\beta)$.

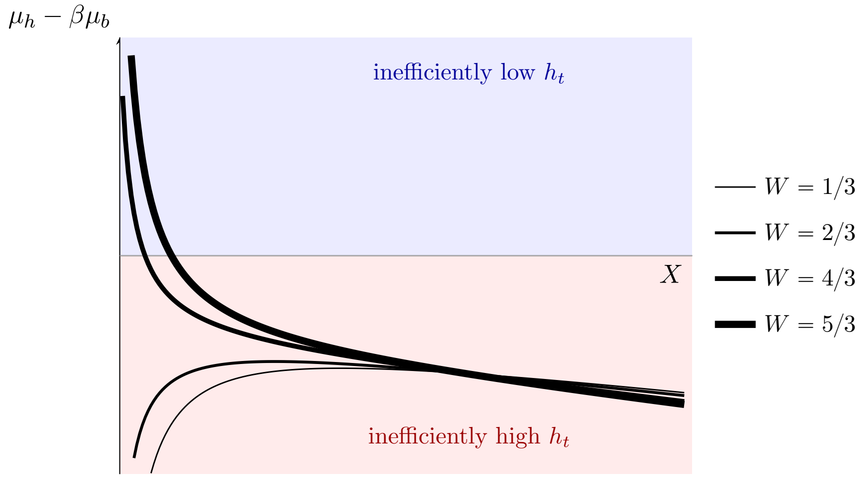


Figure 2: Effect of complementarity X on equilibrium efficiency ($\beta = 1/2$, $\varepsilon = 1/5$, $V = 1$). Thicker lines correspond to larger W. Above zero: h_t inefficiently low. Below zero: h_t inefficiently high.

The last part of this argument depends crucially on the model specification. In the current framework, we assume the presence of a socialization effect in cultural transmission in addition to parental investment. This weakens the parent's incentive to invest in cultural transmission and leads to an inefficiently high level of human capital when complementarity is strong. By contrast, if we assume no socialization in cultural transmission, i.e., $\beta = 1$, the equilibrium allocation converges to $\bar{b}_t = \bar{h}_t = 1/2$ as $X \to \infty$, thereby attaining the optimal allocation.

4.2 Veiling

Religious activities can also serve as a commitment mechanism that limits the temptation to deviate from religious norms of behavior. Carvalho (2012) develops this idea in the context of veiling among Muslim women. We embed this mechanism in our framework.

At each point in time, an individual may encounter an opportunity to engage in religiously prohibited behavior. The joint probability that the opportunity arrives and the individual succumbs equals pl_t, where $p > 0$ captures the degree of temptation and l_t appears because more time working increases exposure to temptation. Yielding to the temptation generates a disutility of $(b_t + \bar{b}_t)pl_t$: the individual regrets the transgression in proportion to her own belief b_t, and experiences additional social pressure in proportion to the society's average belief $\bar{b}_t$.

We modify (13) to incorporate the disutility of religiously prohibited behavior:

$$u_t = A_t h_t l_t - p(b_t + \bar{b}_t)l_t + X l_t(1 - l_t),$$
$$V_t = V b_{t'} + W h_{t'} + X b_{t'} h_{t'}.$$

Proposition 6 *The time devoted to religious activities, $1 - l_t^*$, is increasing in the degree of religiosity in society, $\bar{b}_t$, increasing in the degree of temptation, p, and increasing in the intensity of regret, b_t, thereby replicating the key results of Carvalho (2012, Proposition 2).*

In the Online Appendix A.2.1, we show under which condition there exists a unique interior stable-steady state equilibrium (Proposition A2). In the unique interior steady-state equilibrium, the average levels of religious belief and human capital are given by

$$\bar{h}_t^* = \frac{W + X - \beta V}{X(1+\beta)},$$
$$\bar{b}_t^* = \frac{\beta(V + X) - W}{X(1+\beta)}.$$

The efficiency analysis for the veiling model (Section A.2.2 of the Online Appendix and Proposition A3) yields a richer picture than the baseline. The possibility of inefficiently low human capital investment (as opposed to inefficiently high, as in the baseline) arises when temptation is large: a higher p raises the social cost of religiosity, since temptation disutility is proportional to belief, which reduces the planner's valuation of religious transmission relative to human capital investment. When the parent's attachment to transmission, V, is large, the relationship between p and efficiency is non-monotone: for small p, human capital is inefficiently low; for large p, it becomes inefficiently high.

These results stem from the fact that a parent's education decision generates external effects both directly on her child and indirectly on individuals in subsequent generations (via socialization). An increase in the degree of temptation, p, raises the value for a working individual of having a high level of human capital and a low level of religious belief. As a result, the direct external effect of a parent's human capital investment on her child becomes larger and more likely to be positive as p increases, thereby increasing the likelihood of inefficiently low human capital investment. By contrast, the indirect external effect on subsequent generations, operating through socialization, is always negative, since a parent's human capital investment reduces the average level of religious belief in future generations. Hence, as the parent's valuation of cultural transmission, V, increases, this negative external effect becomes stronger, giving rise to the inverted U-shaped relationship described above.

4.3 Religious conflict

Next, we consider the conflict between different religious traits, as in the cultural transmission models of Bisin and Verdier (2000, 2023, 2025) and Bisin et al. (2023). Suppose there are two cultural traits, c and d.

Unlike the baseline model, where $\bar{b}_t$ denotes the intensity of average religious belief, here $\bar{b}_{it}$ $(i = c, d)$ denotes the population share of religious trait i. The focus therefore shifts from the intensity of religiosity to the transmission of religious identity across groups A parent of trait i successfully socializes her child to her own trait with probability $1-h_{it}$, corresponding to the time devoted to religious transmission. With probability h_{it}, the child is randomly matched with an individual from the population and adopts trait i with probability $\bar{b}_{it}$. The process of cultural transmission is thus characterized by the transition probability b_{ijt} that a child from a family with trait i adopts trait j $(j \neq i)$:

$$\begin{aligned} b_{cct} &= 1 - h_{ct} + h_{ct}\bar{b}_{ct}, \qquad & b_{cdt} &= h_{ct}(1 - \bar{b}_{ct}), \\ b_{ddt} &= 1 - h_{dt} + h_{dt}\bar{b}_{dt}, \qquad & b_{dct} &= h_{dt}(1 - \bar{b}_{dt}). \end{aligned} \tag{14}$$

By assuming the law of large numbers, the dynamics of $\bar{b}_{it}$ is given by:[12]

$$\dot{\bar{b}}_{it} = \varepsilon \left(\bar{b}_{jt} b_{jit} - \bar{b}_{it} b_{ijt} \right). \tag{15}$$

We specify the utility function of an individual with trait i as

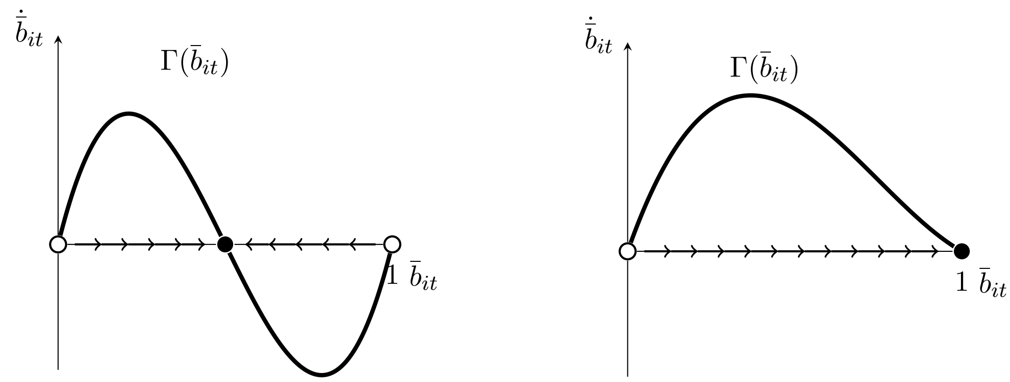
$$\begin{aligned} u_{it} &= A_t h_t l_t + \bar{b}_{it}(1 - l_t) + X_i l_t (1 - l_t), \\ V_{it} &= V_{ii} b_{iit'} + V_{ij} b_{ijt'} + W h_{t'} + X_i (1 - h_{t'}) h_{t'}, \end{aligned} \tag{16}$$

where V_{ii} and V_{ij} represent the returns from the child acquiring the parent's own trait and an alternative trait, respectively. In this section, we abstract from within-trait cultural engagement and focus on the process of cultural transmission across different traits. Accordingly, the utility functions defined in (13) and (16) differ in several respects.

First, in u_{it}, the marginal return to religious activities depends on the individual's own religious belief b_t in (13), whereas it depends on the population share of each cultural trait $\bar{b}_{it}$ in (16). Thus, (13) captures internal belief intensity, while (16) incorporates peer effects through group identity. Second, while the parent derives utility directly from her child's religious belief level in (13), in (16) utility depends on the outcome of the child's cultural transmission across groups. Third, (13) considers complementarity between religious belief and human capital investment, whereas (16) considers complementarity between cultural transmission effort and human capital investment.

[12]Since $\bar{b}_{ct} = 1 - \bar{b}_{dt}$, we have $\dot{\bar{b}}_{ct} = -\dot{\bar{b}}_{dt}$.

In Proposition A4 of Section A.3.1 in the Online Appendix, we show that a sufficiently small difference in complementarity between culture and the economy guarantees the existence and uniqueness of an interior stable steady-state. Panel (a) of Figure 3 illustrates the case described in Proposition A4. In the figure, $\Gamma(\bar{b}_{it})$ denotes the right-hand side of (A.7). If the assumptions of Proposition A4 are not satisfied, the model instead exhibits stable steady states with corner solutions, as depicted in panel (b) of Figure 3.[13]



(a) Stable steady state with interior solution

(b) Stable steady state with corner solution

Figure 3: Dynamics of the model with religious conflict. Panel (a): interior stable steady state at $\bar{b}^* \in (0, 1)$. Panel (b): unique stable steady state at $\bar{b}^* = 1$ in the case of $\dot{\bar{b}}_{it} \geqslant 0$.

We now study efficiency. In Proposition A5 of Online Appendix A.3.2, we show that the equilibrium level of human capital investment is inefficiently low. In a symmetric setting, if the level of cultural transmission is the same for both traits, the share of each trait is also the same, i.e., $\bar{b}_{ct} = \bar{b}_{dt} = 1/2$. Starting from this allocation, if all individuals of two traits coordinate and decrease the cultural transmission level by the same amount, they can increase human capital investment and attain a higher utility without changing the share of traits. Hence, we know that the equilibrium decision on human capital investment results in an inefficiently low human capital level.

Letting $\Delta V_i = V_{ii} - V_{ij}$ denote the cultural *intolerance* of trait i (the extra utility from transmitting one's own trait relative to the other's), the steady-state interior equilibrium has the property:

[13] This represents the case wherein $X_j - X_i < X_j \Delta V_i / W$ holds but $X_i - X_j < X_i \Delta V_j / W$ does not, i.e., the case of $\dot{\bar{b}}_{it} \geqslant 0$. If $X_j - X_i < X_j \Delta V_i / W$ does not hold but $X_i - X_j < X_i \Delta V_j / W$ does, we have the corner solution with $\bar{b}^*_{it} = 0$.

Proposition 7 *Cultural intolerance ΔV_i reduces the equilibrium human capital investment $\bar{h}_i^*$. If human capital raises labor productivity, cultural intolerance therefore reduces economic growth.*

Proposition 7 highlights a trade-off between cultural preservation and human-capital accumulation. Societies with stronger religious intolerance (ΔV_i large) devote more resources to direct cultural transmission and less to human capital investment. As a result, when human capital raises labor productivity (i.e., $\partial A_t/\partial \bar{h}_{it} > 0$), religious intolerance reduces economic growth. The externality is amplified by cultural conflict. In the symmetric case, both groups would benefit from a coordinated reduction in cultural competition and a corresponding increase in shared human-capital investment. However, because each group privately values the transmission of its own identity, equilibrium investment in cultural transmission remains inefficiently high relative to human capital.

This mechanism captures environments in which communities place strong emphasis on identity preservation, sectarian education, or cultural separation. In such settings, inter-group competition for cultural transmission crowds out the human-capital investment that sustains long-run productivity growth.

Proposition 7 is consistent with the empirical evidence in Montalvo and Reynal-Querol (2003), who document a robust negative relationship between religious polarization and economic development across countries. While their polarization index captures the distribution of religious groups rather than the preference parameter ΔV_i directly, societies with stronger inter-group competition plausibly exhibit stronger incentives for cultural transmission, consistent with the mechanism above. Alesina et al. (1999) provide complementary evidence that ethnic fragmentation reduces investment in productive public goods across US cities, suggesting a similar mechanism may apply to religious divisions.

4.4 City and religion

The transmission mechanism developed in the baseline model also provides a natural interpretation of the negative relationship between religiosity and urbanization documented by McCleary and Barro (2019). In productive cities, the opportunity cost of religious activities is higher, increasing labor supply and human-capital investment while weakening direct religious transmission.

We now embed the model in a system of M cities to formalize this mechanism.

Consider M cities, where city m ($m = 1, 2, \ldots, M$) is characterized by labor productivity A_m, and where the corresponding parental return from human capital investment in the child is W_m. We assume no economic growth, so that A_m is constant over time. Cities only differ in labor productivity A_m and in the return from human capital investment W_m, with $A_1 > A_2 > \cdots > A_M$ and $W_1 > W_2 > \cdots > W_M$. Let n_m denote the population size of city m, which, due to normalization of the total population, also corresponds to its population share, so that $\sum_{k=1}^{M} n_k = 1$. We specify u_t and v_t for an individual living in city m as

$$u_{mt} = z_{mi} c(n_{mt}) \left[A_m h_t l_t + b_t(1 - l_t) + X l_t(1 - l_t) \right], \tag{17}$$

$$V_{mt} = z_{mi} c(n_{mt}) \left[V b_{mt'} + W_m h_{mt'} + X b_{mt'} h_{mt'} \right].$$

The terms in brackets on the right-hand side are the same as in (13). The new term, $c(n_{mt})$, represents congestion costs: cities with larger populations face higher congestion, captured by a continuously differentiable function $0 \leqslant c(n_{mt}) \leqslant 1$, with $c(0) = 1$ and $c'(n_{mt}) < 0$. This implies that utility is discounted according to the severity of congestion.

Workers choose their city of residence by comparing city-specific utilities. Let z_{mi} denote the idiosyncratic preference of individual i for city m, where z_{mi} is drawn from a Fréchet distribution with shape parameter σ, yielding gravity-like population shares. The utility of a working individual is then given by $U_{mt} = (u_{mt} + \varepsilon V_{mt})/(r + \varepsilon)$. Upon entering the economy and observing the realizations of z_{mi}, each individual i chooses the city that yields the highest U_{mt}.

Proposition 8 *If labor productivity is sufficiently high ($A_m > \max[1, \tilde{A}]$), then in any stable steady-state equilibrium:*

1. *More productive cities attract larger populations.*

2. *Workers in larger cities devote more time to labor (and less to religious activities) and have higher human capital (and lower religious belief).*

The model thus generates a negative cross-city relationship between city size and religiosity.

The mechanism has two parts. First, higher productivity and higher returns to human capital directly raise the opportunity cost of religious activities, reducing religious belief and increasing labor supply. Second, because more productive cities attract more workers, the congestion cost adjusts to restore the free-mobility equilibrium: the larger city must offer a higher gross utility to compensate for crowding, and this is achieved through both higher wages and lower religiosity.

Proposition 8 rationalizes the secularization hypothesis of Norris and Inglehart (2011), who document a robust negative relationship between economic development and religiosity across countries and over time. In our framework, secularization is not an autonomous cultural process but an equilibrium outcome driven by the productivity gradient across cities: as economies develop and productive cities grow, workers endogenously sort into urban areas where the opportunity cost of religious activities is highest, generating a market-driven decline in aggregate religiosity consistent with the cross-country evidence in McCleary and Barro (2019).

5 Conclusion

This paper has developed a unified theory of religion, human capital, and economic growth. Starting from the observation that belief and religious activities have *opposite* effects on growth—a robust empirical finding due to Barro and McCleary (2003) and McCleary and Barro (2019)—we have built a dynamic model in which this pattern emerges from first principles. Our central finding is that the labor-supply margin of individual religious choice is privately and socially optimal, while the human-capital investment margin is not: when the social value of religious transmission is large, the socialization externality causes parents to over-invest in human capital relative to the social planner's optimum, because they do not internalize the negative spillover of human capital investment on the economy's stock of religious belief. This result suggests that policies supporting religious or cultural transmission may be welfare-improving, in economies where religious belief is a strong determinant of human capital investment.

Several extensions enrich this picture. The Protestant-ethic complementarity between belief and human capital generates a non-monotone relationship between complementarity strength and efficiency: strong complementarities can reverse the direction of the distortion. This extension also enables us to discuss the effects of temptation to deviate from religious norms. The religious conflict extension shows that intolerance between religious groups reduces aggregate human capital and reduces growth, a mechanism with direct relevance to societies experiencing religious polarization. The multi-city extension endogenizes the urban-rural religiosity gradient, explaining why larger and more productive cities are systematically less religious.

Our model assumes one-directional inter-generational linkage, from parents to children. Introducing a dynastic component—whereby individuals also care about their parents' utility—would generate additional externalities in the labor-supply decision and is an interesting direction for future work.

Appendix: Proofs

Proof of Proposition 3: The corresponding present-value Hamiltonian can be written as

$$H_t = e^{-rt}S_t + \mu_{bt}\varepsilon(b_{t'} - \bar{b}_t) + \mu_{ht}\varepsilon(h_{t'} - \bar{h}_t), \tag{18}$$

where $r > 0$ is the discount rate.

Lemma 1 *The multipliers are given by*

$$\mu_{bt} = e^{\varepsilon\beta t}\mu_{b0} - \int_0^t e^{\varepsilon\beta(t-\tau)}\eta_\tau d\tau,$$
$$\mu_{ht} = e^{\varepsilon t}\mu_{h0} - \int_0^t e^{\varepsilon(t-\tau)}\xi_\tau d\tau.$$

Proof of Lemma 1: Define η_t and ξ_t as

$$\eta_t = e^{-rt}\left[(1-l_t)u_2 + \varepsilon(1-\beta)v_1\right],$$
$$\xi_t = e^{-rt}\left(A_t l_t + A_2\bar{h}_t l_t\right)u_1,$$

We can rewrite the last two equations of (19) as

$$e^{-\varepsilon\beta t}\dot{\mu}bt - e^{-\varepsilon\beta t}\varepsilon\beta\mu bt = -e^{-\varepsilon\beta t}\eta_t,$$
$$e^{-\varepsilon t}\dot{\mu}ht - e^{-\varepsilon t}\varepsilon\mu ht = -e^{-\varepsilon t}\xi_t.$$

Taking integrals from 0 to t and rearranging the equations, we obtain

$$\mu_{bt} = e^{\varepsilon\beta t}\mu_{b0} - \int_0^t e^{\varepsilon\beta(t-\tau)}\eta_\tau d\tau,$$
$$\mu_{ht} = e^{\varepsilon t}\mu_{h0} - \int_0^t e^{\varepsilon(t-\tau)}\xi_\tau d\tau.$$

We can take the limit of $t \to \infty$ to obtain

$$\mu_{b0} = \int_0^\infty e^{-\varepsilon\beta\tau}\eta_\tau d\tau,$$
$$\mu_{h0} = \int_0^\infty e^{-\varepsilon\tau}\xi_\tau d\tau,$$

□

The first-order conditions for the maximization of the Hamiltonian (18) are

$$\begin{aligned}
l_t :\quad & 0 = \frac{\partial H_t}{\partial l_t} = e^{-rt}\left(u_1 A_t\bar{h}_t - u_2\bar{b}_t\right), \\
h_{t'} :\quad & 0 = \frac{\partial H_t}{\partial h_{t'}} = e^{-rt}\varepsilon\left(v_2 - \beta v_1\right) - \varepsilon\beta\mu_{bt} + \varepsilon\mu_{ht}, \\
\bar{b}_t :\quad & \dot{\mu_{bt}} = -\frac{\partial H_t}{\partial \bar{t} = -e^{-rt}\left[(1-l_t)u_2 + \varepsilon(1-\beta)v_1\right] + \varepsilon\beta\mu_{bt},} \\
\bar{h}_t :\quad & \dot{\mu_{ht}} = -\frac{\partial H_t}{\partial \bar{h}_t} = -e^{-rt}\left(A_t l_t + A_2\bar{h}_t l_t\right)u_1 + \varepsilon\mu_{ht}.
\end{aligned} \tag{19}$$

The transversality conditions are

$$\lim_{t\to\infty} \mu_{bt}\bar{b}_t = \lim_{t\to\infty} \mu_{ht}\bar{h}_t = 0. \tag{20}$$

We evaluate $\partial H_t/\partial l_t$ and $\partial H_t/h_{t'}$ at the steady-state equilibrium where we have $h_t = \bar{h}_t$ and $b_t = \bar{b}_t$, $\forall t$. If the evaluated value is positive (resp. negative), we know the corresponding variable in equilibrium is inefficiently low (resp. high). Combining (5) and (6) with $h_t = \bar{h}_t$ and $b_t = \bar{b}_t$, we obtain

$$\begin{aligned} \left.\frac{\partial H_t}{\partial l_t}\right|_{\text{equilibrium}} &= 0, \\ \left.\frac{\partial H_t}{\partial h_{t'}}\right|_{\text{equilibrium}} &= \varepsilon(\mu_{ht} - \beta\mu_{bt}). \end{aligned} \tag{21}$$

Hence, the equilibrium condition for the time spent on working (hence, religious activities) is optimal whereas that for human capital investment (hence, religious engagement) is not. □

Proof of Proposition 4: In the steady-state equilibrium, the average levels of religious belief and human capital are given by

$$\begin{aligned} \bar{b}^* &= \frac{\beta(X+V)-W}{(1+\beta)X}, \\ \bar{h}^* &= \frac{X+W-\beta V}{(1+\beta)X}. \end{aligned}$$

Hence, we can see that

$$\begin{aligned} \frac{\partial \bar{b}^*}{\partial X} &= \frac{W-\beta V}{(1+\beta)X^2}, \\ \frac{\partial \bar{h}^*}{\partial X} &= \frac{\beta V - W}{(1+\beta)X^2}. \end{aligned}$$

This completes the proof. □

Proof of Proposition 5: In the steady-state optimum with no-discounting, the shadow prices become

$$\mu_h = \frac{l^{**}}{\varepsilon}, \qquad \mu_b = \frac{1-l^{**}+\varepsilon(1-\beta)(V+X\bar{h}^{**})}{\varepsilon\beta}.$$

Then, we can solve the first-order conditions (19) for the steady-state optimum to obtain

$$l^{**} = \frac{\varepsilon(W+X^2-V)-1}{2(\varepsilon X^2-1)}, \qquad \bar{h}^{**} = \frac{\varepsilon X(X+W-V)-1}{2(\varepsilon X^2-1)}.$$

Hence, by plugging these optimal values into $\mu_h - \beta\mu_b$, we obtain

$$\mu_h - \beta\mu_b = \frac{2(W-\beta V) + (1-\beta)X - \varepsilon X^2(1-\beta)(W+V+X)}{2(\varepsilon X^2 - 1)}.$$

This completes the proof. □

Proof of Proposition 6: The first-order conditions for utility maximization yield

$$\begin{aligned} l_t^* &= \frac{A_t h_t - p(b_t + \bar{b}_t) + X}{2X}, \\ h_{t'}^* &= \frac{W - \beta V + X[\beta + (1-\beta)\bar{b}_t]}{2\beta X}. \end{aligned} \tag{22}$$

From these equations, it is straightforward to obtain the results in Proposition 6. □

Proof of Proposition 7: We focus on the case described by Figure 3(a) and examine the steady-state equilibrium with interior solutions. Then, the share of trait i is given by

$$\bar{b}_i^* = \frac{W(X_i - X_j) + X_j \Delta V_i}{X_i \Delta V_j + X_j \Delta V_i},$$

and the average level of human capital investment is given by

$$\bar{h}_i^* = \frac{(W + X_i)\Delta V_j + (W + X_j - \Delta V_j)\Delta V_i}{2\left(X_i \Delta V_j + X_j \Delta V_i\right)}.$$

Hence, a larger cultural intolerance of either trait affects the level of human capital investment as:

$$\begin{aligned} sgn\left(\frac{\partial \bar{h}_i^*}{\partial \Delta V_i}\right) &= sgn\left(W(X_i - X_j) - X_i \Delta V_j\right), \\ \text{sgn}\left(\frac{\partial \bar{h}_i^*}{\partial \Delta V_j}\right) &= \text{sgn}\left(W(X_j - X_i) - X_j \Delta V_i\right). \end{aligned}$$

Since $X_i - X_j < X_i \Delta V_j / W$, $\forall i, \forall j \neq i$ in the steady-state equilibrium with interior solutions, we know that the signs of these equations are negative. This proves Proposition 7. □

Proof of Proposition 8: Denote the common utility parts as $\overline{u}_{mt}$, $\overline{V}_{mt}$ and $\overline{U}_{mt}$, i.e.,

$$\begin{aligned} \overline{u}_{mt} &= c(n_{mt})\left[A_m h_t l_t + b_t(1-l_t) + X l_t(1-l_t)\right], \\ \overline{V}_{mt} &= c(n_{mt})\left[V b_{mt'} + W_m h_{mt'} + X b_{mt'} h_{mt'}\right], \\ \overline{U}_{mt} &= \frac{\overline{u}_{mt} + \varepsilon \overline{V}_{mt}}{r + \varepsilon} \end{aligned}$$

Then, assuming the law of large numbers, the share of individuals choosing city m is given by

$$n_{mt} = \frac{(\overline{u}_{mt} + \varepsilon \overline{V}_{mt})^{\sigma}}{\sum_{k=1}^{M} (\overline{u}_{kt} + \varepsilon \overline{V}_{kt})^{\sigma}}. \tag{23}$$

After entering to city m, each individual decides on l and h taking the population share n_m as given. The first-order conditions of the utility maximization are given by (A.1). In the followings, we assume stable steady-state equilibrium with interior solution, implying that

$$l_m^* = \frac{A_m \bar{h}_m - \bar{b}_m + X}{2X}, \quad \bar{b}_m^* = \frac{\beta(X+V) - W_m}{(1+\beta)x}, \quad \bar{h}_m^* = \frac{X + W_m - \beta V}{(1+\beta)X}. \tag{24}$$

From this, we readily know that

$$\begin{aligned} &\frac{\partial l_m^*}{\partial A_m} = \frac{\bar{h}_m^*}{2X} > 0, \quad \frac{\partial \bar{b}_m^*}{\partial A_m} = \frac{\partial \bar{h}_m^*}{\partial A_m} = 0, \\ &\frac{\partial l_m^*}{\partial W_m} = \frac{A_m + 1}{2(1+\beta)X^2}, \quad \frac{\partial \bar{b}_m^*}{\partial W_m} = -\frac{\partial \bar{h}_m^*}{\partial W_m} = -\frac{1}{(1+\beta)X} < 0. \end{aligned} \tag{25}$$

We here rewrite $\overline{u}_{mt} + \varepsilon \overline{V}_{mt}$ as

$$\overline{u}_{mt} + \varepsilon \overline{V}_{mt} = c(n_m)\Gamma_m,$$

where Γ_m is defined as

$$\Gamma_m = A_m h_t l_t + b_t(1 - l_t) + X l_t (1 - l_t) + \varepsilon \left[V b_{mt'} + W_m h_{mt'} + X b_{mt'} h_{mt'} \right].$$

Γ_m represents the deterministic utility before discount by congestion. Plugging (24) into Γ_m to obtain Γ_m^*, we know from (25) that

$$\begin{aligned} &\frac{\partial \Gamma_m^*}{\partial A_m} = \bar{h}_m^* l_m^* > 0, \\ &\frac{\partial \Gamma_m^*}{\partial W_m} = \frac{1}{(1+\beta)^2 X} \left\{ (1+\beta)[(A_m+1)l_m^* - 1] + \varepsilon[2\beta(X+W) - (1+\beta^2)V] \right\}.. \end{aligned} \tag{26}$$

Define $\widetilde{A}$ as

$$\widetilde{A} = c.$$

We can now prove part 1 of Proposition 8 by stating the following lemma:

Lemma 2 *If A_m is sufficiently large, i.e., $A_m > \max\{1, \widetilde{A}\}$, the deterministic utility before congestion discounting in the stable steady-state equilibrium, Γ_m^*, is increasing in W_m.*

Proof of Lemma 2: From (24), the time spent on working, l_m^*, is increasing in A_m. Hence, defining $\underline{l}$ as l under $A_m = 1$, i.e.,

$$\underline{l} = \frac{2W + (1-\beta)X + (1+\beta)X^2 - 2\beta V}{2(1+\beta)X^2},$$

we can see that

$$\frac{\partial \Gamma_m^*}{\partial W_m} > \frac{1}{(1+\beta)^2 X} \left\{(1+\beta)[(A_m+1)\underline{l} - 1] + \varepsilon[2\beta(X+W) - (1+\beta^2)V]\right\}.$$

The RHS of the above equation is positive if and only if

$$A_m > \widetilde{A} \equiv \frac{1}{\underline{l}}\left[1 + \frac{\varepsilon[(1+\beta^2)V - 2\beta(X+W)]}{1+\beta}\right] - 1.$$

Hence, we have $\partial\Gamma_m^*/\partial W_m > 0$ if $A_m > \max[1, \widetilde{A}]$. □

Let us now prove part 2 of Proposition 8 by stating the following lemma:

Lemma 3 *Suppose $A_m > \max[1, \widetilde{A}]$. In a stable steady-state equilibrium, an individual residing in a larger city spends more time on working (and less time on religious activities) and has a higher human capital level (and a lower religious belief).*

Proof of Lemma 3: Suppose $A_M > \max[1, \widetilde{A}]$. Then, we know from (26) and Proposition 2 that Γ_m^* is higher for a city with smaller m, i.e., $\Gamma_1^* > \Gamma_2^* > \cdots > \Gamma_M^*$. From (23), the ratio of population shares for cities m and m' with $m < m'$ is determined as

$$\frac{n_m^*}{n_{m'}^*} = \left(\frac{\overline{u}_m + \varepsilon\overline{V}_m}{\overline{u}_{m'} + \varepsilon\overline{V}_{m'}}\right)^\sigma = \left(\frac{c(n_m^*)}{c(n_{m'}^*)}\right)^\sigma \left(\frac{\Gamma_m^*}{\Gamma_{m'}^*}\right)^\sigma,$$

which can be rewritten as

$$\frac{n_m^*}{n_{m'}^*}\left(\frac{c(n_{m'}^*)}{c(n_m^*)}\right)^\sigma = \left(\frac{\Gamma_m^*}{\Gamma_{m'}^*}\right)^\sigma > 1.$$

Hence, we have

$$\frac{n_m^*}{c(n_m^*)^\sigma} > \frac{n_{m'}^*}{c(n_{m'}^*)^\sigma}.$$

Since

$$\frac{d}{dn_m}\left(\frac{n_m}{c(n_m)^\sigma}\right) = \frac{1}{c(n_m)^\sigma} - \frac{\sigma n_m c'(n_m)}{c(n_m)^{\sigma+1}} > 0,$$

we know that $n_m^* > n_{m'}^*$. Moreover, from the assumptions regarding A_m and W_m and (25), we know that

$$l_m^* > l_{m'}^*, \quad \overline{b}_m^* < \overline{b}_{m'}^*, \quad \overline{h}_m^* > \overline{h}_{m'}^*.$$

This completes the proof. □

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Online Appendix

A Additional results

A.1 Complementarity between Culture and Economy (Section 4.1)

The first-order conditions for utility maximization yield

$$\begin{aligned} l_t^* &= \frac{A_t h_t - b_t + X}{2X}, \\ h_{t'}^* &= \frac{W - \beta V + X[\beta + (1-\beta)\bar{b}_t]}{2\beta X}. \end{aligned} \tag{A.1}$$

Plugging (A.1) into (4), we obtain

$$b_{t'}^* = \frac{\beta(X+V) - W + (1-\beta)X\bar{b}_t}{2X}.$$

Combined with (10), this equation, and (A.1) yield the following proposition.

Proposition A1 *Assume that* $\max\{A_t, 1\} < X$ *and* $(1-\beta)X < W + X - \beta V < 2\beta X$*. Then, there exists the unique stable steady-state equilibrium with interior solutions.*

Note that $\max\{A_t, 1\} < X$ and $(1-\beta)X < W + X - \beta V < 2\beta X$ ensure interior solutions for l_t^* and $h_{t'}^*$, respectively.

A.2 Veiling (Section 4.2)

A.2.1 Stable interior equilibrium with veiling

Plugging (22) into (4), we obtain

$$b_{t'}^* = \frac{\beta V - W + X[\beta + (1-\beta)\bar{b}_t]}{2X}$$

Combined with (9), this and (22) yield the following proposition.

Proposition A2 *Assume that* $\max\{A_t, 2p\} < X$ *and* $(1-\beta)X < W - \beta V + X < 2\beta X$*. Then there exists the unique stable-steady state equilibrium with interior solutions.*

Note that $\max\{A_t, 2p\} < X$ and $(1-\beta)X < W - \beta V + X < 2\beta X$ ensure interior solutions for l_t^* and $h_{t'}^*$, respectively.

A.2.2 Efficiency with veiling

The welfare criterion is again given by the sum of expected utility, S_t, defined by (12). The corresponding present-value Hamiltonian, H_t, is given by (18) and the first-order conditions and transversality conditions are given by (19) and (20), respectively. Here, the equilibrium condition for the time spent on working is again optimal whereas that for human capital investment yields an inefficiently high level if and only if $\mu_{ht} - \beta\mu_{bt} < 0$, and an inefficiently low level if and only if $\mu_{ht} - \beta\mu_{bt} > 0$, as shown in (21).

In the followings, we examine the effect of the degree of temptation, p, on the efficiency of equilibrium. To clearly characterize it, we focus on the case of $\gamma = 0$ and $r = 0$ (i.e., no growth and no discounting case) and restrict our attention on the steady-state optimum.

Thus, we obtain the following proposition.

Proposition A3 *Suppose there is no economic growth and no discounting. The steady-state equilibrium condition for time allocated to work is optimal, whereas that for human capital investment is not. The likelihood of inefficiently low human capital investment increases with the degree of temptation, p, when p is small. If the parental return from cultural transmission, V, is sufficiently large, the relationship between p and the likelihood of inefficiently low human capital investment exhibits an inverted U-shape.*

Proof of Proposition A3: In the steady-state optimum with no-discounting, the shadow prices become

$$\mu_h = \frac{l^{**}}{\varepsilon}, \qquad \mu_b = \frac{-2pl^{**} + \varepsilon(1-\beta)(V + X\bar{h}^{**})}{\varepsilon\beta}.$$

Then, we can solve the first-order conditions (19) for the steady-state optimal allocation to obtain

$$\begin{aligned} \bar{h}^{**} &= \frac{2X\varepsilon(W + X - V) + (1+2p)(X-2p)}{4X^2\varepsilon - (1+2p)^2}, \\ l^{**} &= \frac{\varepsilon[X(1 + 2X - 2p) + (1+2p)(W - V)]}{4X^2\varepsilon - (1+2p)^2}. \end{aligned} \tag{A.2}$$

Note here that the cross-derivative of the Hamiltonian yields

$$\frac{\partial H_t}{\partial h_{t'} \partial W} = \varepsilon > 0, \tag{A.3}$$

which implies that a larger return from human capital investment leads to a higher optimal human capital level. Meanwhile, (A.2) results in

$$\frac{\partial h^{**}}{\partial W} = \frac{2X\varepsilon}{4X^2\varepsilon - (1+2p)^2}.$$

Equation (A.3) implies that the RHS of this equation must be positive. Hence, we need to impose a regularity condition that $4X^2\varepsilon - (1+2p)^2 > 0$. Moreover, we need to assume that $4X^2\varepsilon > 1$ so that we can consider a non-empty admissible interval of p. Thus, we focus on p satisfying that $0 < p < \underline{p}$, where $\underline{p}$ is defined as $\underline{p} \equiv -1/2 + X\sqrt{\varepsilon}$.

By plugging these optimal values (A.2) into $\mu_h - \beta\mu_b$, we obtain

$$\mu_h - \beta\mu_b = \frac{\Omega}{4X^2\varepsilon - (1+2p)^2},$$

where Ω is defied as

$$\Omega \equiv (1+2p)\left\{W + X + X^2 - \beta V + \beta X^2 - 2p[\beta(V+X) - W]\right\} - 2X^2\varepsilon(1-\beta)(V+W+X).$$

Because $4X^2\varepsilon - (1+2p)^2 > 0$ holds true for a p satisfying that $0 < p < \underline{p}$, the sign of $\mu_h - \beta\mu_b$ is determined by the sign of Ω, that is,

$$\mathbf{sgn}\left(\mu_h - \beta\mu_b\right) = \mathbf{sgn}\left(\Omega\right). \tag{A.4}$$

Moreover, the assumption that $(1-\beta)X < W - \beta V + X < 2\beta X$ (see Proposition A2) implies that $\beta(V+X) > W$. Hence, we know that Ω is a quadratic function of which parabola opens downward. The maximum point of Ω is then given by[1]

$$\hat{p} = \frac{2(W - \beta V) + X[1 - \beta + (1+\beta)X]}{\beta(V+X) - W} > 0. \tag{A.5}$$

Hence, if $0 < \underline{p} \leqslant \hat{p}$, Ω increases as p increases. If $0 < \hat{p} < \underline{p}$, Ω first increases then falls as p increases. Finally, we readily know that $\hat{p}$ monotonically decreases but $\underline{p}$ is unaltered as V increases. From these arguments and (A.4), we obtain the proposition. □

A.3 Religious conflict (Section 4.3)

A.3.1 Stable interior equilibrium with religious conflict

The first-order condition for the utility maximization yield

$$\begin{aligned} l_{it}^* &= \frac{A_t h_{it} + X_i - \bar{b}_{it}}{2X_i}, \\ h_{it'}^* &= \frac{W + X_i - (1 - b_{it})\Delta V_i}{2X_i}, \end{aligned} \tag{A.6}$$

[1] The inequality is shown as follows. The assumption that $(1-\beta)X < W - \beta V + X < 2\beta X$ implies that $W + X > \beta V$ and $\beta(V+X) > W$. From the latter, we know that the denominator of the RHS of (A.5) is positive. Moreover, from the former, we know that the numerator of the RHS of (A.5) satisfies that

$$\begin{aligned} 2(W - \beta V) + X[1 - \beta + (1+\beta)X] &> 2(W - \beta V) + X(1 - \beta + 1 + \beta) \\ &= 2(W + X - \beta V) > 0, \end{aligned}$$

where we use the assumption that $\max\{A_t, 2p\} = \max\{1, 2p\} < X$ (see Proposition A2).

where ΔV_i is defined as $\Delta V_i = V_{ii} - V_{ij}$, which represents the cultural intolerance of trait i. We assume that $\max[A_t, 1] < X_i$ and $0 < W + X_i - \Delta V_i < 2X_i$ in order to ensure the interior solutions for l_{it} and $h_{it'}$. Plugging (14) and (A.6) into (15), we obtain

$$\dot{\bar{b}}_{it} = \frac{\varepsilon}{2X_i X_j}\bar{b}_{it}(1-\bar{b}_{it})\left[W(X_i - X_j) + (1-\bar{b}_{it})X_j\Delta V_i - \bar{b}_{it}X_i\Delta V_j\right]. \tag{A.7}$$

The RHS of (A.7) is a cubic function, taking zero at $\bar{b}_{it} = 0$ and $\bar{b}_{it} = 1$. Hence, we can check whether (A.7) has a stable steady-state with a interior solution for $\bar{b}_{it}$ by examining its derivative at $\bar{b}_{it} = 0$ and $\bar{b}_{it} = 1$:

$$\left.\frac{d\dot{\bar{b}}_{it}}{d\bar{b}_{it}}\right|_{\bar{b}_{it}=0} = \frac{\varepsilon[X_j\Delta V_i - W(X_j - X_i)]}{2X_iX_j},$$
$$\left.\frac{d\dot{\bar{b}}_{it}}{d\bar{b}_{it}}\right|_{\bar{b}_{it}=1} = \frac{\varepsilon[X_i\Delta V_j - W(X_i - X_j)]}{2X_iX_j}.$$

Thus, we obtain the following proposition.

Proposition A4 *Suppose that* $\max[A_t, 1] < X_i$ *and* $0 < W + X_i - \Delta V_i < 2X_i$. *There exists the unique stable steady-state equilibrium with interior solutions if and only if* $X_i - X_j < X_i\Delta V_j/W$, $\forall i, \forall j \neq i$.

A.3.2 Efficiency with religious conflict

The sum of expected utility accruing to a representative individual, S_t, and the present-value Hamiltonian, H_t, are now given by

$$S_t = \bar{b}_{ct}\left[u_{ct} + \varepsilon V_{ct}\right] + (1-\bar{b}_{ct})\left[u_{dt} + \varepsilon V_{dt}\right],$$
$$H_t = e^{-rt}S_t + \mu_{bt}\varepsilon\left(\bar{b}_{dt}b_{dct} - \bar{b}_{ct}b_{cdt}\right) + \mu_{hct}\varepsilon(h_{ct'} - \bar{h}_{ct}) + \mu_{hdt}(h_{dt'} - \bar{h}_{dt}).$$

Here, to focus on the effects of cultural intolerance on efficiency, we assume no growth and symmetric allocation (i.e., $A_t = A$, $X_c = X_d = X$,$\Delta V_c = \Delta V_d = \Delta V$) and focus on the symmetric steady-state optimum.

We again evaluate the derivatives of H_t with respect to l_{it} and $h_{it'}$ at symmetric stable steady-state equilibrium to obtain

$$\left.\frac{\partial H_t}{\partial l_{ct}}\right|_{\text{s-equilibrium}} = \left.\frac{\partial H_t}{\partial l_{dt}}\right|_{\text{s-equilibrium}} = 0, \tag{A.8}$$
$$\left.\frac{\partial H_t}{\partial h_{ct'}}\right|_{\text{s-equilibrium}} = \left.\frac{\partial H_t}{\partial h_{dt'}}\right|_{\text{s-equilibrium}} = \varepsilon\mu_{ht}.$$

Note that in a symmetric allocation, we have $\bar{b}_{ct} = \bar{b}_{dt} = 1/2$, $l_{ct} = l_{dt} = l_t$, $\mu_{bct} = 0$, and $\mu_{hct} = \mu_{hdt} = \mu_{ht}$.[2] Moreover, we can solve the differential equation of the shadow price μ_h in the steady-state optimum as

$$\mu_{ht} = \frac{e^{-rt} A l^{**}}{2(\varepsilon + r)} > 0. \tag{A.9}$$

From (A.8) and (A.9), we obtain the following proposition.

Proposition A5 *Suppose no economic growth and symmetric steady-state equilibrium. The equilibrium level of human capital investment is inefficiently low.*

[2] In a symmetric allocation, we obtain $\dot{\mu_{bct}} = 0$, implying that μ_{bct} is a constant. Then, from the tansversality condition, we obtain $\mu_{bct} = 0$.