Forbidden fruits: the political economy of science, religion, and growth

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Forbidden Fruits: The Political Economy of Science, Religion, and Growth

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Abstract

We study the coevolution of religion, science and politics. We first uncover, in international and U.S. data, a robust negative relationship between religiosity and patents per capita. The model then combines: (i) scientific discoveries that raise productivity but sometimes erode religious beliefs; (ii) a government that allows innovations to diffuse, or blocks them; (iii) religious institutions that can invest in doctrinal reform. Three long-term outcomes emerge. The "Western-European Secularization" regime has declining religiosity, unimpeded science, and high taxes and transfers. The "Theocratic" regime involves knowledge stagnation, unquestioned dogma, and high religious-public-goods spending. The "American" regime combines scientific progress and stable religiosity through doctrinal adaptations, with low taxes and some fiscal-legal advantages for religious activities. Rising income inequality can, however, empower a Religious-Right alliance that starts blocking belief-eroding ideas.

Keywords: science, discovery, innovation, progress, knowledge, religion, secularization, tolerance, religious right, theocracy, politics, populism, denialism, inequality, redistribution.

JEL Classification: E02, H11, H41, O3, O43, P16, Z12.

"For an economy to create the technical advances that enabled it to make the huge leap of modern growth, it needed a culture of innovation, one in which new and sometimes radical ideas were respected and encouraged, heterodoxy and contestability were valued, and novelty tested, compared, and diffused if found to be superior by some criteria to what was there before." (Mokyr, 2012, p. 39).

"To keep ourselves right in all things, we ought to hold fast to this principle: What I see as white I will believe to be black if the hierarchical church thus determines it." (Ignatius de Loyola, founder of the Jesuit order – Spiritual Exercises (1522-1524), 13th Rule).

"All that stuff I was taught about evolution and embryology and the big bang theory, all that is lies straight from the pit of Hell... It's lies to try to keep me and all the folks who were taught that from understanding that they need a savior... You see, there are a lot of scientific data that I've found out as a scientist that actually show that this is really a young Earth. I don't believe that the earth's but about 9,000 years old. I believe it was created in six days as we know them. That's what the Bible says."
Rep. Paul Broun (R-Ga.), member of the House Committee on Science, Space, and Technology, 2012.

1 Introduction

Throughout history there have been periodic clashes between scientific discoveries and religious doctrines, and even today such conflicts remain important in a number of countries. In such cases the arbiter is often the State, which can allow the diffusion of the new knowledge, or on the contrary try to repress and contain it to protect religious beliefs. Its choice depends in particular on whether its power base and class interests lie more with the secular or religious segments of the population, and thus on the general level of religiosity as well as the distribution of productive abilities among agents. There is therefore a two-way interaction between the dynamics of scientific knowledge and those of religious beliefs, which broad evidence suggests can lead to very different long-term outcomes across countries.

As further motivation for the economic importance of the issue, we carry out a simple empirical exercise, with rather striking results: across countries as well as across U.S. states, there is a clear negative relationship between religiosity and innovation (patents per capita). This finding is quite robust, and in particular unaffected by controlling for the standard variables used in the literature to explain patenting and technological innovation.

To shed light on the workings of the science-religion-politics nexus, we develop a model with three key features: (i) the recurrent arrival of scientific discoveries that, if widely diffused and implemented, generate productivity gains but sometimes also erode valued religious beliefs, by contradicting important aspects of the doctrine; (ii) a government that can allow such ideas and innovations to spread, or spend resources to censor them and impede their diffusion. Through fiscal policy or laws regulating conduct, it also arbitrates between secular public goods and religious (belief-complementary) ones; (iii) A "Church" or religious sector that can, at a cost, undertake an adaptation of the doctrine –reinterpretation, reformation, entry of new cults, etc.– that renders it more compatible with the new knowledge, thereby also alleviating the need for blocking by the State.

The game then unfolds as follows. Each generation, living for two periods, is composed of (up to) four social classes, corresponding to the religious/secular and rich/poor divides. At both stages of life they compete for power, which may involve forming strategic (coalition-proof) alliances with others. The candidate or leader of the group that emerges victorious governs the State, implementing his preferred policy. In the first period (youth), policy choice is over the control of knowledge, namely whether to set up a repressive and/or propaganda apparatus that will block belief-eroding discoveries emanating from the sciences. This decision is forward-looking, taking into account the Church's repairing strategy, and how an erosion of religiosity would affect subsequent political outcomes. In the second period (old age), more short-run policies are chosen: these may be fiscal, such as public spending and its allocation between secular public goods (or transfers) and subsidies (or tax exemptions) for religious activities, or social, such as the conformity of society's laws to religious views. After each generation dies, a new one inherits its predecessor's final stocks of scientific and religious capital.

We characterize the outcome of these strategic interactions and the resulting dynamics of scientific knowledge, TFP, and religious beliefs. We show in particular the emergence of three basins of attraction: (i) a "Western-European" or *"Secularization"* regime, with unimpeded scientific progress, declining religiosity, a passive Church and high levels of secular spending; (ii) a *"Theocratic"* regime with knowledge stagnation, persistently extreme religiosity, a Church that makes no effort to adapt since beliefs are protected by the State, and a very high subsidization of the religious sector; (iii) in-between these two, an *"American"* regime that generally combines scientific progress with stable, intermediate religiosity: the State does not block new knowledge but still implements fiscal or legal policies benefiting religion, and conversely religious institutions find it worthwhile to invest in doctrinal repair.

Using a simple quantitative version of the model as a five-state Markov process, we then study the medium-run (25 years) transitions between these *(religiosity, innovation)* states, and the resulting long-run distribution. The latter is trimodal, reflecting the above three main regimes. A country starting in the "American" mode has probabilities of 17% and 20% per generation of transitioning in the secular or theocratic direction, respectively. These include probabilities of 8% and 5% of moving to the "strongly secular" state, where religiosity erodes unrepaired, or the "strongly theocratic" one, where threatening scientific ideas are blocked. Both have a high persistence (80%), making them the other modes of the distribution.

Finally, we analyze how income inequality interacts with the religious/secular divide, and how this affects equilibrium dynamics. In the "American" regime, rising inequality fosters the emergence of a *Religious-Right coalition* between religious rich and religious poor, which then starts blocking belief-eroding ideas. Inequality is thus harmful to knowledge and growth, by inducing obscurantist, anti-science attitudes and polices.

1.1 Related Literature

Within the literature on the political economy of growth, the most closely related papers are those in which governments resist the adoption of technological innovations, due to , Bridgman et al. (2007)). Through the "adaptation" work of the Church, the paper also relates to those in which new technologies diffuse only slowly because they require costly learning (Chari and Hopenhayn (1991), Caselli (1999)). Unlike previous work we focus on fundamental science rather than specific devices, and on religious beliefs as a *coevolving* form of (social) capital, occasionally threatened by new discoveries. Our study thereby relates to historical work on scientific-economic progress and religion, such as Koyré (1957), Mokyr (1998, 2004), Landes (1998), Greif (2005), Chaney (2011, 2016), Deming (2010), Saleh (2016), Rubin (2017), and Kuru (2019).

The paper also contributes to the literature on distributional politics and institutional persistence (e.g., Bénabou (1996, 2000), Acemoglu and Robinson (2008), Persson and Tabellini (2009), Acemoglu et al. (2011)). We focus on a very different source of endogenous persistence, however, namely a population's religiosity. In this respect, the paper relates to work on the dynamics of political beliefs and culture (e.g., North (1990), Greif (1994), Piketty (1995), Bisin and Verdier (2000), Alesina and Angeletos (2005), Bénabou and Tirole (2006), Tabellini (2008, 2010), Bénabou (2008), Doepke and Zilibotti (2008), Saint-Paul (2010), Ticchi et al. (2013), Alesina and Giuliano (2015), Guiso et al. (2016)).

Finally, the paper belongs to the literature on the economic determinants and consequences of religiosity, pioneered by Weber (1905). Modern contributions include Barro and McCleary (2003) and Guiso et al. (2003), both linking religious beliefs to growth-related attitudes, at the country and individual levels respectively; on the theoretical side, see Levy and Razin (2012, 2014). Cavalcanti et al. (2007), Glaeser and Sacerdote (2008), Becker and Woessmann (2009), Kuran (2011) and Botticini and Eckstein (2012) examine the relationships between religion and human or physical capital accumulation. Iannaccone et al. (1997), Swatos and Christiano (1999), and Berger et al. (2008) debate the "secularization hypothesis" (as societies modernize, they will become less religious), with emphasis on the US vs. Western Europe contrast. Roemer (1998), Scheve and Stasavage (2006) and Huber and Stanig (2011) examine how (exogenous) religiosity affects redistribution.

Sections 2 and 3 present *motivating evidence,* including our empirical findings. Section 4 develops the basic model, which Sections 5 and 6 solve for equilibrium behaviors and the coevolution of religiosity and knowledge. Section 7 combines belief and income differences, studying how inequality shapes political coalitions and science policies. Section 8 concludes.

Main proofs are in Appendix B, additional ones and extensions in Online Appendices C to F.

2 Historical and Contemporary Examples

Table 1 summarizes important instances of conflicts between religion and science, often initially arbitrated in favor of dogma by the ruling powers, and sometimes resolved through doctrinal adaptations. They serve to concretely demonstrate the notions of "blocking" and "repairing" central to the model, which in turn will be used to shed light on some of this evidence.

• **Historical cases.** Appendix A discusses these instances in more detail. While some are broadly known (Galileo's trial, Darwinism), others much less so, both for the Christian World (bans on Aristotle's "heretical" works, infinitesimal calculus, and atomism; opposition to Newtonism and to technical education) and in the Muslim one (centuries-long ban on printing, opposition to "foreign" knowledge). Also less known is how such blocking delayed the Industrial Revolution in more intensely Catholic areas of Europe, and how the attitudes that took hold in the Muslim world in the 11th century are still apparent in very low rates of publishing, translation and innovation.[1] The Muslim World Science Initiative Report (2015) thus compared O.I.C. countries to others with similar levels of GDP per capita. While noting some recent "takeoffs" such as Malaysia and Jordan, its main assessment was that "overall, we find the Muslim world to be lagging behind on most, if not all, indicators of scientific output and productivity."

• **Science, religion and politics today.** Table 1 also shows that these issues are neither obsolete, nor specific to any religion. The United States is a striking case of a rich and technologically advanced country where creationism is taught in 15-20% of schools, many textbooks promote climate-change skepticism, and a powerful alliance of religious conservatives and small-government interests –the *"Religious Right"* – has exerted growing political influence, impacting research in the Life and Earth sciences. Upon his election, owed importantly to this constituency, President George W. Bush severely restricted federal funding for embryonic stem-cell research, invoking in explicitly religious terms the sacredness of all human life. In his second term, his first veto struck down the Stem Cell Research Enhancement Act.[2] Religious conservatives were again critical in the election of President Trump and Vice President Pence (81% of White Evangelicals voted for the ticket), both of whom have often expressed counter-scientific attitudes about climate change, evolution, vaccines, and viruses. Their ad-

[1] Hoodbhoy (2007) reports that the top 46 countries in the Organization of Islamic Cooperation (O.I.C.) combined produced 1.17% of world scientific literature, versus 1.48% for Spain. In the 1970's, the total number of books translated into Arabic was one-fifth that for modern Greek (United Nations (2002) *Arab Human Development Report*). In the 1980's, over a five-year period, only 4.4 books per million inhabitants were translated in the Arab world, versus 519 for Hungary and 920 for Spain (Diner (2009)).

[2] Only eight years later, a long time in modern research, were the restrictions lifted by President Obama.

ministration's first (2018) budget request to Congress featured unprecedented cuts to Federal funding for science: basic research would decline by 13%, with cuts of 22% to the NIH, 11% to NSF and 22% to NOAA's Office of Oceanic and Atmospheric Research.[3] In each year since, it sought to cut the CDC's budget by 10-20% in real terms, and dismantled its Global Health Program for epidemic surveillance. During the Covid-19 pandemic it repeatedly dismissed the advice of leading epidemiologists, and several of the scientists themselves –as memorably epitomized by White House spokesperson's words in July 2020: *"The science should not stand in the way of this".*

Religion-politics-science dynamics are even more powerful at the local level. In 2011, Kentucky allocated over $40 million in tax incentives for an expansion of the Creation Museum, with a theme park designed to demonstrate the literal truth of the story of Noah's ark. In 2012, a North Carolina law banned its state agencies from basing coastal policies on scientific predictions concerning rising sea levels. As of 2020, fourteen states allow creationism to be taught in schools receiving public funds, eight still ban or limit human stem-cell research, twenty grant religious exemptions from school-required vaccinations, and fifteen allowed religious gatherings to continue, with no size restriction, during the pandemic. In each instance there is a high correlation with the ranking of most religious states, and we will formally document such a pattern for technological innovation. Another noteworthy pattern is that the rise of the Religious-Right coalition coincided with a sharp and lasting *rise in US income inequality,* especially since the 80's.[4] Explaining this "coincidence" is another important motivation of our paper.

3 Innovation and Religiosity Across Countries and States

To further demonstrate that the interplay of religiosity and innovation is not "just" a historical question, we use international and U.S. data to examine their relationship, both unconditionally and with multiple controls. To our knowledge, these are novel analyses and findings.[5]

[3] The House spending panel narrowly rejected some of these proposals, approving instead nominal freezes (NSF) or minimal increases (NIH); see Science News (2017).

[4] On the rising influence in American politic of the alliance between religious-fundamentalist and anti-government forces, see Mooney (2005), Phillips (2006), Gelman (2010), Wuthnow (2011), Kruse (2015), and Stewart (2020).

[5] First, we focus on a specific channel –innovation– whereas Barro and McCleary (2003) studied overall growth. Second, their results vary across measures of religiosity: the association is positive for beliefs in Heaven and Hell, negative for Church attendance. Third, studies using individual data find the reverse pattern. In Guiso et al. (2003), Church attendance is positively associated with trust, trusthworthiness and other "societal attitudes... conducive to higher productivity and growth." In Glaeser and Sacerdote (2008), it is positively associated with human capital, whereas supernatural beliefs and beliefs in the literal truth of the Bible have a strong negative association. Our results are entirely robust to which measure of religiosity is used, and this invariance holds equally across countries, US states, and individual attitudes (Bénabou et al. (2015)).

3.1 Cross-Country Patterns

• **Data.** We focus on three main measures of religiosity from the World Values Survey (WVS: 1980, 1990, 1995, 2000, 2005, 2010), supplemented by the European Values Study (EVS: 1980, 1990, 2000, 2010): *Religious Person*, *Belief in God*, and *Church Attendance*.[6] All variables are scaled to [0,1], corresponding to the shares of people who consider themselves religious, believe in God, and attend services at least once a week. To measure innovation, we use (log-) patents per capita. The patent counts, from the World Intellectual Policy Organization (WIPO), are total patent applications filed in a country by its residents. They are measured in the same six years as the religion data, as are the control variables described further below.

• **Results.** Figure 1a displays the scatterplot between the share of "Religious Person" and the level of innovation, while Columns 1-3 of Table 2 report the regression estimates using all three measures of religiosity: a *strong negative relationship* is clearly apparent in all cases.

We next include as controls a religious-freedom index, plus the main variables used in empirical work on innovation: (i) (log) GDP per capita; (ii) (log) population; (iii) intellectual property protection; (iv) years of tertiary schooling; (v) net foreign direct investment as a share of GDP.[7] Columns 4-6 of Table 2 report the regressions for all three measures of religiosity, and Figure 1b displays the main result using the first one (the others are in Appendix F), by plotting the residuals of innovation versus religiosity from regressing each on the set of control variables. The strong negative relationship found in the raw data is clearly confirmed.

• **Robustness.** Columns 7-9 add in year fixed effects and Columns 10-12 dummy variables for a country's predominant religion, namely that (if any) professed by more than half of the population. A number of further robustness checks (see Appendix F) also leave the key findings unchanged, such as: (i) using two other measures of religiosity from the WVS/EVS, namely the country averages of *Importance of Religion,* and *God Very Important*; (ii) using total patents per capita, namely those filed in a country by both residents and foreigners; (iii) including dummies for current and formerly Communist countries, as well their interactions with religiosity measures;[8] (iv) controlling for the population shares of major religions, rather than which one is dominant. *Across the board,* religiosity is significantly and negatively associated with innovation per capita.[9]

[6] These correspond, respectively, to the questions: (i) "Independently of whether you go to church or not, would you say you are: a religious person, not a religious person, a convinced atheist"; (ii) "Do you believe in God?"; (iii) "Apart from weddings, funerals and christenings, about how often do you attend religious services these days?" See the online Data Appendix G.

[7] The religious-freedom index is taken from Norris and Inglehart (2011), the index of patent protection from Park (2008), the average years of tertiary schooling from Barro and Lee (2013), while the GDP, the population and the net foreign direct investment all come from the World Development Indicators (WDI).

[8] In never-Communist countries, the estimated effect of religiosity on innovation is always significantly negative; in ever-Communist ones, it is always insignificant. See Appendix F, Figures F6a-6b and Table F3.

[9] These findings were recently confirmed by Osiri et al. (2019), using: (i) the Global Innovation Index, which

3.2 The United States

We now carry out a similar investigation across U.S. states, thus keeping constant many historical and institutional factors that vary across countries.

• **Data.** We use three measures of religiosity, constructed from the 2008 Religious Landscape Survey conducted by the Pew Forum on Religion and Public Life: *Importance of Religion*, *Belief in God*, and *Church Attendance.*[10] Innovation is again measured by (log) patents per capita, defined as the ratio between total patents submitted by State residents to the U.S. Patent and Trademark Office and the State's population, both in 2007.

• **Results.** *A strong negative relationship* is again evident, both in scatterplots like Figure 2a (Appendix F provides the others) and in the regressions reported in Columns 1-3 of Table 3, for all three measures of religiosity. As in the cross-country analysis, we next control for: (i) the (log) Gross State Product per capita; (ii) the (log) population of the State; (iii) tertiary education, measured here by the share of population over 25 with at least a Bachelor's degree; (iv) FDI inflows as a share of GSP. The results are reported in Columns 4 to 9 of Table 3, with the main findings illustrated in Figure 2b by a scatterplot of the components of innovation and religiosity that are orthogonal to all four control variables. *In all cases,* the strong negative relationship displayed in the raw data is again confirmed. Innovation, unconditional or conditional, is especially low in the "Bible Belt" states, but the negative association holds *throughout the sample.*

3.3 Remarks

Even with controls, we make no claim of causal identification. First, this would require instrumental variables. Second, our model itself will have causality running both ways.[11] Our simple empirics are meant instead to bring to light a *striking fact,* calling for a formal analysis of how innovation and religiosity *coevolve.* Given the historical and modern evidence, the model will first explain how the interplay of science, religion and politics leads societies toward different, recognizable, *long-term* regimes. Second, it will generate, at *almost any* horizon, a negative cross-sectional relationship like that found in the data. Third, and with a *contemporary* focus, it will link rising income inequality to regime-specific shifts in the politics of science.

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includes not only patents but a combination of 79 input and output variables relating to innovation for 141 countries; (ii) a superset of our 5 religiosity variables from the WVS; (iii) alternative controls.

[10] Fractions answering: (i) "very important", when asked "How important is religion in your life?"; (ii) "Yes", when asked "Do you believe in God or a universal spirit?"; (iii) "at least once a week", to "Aside from weddings and funerals, how often do you attend religious services?" See Data Appendix G.

[11] Using plague outbreaks as an instrument for being a historically more religious area of France, Squicciarini (2020) substantiates the "blocking" causal channel for delayed development during the Industrial Revolution. Using Granger tests on panel data for Church attendance and income per capita (not innovation) from sixteen countries between 1930 and 1990, Herzer and Strulik (2017) find long-run causality running in both directions.

4 The Model

4.1 Agents and Government

• **Preferences and endowments.** The economy is populated by non-overlapping generations of agents living for two periods: youth (t even) and old age ($t+1$ odd). Each generation is formed by a continuum of risk-neutral individuals $i \in [0,1]$, with preferences

$$U_t^i = \mathbb{E}_t[c_t^i + (c_{t+1}^i + \beta^i b_{t+1} G_{t+1})\,(a_{t+1}/a_t)\ \mid a_t, b_t\ ], \tag{1}$$

where (c_t^i, c_{t+1}^i) denote agent i's consumption levels and $\beta^i b_{t+1} G_{t+1}$ the utility which he derives from organized religion. A fraction $1-r$ of agents are "secular", $\beta^i = 0$, whereas $\beta^i = 1$ for "religious" individuals, who are in the majority, $r > 1/2$. While the distribution of types is fixed, the *intensity* of religious agents' beliefs during their lifetimes, (b_t, b_{t+1}), will be endogenous. In old age (for simplicity), beliefs are complementary with a "religious public good" G_{t+1} such as temples, priests, or/and religion-based regulations of social mores.

All real magnitudes such as c_t^i, c_{t+1}^i, G_{t+1}, are measured relative to contemporary TFP, denoted a_t in period t, hence the last term in (1). The expectation is taken over next period's levels of TFP and religiosity, which will depend on the occurrence, nature and implementation of scientific discoveries. In particular, we will model faith not as a probability distribution over some state of the (after)world, but as a durable stock of "religious capital" b_t that may be eroded by certain shocks, and augmented by others.[12]

Until Section 7, we abstract from (re)distributional conflict, focusing solely on secular-religious interactions. Thus all agents have the same income, normalized to the economy's total factor productivity in each period of their life. For any linear income tax rate τ, government revenues (per unit of TFP) will be denoted as $R(\tau)$, and assumed to satisfy standard properties.

Assumption 1 *$R(\tau)$ is $\mathcal{C}^3$ and strictly concave, with $R(0) = 0$, $R'(0) = 1$ and $R'(\hat{\tau}) = 0$, where $\hat{\tau} < 1$ is the revenue-maximizing tax rate.*

• **Public goods.** During old age ($t+1$), agents potentially value two types of public goods.

1. Religion-complementary public goods or/and laws. We refer to G_{t+1} as "religious public goods" for short, but depending on time and place they take a wide variety of forms:

(a) Historically, and still today in many countries (most Muslim nations, Russia, Greece), the government pays directly for priests' salaries, the building and upkeep of temples, and substantially subsidizes religious schools.

[12] For explicit models of religious beliefs as subjective probabilities thus providing microfoundations for b, see Bénabou and Tirole (2006, 2011) and Levy and Razin (2012, 2014).

(b) Even with Church-State separation, significant tax exemptions are often granted to the religious sector and its subsidiary activities, as in Italy and the United States.[13]

(c) The decisions at stake may not be fiscal ones, but involve the *conformity of society's laws* to religious precepts: mandatory prayers and rituals, restrictions on working certain days, on women's activities, contraception, prohibited types of behaviors and consumptions, etc.

The case where G_{t+1} is directly financed from government revenues is somewhat simpler analytically, so we will focus the exposition on it. We emphasize, however, that the other channels are equivalent to (a), leading to fully parallel results. This is clear for (b), and shown for (c) in Appendix C, where an index $\tilde{\tau}_{t+1} \leq 1$ measures the severity of religion-based societal or "moral" restrictions, and $G_{t+1} = b_{t+1}R(\tilde{\tau}_{t+1})$ their value to religious agent.[14]

(2) Secular public goods. The second type of public good, denoted T_{t+1}, is valued equally by those with $\beta^i = 1$ and $\beta^i = 0$: infrastructure, safety, basic education, etc. Alternatively, T_{t+1} may represent public transfers, as in Section 7 where it will be demanded by the poor but not by the rich, thus introducing a second dimension of political conflict. A unit of T_{t+1} is worth $\nu > 1$ units of private good, so the net consumption levels of generation t are

$$c_t^i = 1 - \tau_t \text{ and } c_{t+1}^i = 1 - \tau_{t+1} + \nu T_{t+1}.$$

• **Government budget constraints.** During youth (period t), the State's only decision, $\chi_t \in \{0, 1\}$, is whether to invest resources in a control apparatus designed to impede the diffusion of ideas deemed dangerous to the faith. The incentives and technology for such blocking are described below. Denoting by φ_t the direct resource cost required to set up a repressive apparatus, the government's budget constraints at t and $t+1$ are, respectively,

$$\chi_t \varphi_t \leq R(\tau_t) \quad \text{and} \quad T_{t+1} + G_{t+1} \leq R(\tau_{t+1}). \tag{2}$$

4.2 Discoveries, Productivity Growth, and Blocking

• **Innovations.** Scientific discoveries occur, with some exogenous Poisson arrival rate λ, during the first subperiod in the life-cycle of each generation.[15] If allowed to disseminate widely each

[13] In the U.S., religious organizations are increasingly engaging in commercial ventures (mega-churches, "health-care sharing organizations", investment funds). Cragun et al.'s (2012) conservative estimate of religious "tax expenditures" (excluding exemptions of local income, sales and property taxes, and all charitable deductions for religious giving) was 82 billion dollars for the U.S. in fiscal year 2012. Although a small fraction of total federal spending, this exceeds by 50% the combined budgets of the NSF, NIH and NASA that year (7, 31 and 19 billion respectively), and exactly equals the total Federal budget for R&D spending.

[14] All that matters is that secular and religious agents have divergent preferences over G_{t+1}. On intergroup conflict over the mix of public goods, see Alesina et al. (1999), Luttmer (2001), and Alesina and La Ferrara (2005); on religious restrictions to individual choices, see Esteban et al. (2018).

[15] One could also endogenize λ, but since the diffusion and implementation of ideas will already be endogenous, this would add no further insight. Also, in many historical cases the "impious" ideas originated abroad.

produces, in the second subperiod, advances in practical knowledge and technology that raise TFP from a_t to $a_{t+1} = (1+ \gamma)a_t$. Some new discoveries, however, also contradict professed doctrines and sacred texts' statements about the natural world (origins of the universe, of mankind, abilities of women, foundations of moral behavior), thereby undermining the faith of religious agents.[16] We thus distinguish between two main types of discoveries:

- A fraction p_N of them are *belief-neutral* (BN): these have no impact on b_t.

- A fraction $p_R = 1 - p_N$ are *belief-eroding* (BR): if they diffuse widely in the population, they reduce the stock of religious capital from b_t to $b_{t+1} = (1- \delta)b_t$.

While religiosity may benefit from certain applied innovations (e.g., televised evangelism), one is hard-pressed to think of major findings from science that had such an effect. Increases in religiosity arise instead from disasters like earthquakes, floods, plagues, or famines, or from colonization and missionary expeditions.[17] We shall therefore introduce belief-enhancing shocks only later on, as events affecting b that may occur *between* rather than *within* generations, independently of scientific discoveries and policies. For the moment, we abstract from them.

• **Blocking.** If allowed to disseminate, a BR discovery will reduce the utility $b_{t+1}G_{t+1}$ of religious agents, through both its direct erosion of faith and an ensuing reduction in G_{t+1}. If this loss more than offsets the gains to be reaped through higher productivity, a government acting on behalf of religious agents may want to censor or restrict access to the new knowledge. We assume that such blocking can be targeted at BR innovations and is then fully effective, so that beliefs and TFP both remain unchanged: $a_{t+1} = a_t$ and $b_{t+1} = b_t$.

To stand ready to quash threatening ideas or impede their diffusion, the State must set up, *in advance,* a repressive or knowledge-garbling apparatus. Past and current examples include the Catholic Inquisition, Islamic religious police, censorship of school lessons and textbooks (or banning printing outright), and the subsidization of a doctrine-friendly pseudoscience: creationism, climate-change denial, anti-vaccination movements, etc.[18] The normalized resource cost φ_t required is assumed to depend only on society's level of knowledge and TFP: $\varphi_t = \varphi\,(a_t)$, where $\varphi : \mathbb{R}_+ \to \mathbb{R}_+$ is strictly increasing, with $\overline{\varphi} \equiv \lim_{a \to +\infty} \varphi(a) < R(\hat{\tau})$ so

[16] The model extends to other ideologies wielding political power (e.g., Communism, Nazism), and scientific ideas undermining factual claims of the doctrine. Religion is, however, the most widespread and long-lasting class of valued beliefs, and unique in how its foundational texts bundle positive claims about the workings of the universe with normative claims about the right ways to live and die, both set down "for all eternity". This is especially true for "revealed" religions, but for others as well, such as Hinduism.

[17] For evidence see, e.g., Chaney (2013), Belloc et al. (2016) and Sinding-Bentzen (2019).

[18] We assume that the repressive apparatus (or state-subsidized information-garbling, pseudo-science sector) insulates not only religious citizens, but also any government that blocks on their behalf, from learning or properly assimilating BR discoveries –e.g., the book is burnt, or confined to an inaccessible Index. One can also reformulate the model's timing so that, instead of its own religious beliefs and scientific knowledge, each generation now molds *those of its children*, internalizing their material and spiritual utility (as in Bisin and Verdier (2000), Bénabou and Tirole (2006) or Doepke and Zilibotti (2008)). See Appendix E.1.

that repression remains feasible at any level of a. The monotonicity reflects the fact that new knowledge is harder to contain or counteract in a society that is intellectually and technologically more sophisticated.[19] In contrast, the independence of φ_t from b captures the idea that the costs of impeding the flow of free information –censoring, threatening scientists, controlling the press, etc.– are largely unrelated its contents and the beliefs it might impact.[20]

4.3 The Church or Religious Sector

Besides citizens and the government, there is also a small (zero-measure) set of agents who produce no income, but may engage in another type of work. Whenever a belief-eroding discovery diffuses, this player, referred to as the Church or religious sector, can endeavor to "repair" the damage done to the faith. This may occur through internal reform, such as working out a reinterpretation of doctrine more compatible with the new scientific facts. It can also take the form of a major Reformation or schism, or the creation of new sects by faith entrepreneurs. For simplicity we treat organized religion as a single actor, with utility

$$U_t^C = b_{t+1} G_{t+1} - \rho_t \eta b_t. \tag{3}$$

The Church thus cares primarily about the strength of beliefs b_{t+1} and the provision of complementary goods and services, G_{t+1}, which together generate benefits $b_{t+1}G_{t+1}$ for the faithful. These preferences can indifferently (for our purposes) represent a religious sector that internalizes the spiritual welfare of its brethren or one that *appropriates rents from it,* say by being the main conduit for the delivery or consumption of G_{t+1}.

The second term in (3) reflects the decision $\rho_t \in \{0, 1\}$ of whether to undertake *doctrinal-repair* work, at a cost (per unit of TFP) of ηb_t, where: (i) b_t captures the fact that a larger stock of religious capital (e.g., more devout beliefs) is more expensive to adapt and reform; (ii) η parametrizes the difficulty for heterodox interpretations or new sects to emerge, and for people to switch affiliation. A strictly enforced *state religion* thus corresponds to high η, a *competitive religious sector* to a low one (Iannaccone et al. (1997), Swatos and Christiano (1999)). Doctrinal revisions are only possible once the new discovery diffuses, as they must be appropriately tailored to it; for simplicity, we assume here that their effect is to exactly offset the initial or threatened erosion, so that $b_{t+1} = b_t$ instead of falling to $(1 - \delta)b_t$.[21]

• **Church and State.** In most countries, the religious and state sectors are clearly separate

[19] For instance, the dissemination of information became faster and less controllable with the availability of the printing press, radio, TV, telephones and faxes, the internet, etc.

[20] The assumption also serves as a neutral benchmark in which two offsetting effects cancel out: (i) more "explosive" information may be harder to block *per se;* (ii) more devout citizens may be more willing to cooperate with politico-religious authorities. More generally, φ should not increase too fast with b.

[21] All results are unchanged if repair succeeds only with probability $q \in (1/(1 + \gamma), 1)$; see Appendix B.

actors. Historically, there was substantial overlap (Catholic Church, Ottoman Empire), but also periodic conflicts. Our model thus treats the two as having different objectives (a fortiori in Section 7, where secular agents will sometimes be in power), and access to different instruments. Thus, doctrinal repair is less inimical to innovation than blocking, but this is not internalized by the Church. Conversely, its cost is borne as effort by priests, monks, etc., which does not enter the government's budget constraint.[22]

4.4 Timeline

The timing of events is illustrated in Figure 3. The "political competition" module will become fully relevant when income differences are introduced in Section 7, generating a game of strategic coalitions between four groups vying for power: rich/poor, secular/religious. Until then politics are kept very simple, to focus on the core *science-doctrine tradeoff:* religious agents, being more powerful than secular ones ($r > 1/2$), control the State, whether through the sword or the ballot.[23] Thus, in every period they set policy to maximize (1), with $\beta^i = 1$.

- **First period** (t **even**):
  1. The government decides whether to invest in the capacity to block: $\chi_t \in \{0, 1\}$, at cost $\chi_t \varphi(a_t)$, requiring taxes to be set at the level τ_t such that $R(\tau_t) = \chi_t \varphi(a_t)$.
  2. With probability λ, a new discovery occurs. If it is belief-neutral or if there is no blocking of belief-eroding ideas, it diffuses and becomes embodied in new technologies, so that $a_{t+1} = (1+\gamma)a_t$. If repressed, it withers, so $a_{t+1} = a_t$.
  3. If a BR discovery occurred and the State allowed it to diffuse, the Church decides whether to repair the resulting damage to religious capital, at a cost of ηb_t. If it does, then $b_{t+1} = b_t$, otherwise beliefs erode to $b_{t+1} = (1-\delta)b_t$.

- **Second period** ($t+1$ **odd**):
  1. Given the realized values of (a_{t+1}, b_{t+1}), the government chooses fiscal and spending policies, $(\tau_{t+1}, T_{t+1}, G_{t+1})$, subject to its budget constraint. Consumptions take place.
  2. A new generation inherits the stocks of knowledge and religious capital, $(a_{t+2}, b_{t+2}) = (a_{t+1}, b_{t+1})$, then plays the same two-stage game, starting in (even) period $t+2$.

[22] Appendix E.2 shows that our main results are robust to a merging of Church and State, as would occur if they could compensate each other with lump-sum transfers and maximize their overall utility.

[23] Importantly, *the political system need not be democratic:* group sizes are to be understood as *power-weighted,* and outcomes may be determined through conflict (e.g., the larger military force wins) rather than voting.

• **Equilibrium.** Absent individual-level links across generations such as altruism or bequests, each cohort's horizon is limited to its two-period lifespan. The model's subgame-perfect equilibria (SPE) therefore correspond to sequences of SPE's of the basic game played within each generation, linked through the evolution of the aggregate state variables (a_t, b_t).

5 Political Equilibrium

5.1 Fiscal Policy (Second Subperiod)

Given its constituents' beliefs b, the government sets taxes and spending (or exemptions) as

$$\max_{\tau,G} \ \{1-\tau+\nu\,[R(\tau)-G]+bG \mid 0\leq\tau\leq\hat{\tau},\ 0\leq G\leq R(\tau)\}\,. \tag{4}$$

When beliefs are weak, $b<\nu$, secular public goods are valued more than religious ones, so $G=0$ and all revenue is spent on $T=R(\tau)$. Therefore, agents' utility is $1-\tau+\nu R(\tau)$, and the optimality condition uniquely yields $\tau=\tau^*(\nu)$, where

$$\tau^*(x)\equiv(R')^{-1}(1/x) \tag{5}$$

defines a strictly increasing function $\tau^*:\mathbb{R}_+\longmapsto[0,\hat{\tau}]$. When beliefs are strong enough, $b\geq\nu$, $T=0$ and all revenues are spent instead on $G=R(\tau)$. Religious individuals' utility is then $1-\tau+bR(\tau)$, with $\tau=\tau^*(b)$; see Figure 4a.[24]

Proposition 1 *The policy mix implemented in the second period is the following:*
(1) If $b<\nu$, then $(\tau,T,G)=(\tau^*(\nu),R(\tau^*(\nu)),0)$, with $\tau^*(\nu)$ and $R(\tau^*(\nu))$ increasing in ν.
(2) If $b\geq\nu$, then $(\tau,T,G)=(\tau^*(b),0,R(\tau^*(b)))$, with $\tau^*(b)$ and $R(\tau^*(b))$ increasing in b until $\tau^*(b)$ reaches $\hat{\tau}$, then constant afterwards.

For any b and ν, we shall denote second-period equilibrium provision of G as

$$G\,(b,\nu)\equiv\begin{cases}0 & \text{if } b<\nu\\ R\,(\tau^*(b)) & \text{if } b\geq\nu\end{cases}. \tag{6}$$

5.2 Church's Doctrinal-Repair Strategy

Following a BR innovation, the Church will want to prevent or offset the erosion of b to $(1-\delta)b$ if $bG\,(b,\nu)-\eta b\geq(1-\delta)\,bG\,((1-\delta)\,b,\nu)$. Normalizing by b, the *net payoff from repair,*

$$\pi\,(b,\nu)\equiv G\,(b,\nu)-(1-\delta)\,G\,((1-\delta)\,b,\nu) \tag{7}$$

[24] When $b=\nu$ we break indifference in favor of G. Note that when $\nu<b$ religious agents are indistinguishable from secular ones, so one can interpret b as affecting both the *extensive* and *intensive* margins of religiosity.

must exceed the cost η. It is clear from Figure 4a that π is highest in the intermediate range where b strongly affects public policy. In contrast, it is zero for $b \leq \nu$, and small when b is high enough that some depreciation can occur without much impact on G. Formally, we show (Appendix B, Lemma 2) that $\pi(\cdot, \nu)$ *is single-peaked* and varies as depicted in Figure 4b. The following condition then ensures that the repairing region, $\pi(b, \nu) > \eta$, is non-empty.

Assumption 2 $\delta R(\hat{\tau}) < \eta < R(\tau^*(\nu/(1-\delta))) - (1-\delta) R(\tau^*(\nu))$.[25]

We can now fully characterize the equilibrium behavior of the religious sector.

Proposition 2 *There exist a unique* $\underline{b}$ *and* $\bar{b}$*, with* $\nu \leq \underline{b} < \nu/(1-\delta) < \bar{b}$*, such that the Church engages in doctrinal adaptation following belief-eroding innovations (not blocked by the State) if and only if* b *lies in* $\left[\underline{b}, \bar{b}\right]$.

Intuitively, when religious capital is below $\underline{b}$ it is not worth repairing (relative to the cost η). Conversely, when it exceeds $\bar{b}$ there is enough of it (and therefore also enough demand for G) that the Church can afford to let it depreciate somewhat.

5.3 State Policy Toward Science (First Subperiod)

In period t, the State decides whether to invest in a knowledge-repressing apparatus, trading off the direct cost and potential foregone TFP gains against the option value of preserving religious capital. There are two cases in which it will never do so. First, when $b \leq \nu$, even religious agents prefer secular public goods: they set $G = 0$, so $bG = 0$ and nothing will change if b falls to $(1-\delta)b$. Second, when $b \in \left[\underline{b}, \bar{b}\right]$, the Church can be expected to engage in doctrinal adaptation, so the State will strategically "take a pass" and let the priesthood do the work.

Knowledge policy can thus be analyzed only in the two *no-repair regions,* $b > \bar{b}$ and $\nu \leq b < \underline{b}$. As illustrated in Figure 5, in each case blocking will occur when (a_t, b_t) lies above an upward-sloping locus $B(a)$ in the state space, meaning that society is *sufficiently religious, relative to its state of scientific and technical development.*

To derive this blocking locus, it will be useful to define, for all $u \geq 0$,

$$V(u) \equiv 1 - \tau^*(u) + uR(\tau^*(u)), \tag{8}$$

corresponding to religious agents' old-age utility when the government provides a public good which they value at u per unit relative to the numeraire, and does so by setting the tax rate at the corresponding optimal level $\tau^*(u)$. In equilibrium, $u = \max\{b, \nu\}$ by Proposition 1.

[25] The interval in which η must lie is always nonempty, as the function $R(\tau^*(b)) - (1-\delta)R(\tau^*((1-\delta)b))$ is decreasing (see Lemma 2). The discontinuity in π at its peak reflects the fact that, as $b' = b(1-\delta)$ falls below ν, agents will switch to secular public goods, so G' and hence $b'G'$ will jump down to zero.

- **Case $\mathbf{b} > \bar{\mathbf{b}}$: no repairing, continued provision of religious public goods**

Recall that blocking BR discoveries requires an ex-ante investment of $\varphi(a)$, which must be financed by a tax rate of $\tau = R^{-1}(\varphi(a))$. Beliefs will then be protected from erosion, and the expected intertemporal utility of religious agents equal to

$$V^B(a,b) = 1 - R^{-1}(\varphi(a)) + [1 - \lambda + \lambda p_R + \lambda(1 - p_R)(1+\gamma)] V(b), \tag{9}$$

where $V(b)$ is their second-period utility when no new idea is implemented, either because none occurred (probability $1-\lambda$) or it was of the BR type and thus blocked (probability λp_R). If a BN innovation occurs it sails through, raising TFP and utility by $1+\gamma$.

If the government foregoes blocking, BR innovations will also diffuse and raise living standards, but at the same time erode b to $b' \equiv (1-\delta)b > \nu/(1-\delta)$. Even though the Church does not repair, religious capital remains high enough that $G(b') > 0$ is chosen over secular spending. The expected intertemporal utility of religious agents is then

$$V^{NB}(a,b) = 1 + [1 - \lambda + \lambda(1 - p_R)(1+\gamma)] V(b) + \lambda p_R (1+\gamma) V\left(b'\right). \tag{10}$$

The government opts for blocking when $V^B \geq V^{NB}$, namely

$$R^{-1}(\varphi(a)) \leq \lambda p_R \left[V(b) - (1+\gamma) V\left(b'\right)\right] \equiv \Delta^1(b). \tag{11}$$

The left-hand side is the direct cost of the repressive investment, which is increasing in current TFP a. The right-hand side is the net expected return: with probability λp_R a BR innovation occurs, in which case beliefs are protected from erosion but productivity gains are foregone.

In Appendix B we show that wherever $\Delta^1(b) \geq 0$, it is strictly increasing in b. Therefore, the State will block if and only if (a,b) lies above the upward-sloping locus $b = B^1(a)$, where $B^1 \equiv \left(\Delta^1\right)^{-1} \circ R^{-1} \circ \varphi$. Note that, as a becomes large, $\varphi(a)$ tends to $\overline{\varphi} < R(\hat{\tau})$, implying that $B^1(a)$ tends to the horizontal asymptote $\Delta^1(b) = R(\bar{\varphi})$, as illustrated in Figure 5.

- **Case $\boldsymbol{\nu} \leq \mathbf{b} < \underline{\mathbf{b}}$: no repairing, nor provision of religious public goods**

In this case $b' = (1-\delta)b < \nu$, so an unblocked, unrepaired BR discovery damages beliefs sufficiently that religious agents now prefer secular public spending: $G = 0$ and $T = R(\tau^*(\nu))$. Thus, while the value of blocking remains given by (9), the value of not blocking is

$$V^{NB}(a,b) = 1 + [1 - \lambda + \lambda(1 - p_R)(1+\gamma)] V(b) + \lambda p_R (1+\gamma) V(\nu). \tag{12}$$

The condition $V^{NB} \leq V^B$ therefore becomes

$$R^{-1}(\varphi(a)) \leq \lambda p_R [V(b) - (1+\gamma) V(\nu)] \equiv \Delta^2(b). \tag{13}$$

In Appendix B we show that wherever $\Delta^2(b) \geq 0$ it is strictly increasing, hence so is $B^2 \equiv (\Delta^2)^{-1} \circ R^{-1} \circ \varphi$. Combining this result with the previous one, we have (see Figure 5):

Proposition 3 *Let $B(a) \equiv B^1(a) \cup B^2(a)$. The State blocks BR discoveries if and only if $b \in [\nu, \underline{b}] \cup [\bar{b}, +\infty)$ and (a, b) lies above the upward-sloping locus $b = B(a)$.*

6 Dynamics of Scientific Progress and Religiosity

6.1 Formal analysis

We have derived the law of motion of (a_t, b_t) within each generation. Between successive ones, the young inherit the finals stocks of knowledge and religiosity of the old: $(a_{t+2}, b_{t+2}) = (a_{t+1}, b_{t+1})$; later on, we will add stochastic shocks. Let us define the *Strongly Secular, Mildly Secular, Adaptive-US, Mildly Theocratic* and *Strongly Theocratic* belief ranges as, respectively,

$$S_0 \equiv [0, \nu],\ S_1 = [\nu, \underline{b}],\ S_2 = [\underline{b}, \bar{b}],\ S_3 = [\bar{b}, B^1(\infty)],\ S_4 = [B^1(\infty), \infty). \tag{14}$$

Together with the locus $B(a)$, these determine the system's phase diagram: see Figure 5. Three key attracting regions clearly emerge from the model's equilibrium dynamics.

1. "Secularization": no long-run blocking, no repair. Countries with beliefs in the lowest range, S_0, can be thought of as corresponding to much of modern Western Europe. In such *Strongly Secular* places, knowledge grows unimpeded at rate $\mathbb{E}_t[\Delta a_t/a_t] = \lambda\gamma$, while religiosity erodes at rate $\mathbb{E}_t[\Delta b_t/b_t] = -\lambda p_R \delta$, asymptoting toward 0. Fiscal and legal policies, moreover, provide no substantial religion-specific benefits ($G = 0, T = R(\nu)$). Countries in the *Mildly Secular* tier S_1, in contrast, do provide such benefits ($G = R(b), T = 0$); plausible examples today might be Greece or Poland. On the other hand they do not block new knowledge, except at low levels of development: the growth in a_t occurring through *belief-neutral* discoveries brings them relatively quickly to the right of the $b = B^2(a)$ locus, and from there on both a_t and b_t evolve just as in the S_0 range, which the system will eventually transition into.

2. "Adaptive Coexistence": no blocking, but repair. In the intermediate range S_2, discoveries are again unimpeded, so $\mathbb{E}_t[\Delta a_t/a_t] = \lambda\gamma$, but when they undermine religious tenets this is resolved through doctrinal evolution; thus, $\Delta b_t = 0$. This *Adaptive* regime, which otherwise shares with the *Mildly Secular* one the presence of some religiously-oriented subsidies and/or regulations, corresponds best to the United States, in ordinary times.

3. "Theocratic" region: protracted blocking. For sufficiently high religiosity, $b \in S_3 \cup S_4$, blocking will always occur initially, and whether a country eventually escapes obscurantism or remains forever mired in it hinges on how extreme its initial beliefs are. *Mildly Theocratic* countries, $b \in S_3$, will ultimately cross the blocking locus once they become sufficiently advanced through *belief-neutral* discoveries. This may take a long time, however, proceeding at the low rate $\mathbb{E}_t[\Delta a_t/a_t] = \lambda(1-p_R)\gamma$ toward a "receding" $b = B^1(a)$ boundary. From there on, beliefs will first decay at the rate $\mathbb{E}_t[\Delta b_t/b_t] = -\lambda p_R \delta$ until the system falls into the repairing region S_2, where it will then remain. Note also that, while catching up in terms of growth rates, these countries' *levels* of knowledge and TFP, a_t, will remain permanently below those of countries that never blocked, or stopped doing so earlier. The *Strongly Theocratic* regime, in contrast, is fully absorbing: countries starting in S_4 (e.g., Medieval Europe, Ancient China, Ottoman Empire, some Islamic countries still today) will experience rigid beliefs and knowledge stagnation, $\Delta b_t = 0$ and $\mathbb{E}_t[\Delta a_t/a_t] = \lambda(1-p_R)\gamma$ indefinitely, absent changes in parameters or the environment (which we consider below).

Denoting by μ_t the cross-sectional distribution of countries' beliefs at time t, we have:

Proposition 4 (deterministic steady-states) *For any initial distribution μ_0, religiosity in the long run is distributed over three absorbing states: Complete Secularization, with mass $\mu_\infty(\{0\}) = \mu_0(S_0) + \mu_0(S_1)$; Coexistence, with mass $\mu_\infty(S_2) = \mu_0(S_2) + \mu_0(S_3)$, and Strong Theocracy, with mass $\mu_\infty(S_4) = \mu_0(S_4)$.*

These results make clear how the forces at work in the model, simultaneously arising from and modulating scientific progress, generate three long-run *basins of attraction* with intuitive properties. Of course, non-ergodic dynamics, while useful expositionally, are unrealistic. In reality, a host of shocks unrelated to scientific advances also affect religious beliefs: natural disasters, invasions, power struggles and splits within the Church or between countries allied with different denominations, etc. These will cause recurrent transitions between the different regimes, which we now incorporate into the analysis.

• Ergodic system and long-run distribution

Having modelled scientific progress, belief erosion and doctrinal repair as arising (or not) endogenously *within* each generation, we represent other types of events as exogenous shocks to the transmission of beliefs *between* generations. At the start of every even period, let $a_{t+2} = a_{t+1}$ as before, but b_{t+2} now take values $(1+\zeta)b_{t+1}$, b_{t+1} and $(1-\zeta)b_{t+1}$, with respective probabilities $\phi, 1-\phi-\psi$, and ψ. Figure 6 illustrates the dynamics of this stochastic system, suggesting that it will now be ergodic but maintain strong "attracting" basins corresponding to its lower, intermediate and upper regions. To make this point more formal and concrete, we provide a simple quantitative operationalization of the model.

We focus here on economies that are relatively advanced, in the sense that the current value of a lies in a region where the relevant blocking locus is almost flat, $B^1(a) \approx B^1(\infty)$. Note that any country will eventually reach this region, if only through belief-neutral innovations.

Furthermore, under such long-run conditions, *the dynamical system in* (a, b) *becomes recursive:* the distribution of $(a_{t+1}/a_t, b_{t+1})$ depends only on which of the five horizontal bands S_0 to S_4 b_t lies in. Based on this insight, we discretize the belief space to five points, by: (i) collapsing each region $S_i, i = 0, .., 4$, to one state; (ii) normalizing the sizes of religiosity shocks, δ and ζ, to the gap between consecutive belief states; (iii) imposing "reflecting barriers" at the lowest and highest states. Denoting $\hat{\lambda} \equiv \lambda p_R$ the arrival rate of belief-eroding innovations, the model's laws of motion for b_t result in the transition matrix

$$P \equiv \begin{bmatrix} 1-(1-\hat{\lambda})\phi & (1-\hat{\lambda})\phi & 0 & 0 & 0 \\ \hat{\lambda}(1-\phi)+(1-\hat{\lambda})\psi & (1-\hat{\lambda})(1-\phi-\psi)+\hat{\lambda}\phi & (1-\hat{\lambda})\phi & 0 & 0 \\ 0 & \psi & 1-\phi-\psi & \phi & 0 \\ 0 & 0 & \hat{\lambda}(1-\phi)+(1-\hat{\lambda})\psi & (1-\hat{\lambda})(1-\phi-\psi)+\hat{\lambda}\phi & (1-\hat{\lambda})\phi \\ 0 & 0 & 0 & \psi & 1-\psi \end{bmatrix}.$$

Generically, P is irreducible, ensuring a unique steady-state distribution. Next, we simulate the full system in $(a_{t+1}/a_t, b_t)$ with arguably plausible, "back of the envelope" parameter values. While clearly not a formal calibration, this will provide interesting order-of-magnitude predictions for *medium-run* trajectories and the *long-run* distribution.

Suppose that there is a $\lambda = 24\%$ chance per year of an innovation that can increase productivity by $\gamma = 10\%$, so that mean TFP growth is 2.4% *per annum* in the absence of blocking. Of these innovations, let $p_R = 25\%$ be belief eroding, which corresponds to a 0.6% contribution to TFP growth. A country blocking them will thus fall behind by $(1.006)^{25} - 1 = 16\%$ per generation, or 82% per century. Turning to religiosity, the probability of belief erosion from new knowledge is $\hat{\lambda} \equiv \lambda p_R = 6\%$ per year, which translates to 79% per generation and quasi-certainty over a century. As noted earlier, such events are far from being the sole drivers of religiosity; on the other hand, a model dominated by random noise would not be much use. We therefore set the frequency of the exogenous belief shocks to be of the same order of magnitude as $\hat{\lambda}$, but somewhat lower: $\phi = 2\%$ per year for a "religious revival" (upward shock) and $\psi = 1\%$ per year for a "crisis of faith" (downward shock, not innovation-linked), translating to 40% and and 22% per generation respectively. The resulting value of P^{25}, corresponding to 25-year transition probabilities, is given in Figure 7, left panel.

Consider for instance the middle, US-like regime. A country that starts there has a 63% probability of being unchanged after a generation, versus 17% and 20% chances of having transitioned in the secular or the theocratic direction, respectively. In the first case, chances are about equal (8%) that it will be just *Mildly Secular* (beliefs having eroded but public spending, subsidies or laws still being shaped by religious concerns), or instead *Strongly Secular* (beliefs having weakened enough that policy is fully secular). As to transitions towards more intense religiosity, the most likely one (15%) is to *Moderate Theocracy*, in which doctrine becomes rigid in the face of science –adaptation ceases, beliefs gradually erode– but there is not yet any blocking. There is also, however, a non-negligible 5% chance, rising to 10% over two generations, of a transition to *Strong Theocracy,* which blocks doctrine-threatening ideas and has a high rate of persistence (81%).

In the long-run, the system in $(a_{t+1}/a_t, b_t)$ is ergodic, converging to the *invariant distribution* depicted in the right panel of Figure 7, which is clearly *trimodal:* 45% of countries are *Highly Secular,* 12% *Mildly Secular,* 23% in the *Adaptive* regime, 6% *Mildly Theocratic,* and 13% *Strongly Theocratic* (and scientifically stagnant). The asymptotic convergence speed is 19% per generation, which corresponds a half life of 3.3 generations (82.5 years).

6.2 Applications

We now draw further implications from these dynamics, and use them to shed light on some of the contemporary and historical evidence motivating the paper.

• **Negative Religiosity-Innovation Relationship.** The model readily generates a negative correlation between religiosity b and innovation $\mathbb{E}_t[\Delta a_t/a_t]$, like the one brought to light in the contemporary data. It holds in the short and medium-run for all but a transitory region of low-knowledge and low-religiosity ($b \in (B_2(a), \underline{b})$), and in the long run for *all* countries. Finally, the fact that the negative relationship stems from both knowledge blocking and belief erosion conveys the important message that causality runs in *both* directions.

• **The Secularization Hypothesis.** Modern "Western Europe" and "United States" grow at the same rate $\lambda\gamma$ (neither blocks), but in the former there is a *downward trend* in religiosity, whereas in the latter it is offset by the adaptation of the religious sector, leaving only trendless or very slow-moving shifts in religiosity. Thus, for societies that are not excessively religious ($b < B(a)$), economic growth can occur *both with and without secularization,* as a result of *endogenously* different responses by religious institutions. While there is a large sociology-of-religion literature discussing the ups and downs of this hypothesis (see Section 1.1), we do not know of any previous model for the coevolution of secular knowledge, economic growth, and religiosity. And while the literature points to both the US and conservative Muslim countries as evidence that "religion is far from dead", it does not address these two regimes' radically different implications for innovation and productivity. Our model speaks to these points, and the trimodal long-run distribution in Figure 7 clearly encapsulates both the strengths and limitations of the secularization hypothesis.

• **Europe and the Islamic World**. The model also provides a simple, *unified* account of the end of the Islamic Golden Age and the long stagnation of science and invention that ensued in the Muslim world, while they experienced explosive growth in Europe. Three competing explanations have been put forward by historians:

(a) Rising and more uniform religiosity. By the late 10th to early 11th century, Islam had consolidated as the unchallenged religion of the conquered lands; this corresponds in the model to a substantial rise in b. As discussed in Table 1 and Appendix A, this made scientific arguments, philosophical debates and reason (versus revelation and the rulings of religious scholars) no longer useful as means of proselytism, but now potentially subversive.

(b) Institutional changes. Starting in the 11th century, the pre-Islamic state's public administration, education and legal systems were taken over by a religious elite espousing a traditionalist strand of Islam ("Sunni Revival"), and intent on preserving the spiritual power on which its influence and rents (formally, bG) depended.

(c) External shocks. The Crusades (1096-1271) and the 13th Century Mongol invasions that devastated Baghdad and the Eastern part of the Muslim lands (Iran, Iraq, Central Asia) are external alternative explanation to internal sources of decline. Exogenous losses of productive capacity and especially human capital correspond to a negative shock to a.

Using the model, we now show that (b) follows endogenously from (a), while (c) cannot by itself lead to centuries of stagnation, though it can prolong the direct and indirect effects of (a). Occam's razor thus argues for putting the most weight on (a), though we will also spell out the role of complementary factors.

1. Comparative dynamics. Consider two areas of the world, W and I, represented over time in Figure 6 by the points $W_t = (a_t^W, b_t^W)$ and $I_t = (a_t^I, b_t^I)$. At $t = 0$ (circa 900), let $a_0^W < a_0^I$, $b_0^I \in [\underline{b}, \bar{b}]$ and $b_0^W > \max\{\bar{b}, B(a_I^0)\}$: Islam is thus in its "Golden Age" of religious and scientific progress (repairing region), whereas the West has been in the Theocratic (blocking) region for several centuries, and as a result is less advanced. At $t = 1$ (circa 1100-1200), it has fallen even further behind, but the Muslim World has experienced a major rise in the strength and cohesiveness of religiosity b_1^I, in line with (a) above. In addition (though this is *not* needed), b_1^W may have fallen somewhat in the West due to a number of schisms which the Catholic Church fought during the Middle Ages. The assumed religiosity shock is such that both W_1 and I_1 are now in the blocking region, with I_1 well to the right of W_1 (more advanced) but now above it (more cohesively religious).

The model's first implication is that the Muslim world now starts devoting even more material and legal resources (G in the model) than the West to the religious sector, as well as setting in place a knowledge-repression apparatus to safeguard the utility and rents bG derived from the population's religiosity. This matches the institutional changes in (b) quite well.[26]

[26] Chaney (2016) documents the extensive spread of *madrasas* during that period (Seljuk dynasty) and how they became the dominant, almost solely funded establishments of learning; how this forced increasing numbers

Furthermore, both areas now being strongly theocratic, they move rightward at the same slow pace, with I having a substantial head start. Nonetheless, if $b_1^I - b_1^W$ is sufficiently large compared to $a_1^W - a_1^I$, the West reaches the blocking boundary $B(a)$ *before* Islam. From that time $t = 2$ (circa, 1450) paths sharply diverge along *both* dimensions. While I continues moving slowly towards a receding frontier (and might even never reach it if $b_1^W > B(\infty)$), W experiences a takeoff of knowledge and growth, which also makes it less and less likely (though not impossible) that shocks will cause it to revert to blocking theocracy: it moves fast rightward away from $B(a)$, and moreover religiosity now starts to erode, since W is in the no-blocking, no repair region. The printing press, in particular, is a major innovation of that time blocked in Islam but "let through" in the West, where it proceeded to erode both the cohesiveness of Christianity (dissemination of Protestantism) and its monopoly on knowledge, and on mindsets more generally (Scientific Revolution, Enlightenment).

From there on, W drifts down to the repairing region (reaching $b = \bar{b}$ at $t = 4$): the stream of new discoveries, which the State no longer blocks, now forces the religious sector to gradually *adapt its doctrine* to the spreading secular knowledge, whether through internal reforms or schisms. Table 1 provides key examples, and while the Reformation arose primarily in reaction to the excesses of the Church, our model also suggests that Protestantism's greater *doctrinal openness to science* and inquiry (Merton (1938)) was no accident. It is a highly adaptive or even optimal "doctrinal design" choice for an entrant facing an incumbent bound to a rigid canon that makes it recurrently vulnerable to new discoveries. The above trends (average trajectories) do not, of course, mean the end of all blocking in the West: due to shocks it will recurrently "visit" each region, but starting from $t = 2$ the likelihood of blocking is significantly less, and that of repair, significantly higher, than for Islam, except in the very long run (asymptotically).

External shocks like wars or natural disasters (explanation (c)), in contrast, cannot easily produce such a reversal. As seen in Figure 6, for an area like I that starts in the repairing region, decreases in a (physical and human capital, knowledge) can never induce blocking nor prolonged stagnation: no matter how large is the decrease in the *level* of a, its growth rate remains unchanged, at $\lambda\gamma$. With standard "Solow convergence" effects (which we have abstracted from, assuming constant returns), growth is even faster following negative shocks, be they invasions, plagues, or wars. For entities that are in the blocking region, on the other hand, invasions and natural disasters "set back the clock", confining the system to the left of $B(a)$ and slow growth $\lambda(1 - p_R)$ for even longer. And indeed, the repression of innovative ideas and rational inquiry lasted for centuries after the Mongols had retreated and been replaced by

of scholars to affiliate themselves with them; and, from there on, a sharply rising trend in the proportion of religious and derivative books written, relative to original and scientific-technical ones.

the powerful Ottoman Empire, as did its technological and economic stagnation.

2. Differences in parameters. The above phase dynamics shows how *a single shock* –a large enough rise in b_1^I above $\bar{b}$– suffices to account (qualitatively) for a host of major historical changes, including the "trading places" of Islam and the West along *both* the science and religiosity dimensions, the growing gaps in these over time, and important evolutions in the "grip" and nature of Christianity. The historical account is enriched further if we incorporate differences in blocking loci.[27] To the extent that some institutional changes were (surely) also exogenous to the model, whether in Islam (see (b) above) or in Christianity (Reformation), they are reflected in different model parameters. For instance, it is plausible that the wide dominance of conservative Sunni Islam gradually enhanced the State's capacity to punish dissent, thus making its "repressive apparatus" more effective. This would correspond to a *decrease* in the blocking cost $\varphi(\cdot)$, moving the boundary $B(a)$ *outward* and thus reinforcing the effect of the initial rise in b_I. Europe, in contrast, was a place of high and increasing politico-religious fragmentation into numerous kingdoms, small states and cities, competing for economic supremacy and intellectual prestige (Mokyr (2016)). Together with high geographical mobility, this *raised* the cost of blocking the flows of ideas and thinkers, thus moving $B(a)$ *inward* and shrinking Christianity's *Strongly Theocratic* region.

• **Rise of the US Religious Right.** In the model's distinctive *Adaptive* regime, high innovation and substantial religiosity durably coexist, but with periodic "excursions" into the secular and theocratic regions. In particular, our simulation found a 20% transition probability per generation to *Mild Theocracy,* and even a non-trivial 5% to *Strong Theocracy.* These are only illustrative orders of magnitude, but American society is undeniably marked by recurrent movements of this nature. This occurred first in reaction to the New Deal's progressive policies (Kruse, 2015), and then even more markedly since the eighties (starting with Ronald Reagan's presidency), with pro-religion and *anti-science polices* reaching new heights today. The last forty years were also a period of unprecedented increases in income and wealth disparities, leading us to show in the next section that *rising inequality* can be an important channel for such major *cultural shifts,* with strikingly contrasting predictions across different regimes.

7 Inequality, Religion and the Politics of Science

We now enrich the model to study the interplay of religious and class differences. In each generation, $n < 1/2$ agents are rich, while the majority $1 - n > 1/2$ are poor: their respective pretax incomes are θ_H and θ_L in both youth and old age (per unit of contemporary TFP).

[27] One could think about similar ones for the repairing boundaries, reflecting in particular (through the parameter η) the monopolistic or competitive nature of the religious sector, or the "interpretational flexibility" allowed by a religion's foundational texts, traditions, and institutions.

Assumption 3 : *Let* $\theta_L < \nu < \theta_H$, *with* $n\theta_H + (1-n)\,\theta_L \equiv 1$.

Income and religiosity are distributed independently, so the four social groups in the economy and their respective sizes are: secular poor, $SP = (1-n)(1-r)$; religious poor, $RP = (1-n)r$; secular rich, $SR = n(1-r)$; and religious rich, $RR = nr$. To limit the number of cases to be considered, we assume:

Assumption 4 : *Let* $1/3 < n < 1/2 < r$ *and* $2r(1-n) < 1 < r(1+n)$.

Thus no group constitutes a majority on its own, but all religious agents, as well as all poor agents, do. Specifically, the four groups are ranked in size as follows:

$$SR < SP < SR + SP < RR < RP < 1/2 < 1-n < r. \tag{15}$$

By Assumption 3 the rich, whether secular or religious, have zero demand for public spending on T, as its value ν is less than the tax price θ_H they face. We can thus equivalently interpret T as *pure transfers*, to which only the poor, secular or religious, attach a positive net value.

7.1 The Political Process

At both t and $t+1$ there are now *four groups* vying for power, and furthermore the policy space in the latter period is *two-dimensional* (level and nature of public spending). Standard majority voting is thus not applicable. Instead, in each period political competition takes place –at the ballot box or as open conflict– according to the following sequential game:

1. In each group, one member is randomly selected as leader. The four leaders then simultaneously decide whether to make a bid for power, at no personal cost, or to stay out. Their choices are fully strategic and forward-looking, both within and across periods.[28]

2. Citizens independently choose which of the active contenders for power to support –e.g., whom to vote or fight for. Since no individual (non-leader) has a measurable impact on the overall outcome, each one just chooses, sincerely, his preferred candidate.

3. If a leader gains support from more than half of the population, he wins (in battle, election, etc.). If not, a second round takes place between the two who received the most support in the first round, and the one who garners a majority wins.[29]

[28] As there are neither entry costs nor private benefits from holding power, simple coordination among members suffices to ensure that a single leader is chosen. We thus abstract from potential free-rider problems *within* each group, in order to focus on conflict and coalitions *across* groups.

[29] When indifferent between several candidates, a group's members split their support equally. The assumptions of strategic entry or staying out by randomly drawn leaders, sincere voting or allegiance by atomistic non-leaders, and a runoff stage absent a majority, are similar to those in Osborne and Slivinsky (1996).

4. The victorious leader implements the policy that maximizes his own utility: as in other citizen-candidate models (Osborne and Slivinsky (1996), Besley and Coate (1997)), politicians cannot commit to following a given course of action once in power.[30]

As before, in any even period t the government chooses a blocking policy $\chi_t \in \{0,1\}$ and the implied level of taxes $\tau_t = R^{-1}\left(\chi_t \varphi\left(a_t\right)\right)$. In any odd period $t+1$, the (now possibly different) leader in power chooses the nature and level of public spending, together with the required taxes: $\left\{T_{t+1}, G_{t+1}, \tau_{t+1} = R^{-1}(T_{t+1} + G_{t+1})\right\}$. In Appendix C, alternatively, it chooses both redistributive transfers and the stringency of religion-inspired societal laws.

• **Coalitions and equilibrium concept.** Recall that no single group in $\{SP, RP, SR, RR\}$ is a majority, and denote by g, g', g'' any three among them. Suppose the leader of group g realizes that: (i) if both he and the leaders of group g' and g'' enter the political competition, the ultimate outcome will be that g'' will win, whose policy he dislikes more than that of g'; (ii) if he stays out, the g' candidate will instead prevail, garnering the support of both her own group and the members of g. When the latter case is an equilibrium (no leader wants to deviate) we say, identifying by a minor abuse of language a group and its leader, that group g' comes to power, supported by a *coalition* between groups g and g'.

Because citizen-candidate-type models typically feature multiple Nash equilibria in which different coalitions arise to support different entry profiles, we impose a stronger requirement. We thus look, in the two-period (t and $t+1$) stage game played by each generation, for a pure-strategy *Perfectly Coalition-Proof Nash Equilibrium* (PCPNE, Bernheim et al. (1987)). Unlike the standard Nash concept, CPNE for normal-form games takes into account joint deviations by coalitions; however, only self-enforcing deviations are considered to be credible threats.[31] In extensive-form games, the additional subgame-perfection requirement further restricts admissible coalitional agreements and deviations to be dynamically consistent.

7.2 Inequality and Fiscal Policy

Given state variables (a, b) at $t+1$, we first characterize the preferred fiscal policies of each of the four groups, then the equilibrium outcome that emerges from their competition.

An agent with (normalized) income $\theta^i \in \{\theta_L, \theta_H\}$ and religiosity index $\beta^i \in \{0,1\}$ solves

$$\max_{\tau,\ G}\{(1-\tau)\theta^i + \nu\left[R(\tau) - G\right] + \beta^i bG \mid 0 \leq \tau \leq \hat{\tau} \text{ and } 0 \leq G \leq R(\tau)\}. \tag{16}$$

Recalling that $\theta_L < \nu < \theta_H$ and that $\tau^*(x)$ denotes the solution to $xR'(\tau) = 1$, this yields:

[30] Importantly, the leader's interests at both t and $t+1$ are aligned with those of his core constituency (socioreligious group of origin), summarized by b and θ; see Footnote 18.

[31] The definition is recursive: a deviation by n players is self-enforcing if no subcoalition of size $n' < n$ has a strict incentive to initiate a new deviation from it that is itself self-enforcing.

Lemma 1 *(1) The ideal policy mix of the secular poor is* $(\tau, T, G) = (\tau_L(\nu), R(\tau_L(\nu)), 0)$, *where* $\tau_L(\nu) \equiv \tau^*(\nu/\theta_L)$. *That of the religious poor is the same for* $b < \nu$, *whereas for* $b \geq \nu$ *it is* $(\tau, T, G) = (\tau_L(b), 0, R(\tau_L(b)))$, *where* $\tau_L(b) \equiv \tau^*(b/\theta_L)$.

(2) The ideal policy mix of the secular rich is $(\tau, T, G) = (0, 0, 0)$. *That of the religious rich is the same for* $b < \theta_H$, *whereas for* $b \geq \theta_H$ *it is* $(\tau, T, G) = (\tau_H(b), 0, R(\tau_H(b)))$, *where* $\tau_H(b) \equiv \tau^*(b/\theta_H) < \tau_L(b)$.

• **Whom do the religious poor side with?** When in power, the secular poor provide a lot of T and no G, the religious rich no T and a positive G, but (due to their distaste for taxes) less than what the religious poor desire. The first policy is thus preferred by the RP when beliefs b, which are complements to G, are relatively low compared to the value ν of secular spending or transfers. Formally, using the above properties of the four groups' preferences, we establish the existence and uniqueness of a CPNE outcome in the political subgame at $t + 1$:

Proposition 5 *The equilibrium policy mix in the second period is unique and characterized by a religiosity threshold* $b^*(\nu; \theta_H, \theta_L) > \theta_H > \nu$, *or* $b^*(\nu)$ *for short, such that:*

(1) If $b < b^*(\nu)$, *the religious poor back the secular poor, who thus come to power and implement their preferred policy* $(\tau, T, G) = (\tau_L(\nu), R(\tau_L(\nu)), 0)$.

(2) If $b \geq b^*(\nu)$, *the religious poor back the religious rich, who thus come to power and implement their preferred policy,* $(\tau, T, G) = (\tau_H(b), 0, R(\tau_H(b)))$.

(3) The threshold b^* *is strictly increasing in* ν *and* θ_H, *and strictly decreasing in* θ_L.

The fact that the secular/religious-policy threshold $b^*(\nu)$ shifts up with greater inequality is intuitive. When their relative income rises, the RR face a higher tax price for the religious public good G, and consequently want to reduce its supply. The RP, on the other hand, want to increase redistributive transfers, T. For the RP to still prefer allying themselves with the RR rather than the SP therefore requires a higher level of religiosity.

Why doesn't an RP candidate enter the political fray, offering that group's ideal platform? The analysis of all possible coalitions, deviations, deviations from deviations, etc., is in Appendix B, but the idea is simple. When inequality is low enough that $b^*(\nu; \theta_H, \theta_L) < b$, the RP's platform is one of high taxes devoted to religious subsidies, hence the worst possible for the SP (also the SR, but they are never pivotal). Therefore, if the (leader from) RP were to challenge (the one from) the RR, some SP candidate would either also enter if they will then win, or else strategically stay out, with his constituents now backing their second-best, RR candidate. In both cases the RP leader is beaten. Anticipating this, none comes forward, and that group instead backs the RR candidate, deterring the SP from competing. Once inequality is high enough that $b^*(\nu; \theta_H, \theta_L) > b$, conversely, the SP enter and win unchallenged: if an RR

candidate were to compete, he would be defeated by a coalition in which the RP strategically stay out and back the SP, whose policy they now prefer to that of the RR.[32]

This first set of results already has several important empirical applications.

• **Religion as a wedge issue.** The equilibrium tax rate is illustrated in Figure 8a. In countries with low religiosity, secular governments come to power and implement welfare-state-like policies that (mostly) benefit the poor. Such countries tax more and have a larger public sector than somewhat more religious ones, which provide not only a different set of public goods but also at a lower level. In those latter countries, such as the United States, religion *splits* the standard pro-redistribution coalition of the poor, leading the religious poor to support the religious rich, who gain power as a result. This result echoes that in Roemer (1998), although a closer look reveals major differences in both assumptions and results.[33] At very high levels of religiosity, moreover, resource extraction by the State becomes large again, but now benefiting the religious sector.

• **Differential effects of rising income inequality.** The above results also imply (see again the figure) that greater income inequality leads to the usual effect of *higher* taxes and government spending in low-religiosity countries, but to *lower* levels of both (as well as a different mix of public goods) in more religious ones. In practice, common trends such as aging populations push up social spending in most countries, but the model's differential prediction is broadly in line with the divergent evolutions of redistribution between the United States and most of Western Europe since the 1980's.[34]

7.3 Inequality and Doctrinal Repair

The Church's problem is similar to that in Section 5.2, except that it takes into account that allowing beliefs to erode below $b^*(\nu)$ will now lead to a drastic *reallocation of power* towards secular (poor) agents. The latter will then cut G not just in relation to the decline in b, but all the way to zero. The decision to repair the doctrine is therefore still given by $\pi(b,\nu) \equiv G(b,\nu) - (1-\delta)\, G((1-\delta)\, b,\nu) \geq \eta$, but now with

[32] For $b < \nu$, SP and RP have the same ideal policy so there is also an equilibrium where the latter enter, supported by the former. With identical outcomes, we select the more natural equilibrium with the SP in power: (i) it is unique if $b < \nu < b^*(\nu)$; (ii) the common outcome is the policy which the SP *always* prefer.

[33] The key assumption there is that the voter with median religiosity be richer than average. In the Pew Forum (2008) data, however, respondents with median religiosity (the 57% for whom "religion is very important in my life") had average income 7% *below* the mean ($p < 1\%$). The result, moreover, is a "bang-bang" one: as agents' utility weight on religion vs. income gets large enough, the pivotal voter becomes the one with median religiosity, who dislikes redistribution. This forces the Left party to commit to a tax rate of 0, vs. 100% when religion's weight is low enough that the pivotal vote lies at median income. Between these two extremes, there are no comparative-statics on how taxes vary with religious concerns, with inequality, or their interaction.

[34] As measured, for instance, by the relative difference between pre and poststax Gini coefficients; data for 1980-2016 available from the SWIID database, Solt (2020).

$$G(b,\nu) \equiv \begin{cases} 0 & \text{if } b < b^*(\nu) \\ R(\tau_H(b)) & \text{if } b \geq b^*(\nu) \end{cases}. \tag{17}$$

The analysis of $\pi(\cdot,\nu)$ becomes more complex (see Appendix B.5), but as shown on Figure 8b: (i) it retains the same "tent" shape, with $b^*(\nu)$ and $\tau_H(\cdot)$ replacing ν and $\tau^*(\cdot)$ everywhere, including in Assumption 2; (ii) it shifts left as θ_H rises, or θ_L declines. Hence:

Proposition 6 *(1) There exist a unique $\underline{b}$ and $\bar{b}$, with $b^*(\nu) \leq \underline{b} < b^*(\nu)/(1-\delta) < \bar{b}$, such that the Church engages in doctrinal repair following a belief-eroding innovation (not blocked by the State) if and only if b lies in $[\underline{b}, \bar{b}]$.*

(2) Both $\underline{b}$ and $\bar{b}$ are increasing in θ_H and weakly decreasing in θ_L, hence strictly increasing with income inequality (a marginal or moderate mean-preserving change in θ).

These results embody clear intuitions. At $\bar{b}$, power reallocation is not an issue: the RR will be in control at $t+1$ no matter what, but if their faith erodes they will provide a lower level of G_{t+1}. As they become richer and thus face a higher tax price for G this effect is amplified, so the Church, which cares about $b_{t+1}G_{t+1}$, has a *greater incentive* to preserve b_{t+1}. At $\underline{b}$, on the other hand, repairing or not determines whether the RR or the SP come to power at $t+1$. The SP always set $G=0$, while the level provided by the RR declines with their relative income, *reducing* the Church's incentive to preserve b_{t+1} in order to ensure their victory.

7.4 State's Policy Toward Science

While the aggregate costs of blocking are the same as before (lower consumption at t to finance the repressive apparatus, foregone TFP gains at $t+1$), their *incidence* is different for rich and poor. As to the benefits, they now differ not only between secular and religious but also *by income,* since an erosion can trigger a reallocation of political power from (religious) rich to (secular) poor agents at $t+1$. We start with three intuitive points, formally proved in Appendix B.6. First, the SP are always against blocking. Not only does a BR innovation raise productivity, but the erosion of beliefs it generates is always beneficial for them, as: (i) it reduces taxation and spending on G (which they do not care about) if the RR are in power at $t+1$, namely if $(1-\delta)b_t \geq b^*(\nu)$; (ii) it (weakly) increases the chance that the SP themselves will gain power at $t+1$, which occurs if $(1-\delta)b_t < b^*(\nu)$. Second, we impose a simplifying but very plausible assumption, ensuring that the SR also never want to block.

Assumption 5 : $(1+\gamma)[1-\tau_L(\nu)] \geq 1-\tau_H(b^*(\nu))$.

In words, the productivity gains from implementing new discoveries are large enough that, even if the erosion of beliefs brings the secular poor to power, *aftertax* incomes at $t+1$ are higher than if blocking had occurred and the (lower-taxing) religious rich held power as a result. A simple sufficient condition for this to be the case is $(1+\gamma)\left[1-\tau_L(\nu)\right] \geq 1$.

Third, as before there are two regions in which even a religious government *never blocks*. When $b < b^*(\nu)$ the SP will be in power at $t+1$ anyway and set $G_{t+1} = 0$, so preventing erosion is pointless. When $b \in \left[\underline{b}, \bar{b}\right]$ the Church will adapt its dogma, so the State can let it do the work rather than make a costly and productivity-reducing investment in blocking. The analysis can thus again focus on the two *no-repairing regions,* $b > \bar{b}$ and $b^*(\nu) \leq b < \underline{b}$.

7.4.1 Whose Preferred Blocking Policy Prevails?

Propositions 5-6 characterized the unique outcome of the fiscal-policy and doctrine-repairing subgames. Working backwards, we next compute the date-t *intertemporal utilities* $V^B_{\theta,\beta}(a,b)$ and $V^{NB}_{\theta,\beta}(a,b)$ that each interest group $(\theta,\beta) \in \{\theta_H, \theta_L\} \times \{0,1\}$ can expect under blocking and no blocking, respectively; see (B.19)-(B.20) in Appendix B. Studying the four groups' indifference loci $V^B_{\theta,\beta} = V^{NB}_{\theta,\beta}$, we then show (Lemma 8) that: (i) each one defines an upward-sloping $b = B_{\theta,\beta}(a)$, as in Section 5.3; (ii) whenever the religious rich want to block, then *a fortiori* so do the religious poor: $B_{\theta_L,1}(a) < B_{\theta_H,1}(a) < B_{\theta_L,0}(a)$, for all a.

These invariant preference rankings imply that *the religious rich are always pivotal* in the date-t political competition that determines science policy. Intuitively, when they are against blocking, the SP and the SR agree with them, resulting in a majority. When the RR do want to block, the RP agree with them, again adding up to a majority. Formally, we prove the following results, illustrated by the solid black lines in Figure 9.

Proposition 7 *The unique Perfectly Coalition-Proof Nash Equilibrium (PCPNE) of the two-period game always implements the preferred science policy of the religious rich. The corresponding blocking boundary is an upward-sloping line $b = B(a)$ in the state space.*

Thus, even though the model with four social classes and endogenous dynamic coalitions is far more complex than the simplified version of Section 5, solving it leads to phase diagrams for the evolution of (a_t, b_t) that remains qualitatively unchanged from those in Figures 5-6.

7.5 Income Inequality, Science Policy and the Religious Right

Keeping the sizes $(n, 1-n)$ of the rich and poor classes constant, consider now a mean-preserving change in their income levels: $(d\theta_H, d\theta_L)$, with $nd\theta_H + (1-n)d\theta_L = 0$. We assume that, initially, there is already a certain degree of inequality in society (recall that average income is normalized to 1):

Assumption 6 $\theta_H - 1 \geq \nu \frac{(1-n)^2}{n}\left[-R''(\hat{\tau})\right]\left(1 + \frac{R^{-1}(\bar{\varphi})}{\lambda p_R(1+\gamma)}\right).$

We can then show the following comparative-statics properties.

Proposition 8 *A marginal increase in income inequality causes the blocking locus $B(a)$ to:*

1. *Shift up in the Theocratic region $b > \bar{b}$, where there is no repairing nor power reallocation.*
2. *Shift down in the Mildly Secular region $b^*(\nu) \leq b < \underline{b}$, where there is no repairing and BR discoveries potentially trigger a reallocation of power toward the secular poor.*

These contrasting effects reflect an intuitive tradeoff. With higher inequality, blocking requires the rich to forego more future income ($\theta_H \gamma > \theta_L \gamma$), and also bear more of the direct cost $\varphi(a)$. On the other hand, it can prevent a shift of power to the high-taxing SP at $t+1$. The first effect dominates at high levels of b, as even with eroded beliefs the RP will not switch allegiance. The second one prevails when religiosity is intermediate, as *power is now at stake* if the RP's beliefs come to be eroded.

• **Complete comparative statics.** Figure 9 summarizes, as a shift from solid black to dashed red lines, the *combined effects* of an increase in income inequality on *public spending, doctrinal repair,* and *science policy.* The second-period policy threshold $b^*(\nu)$ and the Church's whole repairing region $[\underline{b}, \bar{b}]$ both shift up (Propositions 5-6), while the State's blocking locus $B(a)$ shifts up at high levels of religiosity ($b > \bar{b}$) and down at low levels of b (Proposition 8). These combined results lead, in turn, to the following important predictions.

Proposition 9 *In the "American" regime, $b \in [\underline{b}, \bar{b}]$, greater income inequality leads to more blocking of "threatening" scientific findings, and to greater doctrinal rigidity of the religious sector. In Theocratic" regimes, $b > \bar{b}$, it has the opposite ("modernizing elites") effects.*

7.6 Applications

• **Rising inequality and the Religious Right.** While each potential coalition at t must envision all subsequent ones at $t+1$ that its actions can empower or defeat, the main intuition for how *greater inequality* can lead to the formation of an *anti-redistribution and anti-science alliance* in the "American" regime is simple. At $t+1$, if the RP's faith has eroded they will ally themselves with the SP and implement high redistribution –the worst possible outcome for the RR. If they remain sufficiently pious, they will instead support the RR's policy of moderate taxes but religion-favoring spending (or laws), which then wins. Looking forward at t, the RR realize that in order to hold power at date $t+1$ they must *preserve the religiosity of the RP*, which requires blocking certain economically valuable ideas. When the stakes of who be in control at $t+1$ are high enough due to high inequality, this concern dominates over the fact that the rich *benefit most* from productivity gains. Consequently, the RR *strategically* give priority to religion over science, and in so doing they are supported by the RP, who always have the greatest incentive to block. The dynamic outcome is that the RR gain power at t, and *thanks to blocking* they keep it at $t + 1$.

• **Inequality and modernizing vs. rentier elites.** Figure 9 also shows that, at high enough levels of religiosity, the same mechanism works in the *opposite* direction. The rich now feel "secure" that the faith of the poor is strong enough to withstand some erosion by BR innovations (possibly with the help of doctrinal repair, which becomes more likely) without triggering a loss of power to a quasi-secular and pro-redistributive coalition. Thus, as their productivity rises, even the RR give greater weight to reaping the benefits of new knowledge. Empirically, "the rich" in this case correspond to a rising upper-middle class in an initially poor and highly religious country, such as Malaysia, Jordan, or in earlier times Chile and Argentina. In contrast, *rentier elites,* whose natural-resource-based wealth is not enhanced much by new knowledge, give precedence to maintaining religious doctrine as the rampart against redistributive demands. In line with this implication of the model, the *Muslim World Science Initiative Report* (2015) shows that rich Gulf states like Saudi Arabia, Kuwait, Qatar and the UAE proportionately invest significantly less in R&D, and are far less productive in science, than countries like Malaysia and Jordan.

8 Conclusion

We developed a model of the coevolution between religion, science, and politics. In the long run, societies gravitate to a distribution concentrated around three attractors. The "Western-European Secularization" regime has declining religiosity, unimpeded science, and high taxes and transfers. The "Theocratic" regime involves knowledge stagnation, unquestioned dogma, and high religious-public-goods spending. In-between, the "American" regime combines scientific progress and stable religiosity through doctrinal adaptations, with low taxes and some fiscal-legal advantages for religious activities. The model's results shed light on a broad range of historical phenomena, on the "secularization hypothesis", and on the striking negative relationship we uncover in contemporary data between religiosity and patents per capita.

We also studied the medium-run (one or two generations) transitions between the different societal regimes, particularly the "American" one's recurrent excursions into the secular and theocratic regions. Finally, we analyzed the effects of rising income inequality in the different regimes. Whereas in theocratic states it can foster "modernizing" elites that become more tolerant of secular knowledge, in the American regime it favors the emergence of a *Religious-Right coalition,* which both curtails redistribution and implements anti-science polices.

The main examples of "forbidden fruits" we discussed involved fundamental sciences on the one hand, religion *stricto sensu* (sacred texts, belief in deities, creation, afterlife, etc.) on the other. It should be clear, however, that both concepts can be taken in a more general sense.

Consider first modern contraception –an applied innovation, though derived from advances in basic biology. Here again we find the four key features of BR discoveries: (i) large potential increases in productivity, by facilitating women's labor-force participation and raising their return to human capital; (ii) conflicts with several of the world's major religious doctrines around the divinely ordered role of women, purpose of sexuality and sacredness of human life; (iii) as a result, condemnation by religious authorities and initial proscription by the State; (iv) over time (and not everywhere), as society becomes more secular or/and religious doctrine is "modernized", the innovation is allowed to diffuse, affecting both productivity and mindsets.

Second, totalitarian *ideologies* also block and distort scientific knowledge that undermines their belief systems. The most extreme case is that of Nazi "racial science", but much longer-lived was that of *Lysenkoism* in the Soviet Union.[35] A contemporary example, now particularly relevant for the social sciences, is that of China (Sharma (2019), Minzner (2020)).[36]

As much as individual discoveries and ideas, it is the scientific method itself, with its emphasis on systematic *doubt*, contradictory *debate* and empirical *falsifiability*, that inevitably runs afoul of preestablished dogmas. The model could thus be extended to the interactions between other types of new knowledge and vested cultural, corporate or political beliefs. At the same time, the interplay of religion with science and innovation remains a rich topic for future research, both theoretical and empirical.

[35] From 1935 to 1964, Inquisition-like methods (forced denunciations, imprisonments, executions) were used to repress "bourgeois" theories and methods in genetics and agronomy, with adverse spillovers onto other fields. Instead, the Stalinist regime promoted and enforced a pseudoscience it saw as more compatible with its dogma of Man's and society's malleability to rapid social change.

[36] Authoritarian regimes repress also political ideas, books, and freedoms, but this is outside the current model's focus and applicability. First, even completely non-ideological, pure kleptocracies, do this. Second, political ideas and movements need not be based on empirically valid claims, nor be productivity enhancing –many of them are not, deriving their appeal from other features instead.

Appendix A: Historical and Contemporary Examples

A.1 Science and Religion in the Christian World

The establishment of Christianity as the official religion of the Roman Empire (380 A.D.) was soon followed by persecutions of pagan (Greek and Roman) and "heretical" (non-Catholic Christian) religions. Over time, the imposition of an increasingly rigid orthodoxy that made all knowledge subordinate to Church dogma, combined with the disruptions following the fall of the Empire (476 A.D.), led to prolonged scientific and technological stagnation. The Hellenistic traditions of free inquiry and debate in science and philosophy decayed (Freeman (2005)), and for several centuries the West largely lived off the remnants of Classical knowledge that had been preserved, or trickled in from the Byzantine Empire and Muslim World.

In the 12^{th} century, Aristotle's (384-322 B.C.) previously lost works in "natural philosophy" (*Physics, On the Soul, On Generation and Corruption, Metaphysics, Meteorology, On the Heavens)* were rediscovered and translated into Latin. Unlike his books on logic and rhetoric, incorporated into the Church's curriculum since the 6^{th} century, these contained doctrines regarding the physical world and human life that seemed incompatible with crucial statements in the Bible.[37] The diffusion of these "heretical" writings was quickly opposed by the Church. In 1210 the Synod of Paris issued a declaration that "nor shall the books of Aristotle on natural philosophy, and the commentaries [of Averroes] be read in Paris, in public or secret; and this we enjoin under pain of excommunication" (Deming (2010), p. 137). In 1277 the Bishop of Paris issued a further list of 219 heretical propositions, also backed by threat of excommunication. The decree was overturned in 1325 following the work of Thomas Aquinas (1225-1974), which offers a perfect example of *doctrinal repair* after a *belief-eroding discovery.* By introducing a fundamental distinction between the domain of reason and that of faith, Aquinas' *Summa Theologica* allowed the Aristotelian corpus to be fully incorporated into official doctrine.

Copernicus' *On the Revolution of Celestial Spheres* (1543) upended the whole Aquinian synthesis, which the Church had by then become heavily vested in. While he (prudently) presented his heliocentric model as a pure mathematical hypothesis, for which he "could provide no empirical support," it stood in sharp opposition to the cosmological teachings of the Church, and attracted interest from many scientists. In 1632, Galileo's *Dialogue on the Two Chief World Systems* "made the clearest, fullest and most persuasive yet of arguments in favor of Copernicanism and against traditional Aristotelian-Ptolemaic astronomy and natural phi-

[37] *Meteorology* states that "there will be no end to time and the world is eternal" (contradicting the description of Creation in the Bible), and *On the Heavens* that "the world must be unique," which for the Church was heretical, as "limiting the possible worlds to one... implied that God was not omnipotent" (Deming (2010), pp. 138-139). Aristotle's writings also denied other fundamental pillars of the doctrine, such as the possibility of salvation and the immortality of the soul. He further claimed that it was possible to know God on rational grounds only, whereas the Christian faith rested upon the principle of divine revelation.

losophy" (McClellan and Dorn (2006), p. 230). In 1633 the Holy Inquisition found him guilty of "vehemently suspected heresy," forced him to "abjure, curse and detest" his opinions, and placed all his works, past and future, in the *Index of Prohibited Books.* The trials of Galileo and other "heretical" scientists like the mathematician and astronomer Giordano Bruno, burned at the stake in 1600, and the Church's lasting prohibitions of fundamental concepts such as *atomism* and *infinitesimals*, led to a waning of innovation in Catholic lands, and the displacement of the Scientific Revolution toward Northern Europe (Trevor-Roper (1967), Gusdorf (1969), Landes (1998), Young (2009)).[38] In Spain, for instance, Inquisition tribunals had lasting effects on local economic development, by significantly delaying the adoption of new technologies (Vidal-Robert (2011)).[39] In France, upon learning of Galileo's trial, Descartes withheld publication of his *"Treatise on the World and Light",* for fear of persecution by religious authorities. This *magnum opus* on the laws on nature (motion, optics, matter, astronomy) was finally published in Latin only thirty years later.

In England, by contrast, The Royal Society accepted Galileo's work with enthusiasm. As Goldstone (2000, p. 184) writes, "Only in Protestant Europe was the entire corpus of classical thinking called into question; Catholic regions under the Counter-Reformations preferred to hold to the mix of Aristotelian and Christian cosmologies received from Augustine, Ptolemy, and Aquinas. And only in England, for at least a generation ahead of any other nation... did a Newtonian culture –featuring a mechanistic world-view, belief in fundamental, discoverable laws of nature, and the ability of man to reshape his world by using those laws."[40] Indeed, Newton's *Mathematical Principles of Natural Philosophy* (1687) once again upended classical teachings, by demonstrating that the same universal laws could explain the motion of celestial bodies and that of falling objects. His theories were quickly adopted in Britain, where the Church of England declared them compatible with the "spirit" of Biblical accounts of the universe –another major *doctrinal adaptation.* Newtonism was also well received in areas of Europe outside the reach of the Inquisition, and the use of scientific principles in craftwork industries paved the way for the Industrial Revolution (Jacob and Stewart (2004)).

In France (the "eldest daughter of the Church"), meanwhile, Squicciarini (2020) shows that historically more religious districts had significantly lower economic development during

[38] Blocking thus occurred even in pure mathematics: *"We consider this proposition [that a line is composed of indivisible, infinitesimal points] to be not only repugnant to the common doctrine of Aristotle, but that it is by itself improbable, and... is disapproved and forbidden in our Society";* Revisors General of the Collegio Romano (1632), cited in Alexander (2014). The Collegio was the Jesuits' supreme teaching and doctrinal body.

[39] Inquisition tribunals persisted in Spain until 1834, with executions until 1826. The Catholic Church "permitted" the teaching of heliocentrism (doctrinal repair) only in 1822, and conceded it as a fact only in 1992.

[40] As Merton (1938, p. 495) notes: "The Puritan complex of a scarcely disguised utilitarianism; of intramundane interests; methodical, unremitting action; thoroughgoing empiricism; of the right and even the duty of "libre examen"; of anti-traditionalism –all this was congenial to the same values in science." In Section 6.2 we propose that this is a very adaptive "mutation", or doctrinal-design strategy, for a new entrant at that time.

the Industrial Revolution, but not before, with *"blocking"* playing a key causal role. In more Catholic areas there was a slower introduction of technical education in primary schools, with the Church pushing instead a strongly anti-scientific program. Adoption of a more religious curriculum, in turn, was negatively associated with industrial development 10 to 15 years later (at the time of labor-market entry), and the more so in more skill-intensive sectors.

A.2 Science and Religion in the Muslim World

The Muslim expansion in the Middle East, North Africa and Southern Europe occurred during 632 to 750 A.D. The resulting confrontation with the "rational sciences" such as philosophy, logic, mathematics and astronomy cultivated in the newly conquered areas presented Muslim authorities with a tradeoff. On the one hand, many viewed these "foreign" sciences as threats to the revealed faith and the authority they derived from it (e.g., Chaney 2011, 2016). On the other hand, being discouraged by Koranic law and demographic realities from implementing forced conversions, they saw engaging in learned debates with non-Muslims as a necessary means of proselytizing. Scientific progress initially flourished in this environment of religious competition and intellectual pluralism –an *Islamic Golden Age* that saw major developments in mathematics, chemistry, medicine, and other fields.[41]

Just as for Christianity centuries earlier, the initial tolerance willingness of Muslim rulers progressively declined once majorities of people had converted, and the Golden Age was followed by centuries of antagonism to the generation and diffusion of new ideas (Lewis (2003), McClellan and Dorn (2006), Rubin (2017)). "In the 11th century A.D., Hellenistic studies in the Islamic civilization were on the wane, and by the end of the twelfth century A.D. they were essentially extinct." (Deming (2010), p. 105). Greek natural philosophy was excluded from the subjects taught in the madrasas, and "any private institution that might teach the 'foreign' sciences was starved out of existence by the laws governing *waqfs* [charitable endowments]".

The most striking case of blocking is that of the *printing press.* Following Gutenberg's first Bible (1455), presses spread very rapidly across Europe.[42] Little opposition initially came from the Church, which found printing useful to disseminate the Holy Scriptures and religious manuals, and profit from selling letters of indulgence (Childress (2008), ch. 6).[43] In Muslim lands, by contrast, printing –especially in Arabic and Turkish– was banned for several

[41] The Caliphs also financed extensive translations of Greek and Indian works in philosophy and science and created important libraries, observatories and other centers of learning, especially in Baghdad.

[42] "By 1500, more than 1,000 printing shops had sprung up in Europe. Printers were turning out an average of 500 books per week" (Vander Hook, It is estimated that just during 1436-1500, approximately 15,000 different texts were printed in 20 million copies, and over the 16^{th} century 150,000 to 200,000 different books and book editions, were printed, totaling more than 200 million copies (Kertcher and Margalit, 2005). 2010, p. 12).

[43] Ironically, half a century later printing proved to be a decisive factor in the diffusion of the Protestant Reformation that radically undermined the Church's hegemony. Later on, it also played a key role in spreading the ideas of the Scientific Revolution and Enlightenment (e.g., Diderot and d'Alembert's *Encyclopedie* of 1751).

centuries. In 1515, Sultan Selim I issued a decree under which the practice of printing would be punishable by death. Printing only took off in the Islamic World in the early 19^{th} century, partly due to the need for defensive modernization against the West.

A.3 Human Evolution

Darwin's *On the Origin of Species* (1859) initially met some opposition, but within a few decades became widely accepted by the scientific community and in more secularized Western countries, where a literal reading of *Genesis* had already been undermined by developments in geology and natural sciences. In more religious parts of the world, human evolution remains a highly controversial, minority view. Hameed (2008) found that fewer than 20% of adults in Indonesia, Malaysia and Pakistan believed Darwin's theory to be "true or possibly true", and only 8% in Egypt. In Europe, the Church kept silent on the issue until Pope Pius XII's 1950 encyclical *Humani Generis.* While still *not* accepting evolution as a fact, it allowed important *doctrinal repair* by introducing a distinction between the "possibly material" origins of the human body and the necessarily divine and immediate imparting of the soul.[44]

The United States is a striking case of a technologically advanced country where significant opposition persists. In 1925, Tennessee's Butler Act prohibited teaching in schools any theory of human origins contradicting the Bible; it remained on the books until 1967. As noted by Ruse (2006, p. 249) "A 2001 Gallup poll reported that 45% of Americans thought that God created humans as they are now, 37% let some kind of guided evolution do the job, and 12% put us down to unguided natural forces."[45] Today, "creation science" is taught in 15 to 20% of American schools.

In 2017, Turkey's religiously-aligned government stopped all teaching of Human Evolution in schools, rewriting the textbooks with the help of religious scholars. In 2018, India's Minister of Education declared Darwin's theory "scientifically wrong" and demanded that it be removed from textbooks, though unsuccessfully due to strong protests from the scientific community. A few years earlier, Prime Minister Narendra Modi cited the supernatural features of Hindu deities and mythological heroes to argue that "Vedic science" had discovered genetics and plastic surgery thousands of years ago. Addressing Children at the 2019 Indian Science Congress, several academic officials made similar claims about aircraft and embryonic transplants being invented by ancient Hindu gods, while Newton and Einstein's theories were just gross mistakes.

[44] "The Teaching Authority of the Church does not forbid that... research and discussions, on the part of men experienced in both [human sciences and sacred theology], take place with regard to the doctrine of evolution, in as far as it inquires into the origin of the human body as coming from pre-existent and living matter –for the Catholic faith [only] obliges us to hold that souls are immediately created by God."

[45] The 2006 GSS included 13 questions on basic scientific knowledge. and reasoning; controlling for standard sociodemographics, greater religiosity was significantly associated with lower scientific literacy (Sherkat (2011)).

Appendix B: Main Proofs

We will allow throughout for a slightly more general (and more realistic) outcome of doctrinal-repair work than in the text. We had assumed that by investing ηb (per unit of TFP) following the diffusion of a BR innovation, the Church could always prevent beliefs from being eroded to $(1-\delta)b$. We now allow such attempts to succeed only with probability q, where:

Assumption 7 : $q \geq 1/(1+\gamma)$.

B.1 Proof of Proposition 2

Lemma 2 *The function* $\pi(b,\nu)$ *equals* 0 *for* $b<\nu$, *then jumps up to* $\pi(\nu,\nu)=R(\tau^*(\nu))$. *It is continuous and strictly increasing on* $[\nu,\nu/(1-\delta))$, *then jumps down to* $\pi(\nu/(1-\delta),\nu)=R(\tau^*(\nu/(1-\delta)))-(1-\delta)R(\tau^*(\nu))$. *Finally, it is continuous and strictly decreasing on* $[\nu/(1-\delta),+\infty)$, *with* $\lim_{b\to+\infty}\pi(b,\nu)=\delta R(\hat{\tau})>0$.

Proof. (1) For $b<\nu$, $G(b,\nu)=G((1-\delta)b,\nu)=0$, hence $\pi(b,\nu)=0$. For $\nu\leq b<\nu/(1-\delta)$, the religious switch to the provision of the secular public good when religiosity is eroded from b to $b'\equiv(1-\delta)b$. Therefore, over this range $\pi(b,\nu)=R(\tau^*(b))$, which is strictly increasing and continuous in b; at $b=\nu$, the function $\pi(b,\nu)$ thus has an upward jump of $R(\tau^*(\nu))$.
(2) For $\nu/(1-\delta)\leq b$, the religious provide G even when b falls to $(1-\delta)b$, so

$$\pi(b,\nu)=R(\tau^*(b))-(1-\delta)R(\tau^*((1-\delta)b)). \tag{B.1}$$

From the first-order condition $bR'(\tau^*(b))=1$ follows that $\tau^{*\prime}(b)=-1/[b^2R''(\tau^*(b))]>0$, so

$$\begin{aligned}\frac{\partial\pi(b,\nu)}{\partial b} &= R'(\tau^*(b))\tau^{*\prime}(b)-(1-\delta)^2R'(\tau^*((1-\delta)b))\tau^{*\prime}((1-\delta)b)\\ &= \frac{1}{b^2}\left[\frac{R'(\tau^*(b))}{-R''(\tau^*(b))}-\frac{R'(\tau^*(b'))}{-R''(\tau^*(b'))}\right].\end{aligned} \tag{B.2}$$

This expression is negative if $-R'(\tau)/R''(\tau)$ is decreasing (as $\tau^*(b)$ is increasing), which is implied by Assumption 1. The function $\pi(b,\nu)$ in (B.1) is therefore decreasing on $[\nu/(1-\delta),+\infty)$; at $b=\nu/(1-\delta)$ it has a downward jump of $-(1-\delta)R(\tau^*(\nu))$. As b tends to $+\infty$, finally, both $\tau^*(b)$ and $\tau^*((1-\delta)b)$ tend to $\hat{\tau}$, so by (B.1) $\pi(b,\nu)$ tends to $\delta R(\hat{\tau})>0$. ‖

Lemma 2 implies that, for all y in $(\delta R(\hat{\tau}),\ \pi(\nu/(1-\delta),\nu))$, the set of b's where $\pi(b,\nu)\geq y$ is an interval $[b^-(\nu;y),b^+(\nu;y)]$, with $\nu\leq b^-(\nu;y)<\nu/(1-\delta)<b^+(\nu;y)$. Given Assumption 2, setting $\underline{b}\equiv b^-(\nu;\eta/q)$ and $\bar{b}\equiv b^+(\nu;\eta/q)$ concludes. ■

B.2 Proof of No Blocking When Repairing, i.e. When $\mathbf{b} \in [\underline{\mathbf{b}}, \bar{\mathbf{b}}]$

(1) When $b \in [\nu/(1-\delta), \bar{b}]$, the Church's attempts at doctrinal repairing following a BR innovation are successful with probability q, in which case b and G remain unchanged. With probability $1-q$ repairing fails and b drops to $b' \geq \nu$, so that the religious public good is still provided but at a lower level. The value of not blocking is therefore

$$V^{NB} = 1 + [1 - \lambda + \lambda(1-p_R)(1+\gamma) + \lambda p_R q (1+\gamma)] V(b) + \lambda p_R (1-q)(1+\gamma) V(b'), \quad \text{(B.3)}$$

where $V(b')$ is given by (8). Combining (B.3) and (9), $V^{NB} < V^B$ takes the form:

$$R^{-1}(\varphi(a)) \leq \lambda p_R \left\{ [1 - q(1+\gamma)] V(b) - (1-q)(1+\gamma) V(b') \right\} \equiv \Delta^{3I}(b). \quad \text{(B.4)}$$

(2) When $b \in [\underline{b}, \nu/(1-\delta))$ and repair fails, religiosity falls to $b' < \nu$, so $G_{t+1} = 0$ and the value of not blocking becomes

$$V^{NB} = 1 + [1 - \lambda + \lambda(1-p_R)(1+\gamma) + \lambda p_R q (1+\gamma)] V(b) + \lambda p_R (1-q)(1+\gamma) V(\nu), \quad \text{(B.5)}$$

which is equivalent to (B.3) with $V(\nu)$ replacing $V(b')$. Hence, the blocking condition becomes

$$R^{-1}(\varphi(a)) \leq \lambda p_R \{ [1 - q(1+\gamma)] V(b) - (1-q)(1+\gamma) V(\nu) \} \equiv \Delta^{3II}(b). \quad \text{(B.6)}$$

Lemma 3 *There exists a $q = q^* < 1/(1+\gamma)$ such that, for any $q > q^*$, the religious majority prefers not to block ($V^{NB} > V^B$) for any $(a, b) \in \mathbb{R}_+ \times [\underline{b}, \bar{b}]$. Consequently, under Assumption 7, the State does not block in this region.*

Proof. Consider (B.4) and note that $\Delta^{3I}(b) < 0$ for all $q \geq 1/(1+\gamma)$. Moreover $V(b)$ is increasing in b, so $\partial \Delta^{3I}(b)/\partial q = -\lambda p_R (1+\gamma)[V(b) - V(b')] < 0$. Hence, there exists a $q_I^* < 1/(1+\gamma)$ such that $\Delta^{3I}(b)$ has the sign of $q_I^* - q$. Similarly, (B.6) implies, for all $b > \nu$, $\partial \Delta^{3I}(b)/\partial q = -\lambda p_R (1+\gamma)[V(b) - V(\nu)] < 0$, so there exists a $q_{II}^* < 1/(1+\gamma)$ such that $\Delta^{3II}(b)$ has the sign of $q_{II}^* - q$. Under Assumption 7, $q > \max\{q_I^*, q_{II}^*\} \equiv q^*$, so there is no blocking for $b \in [\underline{b}, \bar{b}]$. ■

B.3 Proof that the $\Delta^i(b)$, $i = 1, 2$, Are Increasing in b

- **Case $\mathbf{b} > \bar{\mathbf{b}}$** : we explicit the net return to blocking $\Delta^1(b)$ by substituting (8) into (11):

$$\Delta^1(b) = \lambda p_R \left\{ 1 - \tau^*(b) + bR(\tau^*(b)) - (1+\gamma)\left[1 - \tau^*(b') + b'R(\tau^*(b'))\right] \right\}. \quad \text{(B.7)}$$

Differentiating (B.7) and using the envelope theorem (note that $\Delta^1(b)$ is the difference between two maximized functions) yields

$$\frac{\partial \Delta^1(b)}{\partial b} = \lambda p_R \left[R(\tau^*(b)) - (1+\gamma)(1-\delta) R\left(\tau^*(b')\right) \right]. \tag{B.8}$$

Any blocking of BR innovations requires that $\Delta^1(b) \geq 0$, which by (B.7) takes the form

$$R(\tau^*(b)) - (1+\gamma)(1-\delta) R\left(\tau^*(b')\right) \geq (1/b) \left[(1+\gamma)\left(1 - \tau^*(b')\right) - (1 - \tau^*(b)) \right]. \tag{B.9}$$

Since $\tau^*(b)$ is nondecreasing and $b' \equiv (1-\delta) b$, the right-hand side of (B.9) is strictly positive. Therefore, $\Delta^1(b) \geq 0$ implies that $\partial \Delta^1(b)/\partial b > 0$ in (B.8).

- **Case $\boldsymbol{\nu} \leq \mathbf{b} < \underline{\mathbf{b}}$**: we explicit the net return $\Delta^2(b)$ by substituting (8) into (13):

$$\Delta^2(b) = \lambda p_R \left\{ 1 - \tau^*(b) + bR(\tau^*(b)) - (1+\gamma)\left[1 - \tau^*(\nu) + \nu R(\tau^*(\nu))\right] \right\}. \tag{B.10}$$

Differentiating, we obtain $\partial \Delta^2(b)/\partial b = \lambda p_R R(\tau^*(b))$, which is always positive.

B.4 Proof of Proposition 5

We first establish the existence and properties of the religiosity threshold $b^*(\nu, \theta_H, \theta_L)$ above which the RP prefer the ideal policy of the RR to that of the secular poor. We them use them to show the existence and uniqueness of the CPNE outcome.

B.4.1 Preferred alliance of the religious poor

Lemma 4 *(1) For any ν there exists a unique $b^*(\nu; \theta_H, \theta_L) > \theta_H > \nu$, or $b^*(\nu)$ for short, such that the religious poor prefer the ideal policy of the secular poor (defined by $\tau_L(\nu)$) to that of the religious rich (defined by $\tau_H(b)$) if and only if $b \leq b^*(\nu)$.*
(2) The function b^* is strictly decreasing in θ_L and strictly increasing in θ_H.
(3) The function b^* is strictly increasing in ν.

Proof. (1) The utility of the religious poor under the ideal policy of the religious rich is

$$f(b) \equiv [1 - \tau_H(b)]\theta_L + bR(\tau_H(b)) \quad \text{for} \quad b \geq \theta_H, \quad f(b) \equiv \theta_L \quad \text{otherwise}, \tag{B.11}$$

whereas under that of the secular poor it equals

$$g(\nu) \equiv [1 - \tau_L(\nu)]\theta_L + \nu R(\tau_L(\nu)). \tag{B.12}$$

For $b \leq \theta_H$, $f(b) < g(\nu)$. For $b \geq \theta_H$, $f(b)$ is an increasing function, since

$$f'(b) = R(\tau_H(b)) + \left[bR'(\tau_H(b)) - \theta_L\right]\tau'_H(b) = R(\tau_H(b)) + [\theta_H - \theta_L]\tau'_H(b) > 0.$$

Finally, as b tends to $+\infty$, $\tau_H(b) = \tau^*(b/\theta_H)$ tends to $\hat{\tau}$, so $f(b)$ tends to $+\infty$. This shows the existence of a unique indifference point, $b^*(\nu) > \theta_H > \nu$. Before studying its variations, we prove two simple properties linking the preferred tax rates of poor and rich agents.

Lemma 5 *For any $\nu \in (\theta_L, \theta_H)$, let $\tilde{b}(\nu) \equiv \nu(\theta_H/\theta_L) > \theta_H$. Then $\tau_L(\nu) = \tau_H(\tilde{b}(\nu)) > \tau_H(b^*(\nu))$.*

Proof. The equality follows from $\tau_L(\nu) = \tau^*(\nu/\theta_L)$ and $\tau_H(b) = \tau^*(b/\theta_H)$ for $b \geq \theta_H$. The inequality then holds if $\tilde{b}(\nu) > b^*(\nu)$ or, by monotonicity of f, $f(\tilde{b}(\nu)) > f(b^*(\nu))$. We have

$$\begin{aligned} f(\tilde{b}(\nu)) &= [1 - \tau_H(\tilde{b}(\nu))]\theta_L + \tilde{b}(\nu)R(\tau_H(\tilde{b}(\nu))) = [1 - \tau_L(\nu)]\theta_L + \tilde{b}(\nu)R(\tau_L(\nu)) \\ &> [1 - \tau_L(\nu)]\theta_L + \nu R(\tau_L(\nu)) = g(\nu) \equiv f(b^*(\nu)), \end{aligned}$$

using the definition of $b^*(\nu)$, hence the result. $\|$

(2) For the comparative statics, we make the dependence of f and g on (θ_L, θ_H) explicit. Thus

$$\begin{aligned} \frac{\partial f(b; \theta_L, \theta_H)}{\partial \theta_L} &= 1 - \tau_H(b), \\ \frac{\partial g(\nu; \theta_L)}{\partial \theta_L} &= 1 - \tau_L(\nu) + \left[-\theta_L + \nu R'(\tau_L(\nu))\right]\frac{\partial \tau_L(b)}{\partial \theta_L} = 1 - \tau_L(\nu), \end{aligned}$$

by the first-order condition of the SP. Therefore,

$$\frac{\partial f(b; \theta_L, \theta_H)}{\partial \theta_L} - \frac{\partial g(\nu; \theta_L)}{\partial \theta_L} = \tau_L(\nu) - \tau_H(b),$$

which is always positive at $b = b^*$ since $\tau_H(b^*(\nu)) < \tau_L(\nu)$, by Lemma 5.(2) above. Since $f(b) - g(\nu)$ is also increasing in b, its unique zero, $b^*(\nu)$, is therefore strictly decreasing in θ_L. Similarly, $\partial b^*/\partial \theta_H > 0$ follows from the fact that

$$\frac{\partial f(b; \theta_L, \theta_H)}{\partial \theta_H} - \frac{\partial g(\nu; \theta_L)}{\partial \theta_H} = \left[-\theta_L + bR'(\tau_H(b))\right]\frac{\partial \tau_H(b)}{\partial \theta_H} = (\theta_H - \theta_L)\frac{\partial \tau_H(b)}{\partial \theta_H} < 0,$$

where we used first-order condition $bR'(\tau_H(b)) = \theta_H$, which implies

$$\frac{\partial \tau_H(b)}{\partial \theta_H} = \frac{1}{bR''(\tau_H(b))} < 0 < \frac{\theta_H}{-b^2 R''(\tau_H(b))} = \tau'_H(b). \tag{B.13}$$

(3) Recall that $b^*(\nu)$ is uniquely defined by the indifference condition

$$[1-\tau_H(b^*(\nu))]\,\theta_L + b^*(\nu)\,R(\tau_H(b^*(\nu))) = [1-\tau_L(\nu)]\,\theta_L + \nu R(\tau_L(\nu)). \tag{B.14}$$

Differentiating in ν then using $\nu R'(\tau_L(\nu)) = \theta$ and $bR'(\tau_H(b)) = \theta_H$ yields

$$b^{*\prime}(\nu) = \frac{R(\tau_L(\nu))}{(\theta_H-\theta_L)\,\tau_H'(b^*(\nu)) + R(\tau_H(b^*(\nu)))}. \tag{B.15}$$

From the second part of (B.13), it then follows that $b^{*\prime}(\nu) > 0$. ■

B.4.2 Political equilibrium in the second period

Using the key properties of the different groups' preferences established in Lemma 4, we now prove the existence and uniqueness of a CPNE in the political subgame played at $t+1$.[46]

A - Region $\nu < b < b^*(\nu)$

Case 1: $\theta_H \leq b < b^*(\nu)$. In this case, the optimal tax rate of the RR is $\tau_H(b) > 0$. This implies that the SP *strictly* prefer the SR to the RR, and the RP *strictly* prefer the RR to the SR. The Table B.1 displays the *rankings* of each group i over the ideal fiscal policies of the four groups j; naturally, its own policy is always ranked first.

	SP	RP	RR	SR
SP	1	4	3	2
RP	2	1	3	4
RR	x	y	1	z
SR	x'	4	y'	1

where $(x, y, z) = (3, 4, 2)$ [subcase(a)], or (4,2,3) or (4,3,2) [subcase b]; $(x\prime, y\prime) = (2, 3)$ or $(3, 2)$.

Table B.1. Fiscal preferences of each group when $\theta_H \leq b < b^*(\nu)$.

The first two rows are self-explanatory. In the third, subcase (a) occurs when the RR prefer the SP to the RP (they will then also prefer the SR to the SP), and subcase (b) when they prefer the RP to the SP; we then do not know a priori how the SR are ranked relative to the RP. The last row shows that the SR's least preferred policy is that of the RP and that they may rank that of the SP ahead of that of the RR, or vice versa.

We now show that the SP winning –implementing their preferred fiscal policy– in the

[46] For $b < \nu$ the preferred policy of the SP and RP coincide, so there is also an equilibrium in which it is the latter who enter, supported by the former. As both yield the same outcome this multiplicity is inconsequential, so without loss of generality, we will select the one with the SP in power. This seems most natural, as it is their policy that is implemented in all cases, and it is also the unique equilibrium for $\nu < b < b^*(\nu)$.

second period of the political game (a generation's old age) is a CPNE outcome (Claim 1), and then that this equilibrium is unique (see Claims 2–4).

Claim 1: *The SP winning at $t+1$ is a CPNE outcome.*

Proof: Consider the case where only the SP and the RR candidates enter, so that the strategy profile is $(SP = E, RP = N, RR = E, SR = N)$ where E and N denote respectively the entry and non-entry of the candidate. The SP are the winner, as they get the support of the RP and the poor add up to a majority. This is clearly a Nash Equilibrium (NE), as no player has an incentive to deviate; we next show that there is no self-enforcing coalitional deviation.

Note first that any winning deviating coalition must contain the RP and that the SP must be their 2^{nd} choice. The coalition (RP, RR) gets $(2, x)$ when the SP wins. The only available vector that could Pareto-dominate $(2, x)$ is $(1, y)$, achieved in subcase (b) by $(RP = E, RR = N)$, with the RP winning, since $(x, y, z) \in \{(4, 2, 3), (4, 3, 2)\}$. This coalition is not self-enforcing, however. If the RR stays in, no one gets a majority in the first round (where there are at least three candidates—SP, RP and RR). By (15), the SP (and eventually the SR) drop out, and the RR win against the RP in the second round; hence it is optimal for the RR to deviate by playing E rather than N. The only possible coalitional deviation is thus not self-enforcing, so the NE with the SP winning is coalition-proof.

Claim 2: *The RR winning at $t+1$ cannot be a CPNE outcome.*

Proof: Assume that there is a NE with the RR winning, and consider the deviating coalition $(SP = E, RP = N)$. The SP win with the support of the RP and are better off, since $(1, 2) < (3, 3)$; see Table B.1. The deviation is also self-enforcing. Indeed, if the RP deviate and stay in, there are at least three candidates in the first round, none with an absolute majority. By (15), the SP (and then the SR) drop out, so that in the second round the RP lose to the RR, ending up with their 3^{rd} rather than 2^{nd} choice; it was therefore not optimal to deviate.

Claim 3: *The RP winning at $t+1$ cannot be a CPNE outcome.*

Proof: Assume there is a NE with the RP winning. The deviation $(SP = N, RR = E)$ brings the RR to power [47] and is profitable, as $(3, 1) < (4, y)$ since $y \geq 2$. This coalition is also self-enforcing. If the SP deviate and stay in, there will be at least three candidates in the first round. By (15), the RR and the RP will go to the second round, where the RR win anyway.

Claim 4: *The SR winning at $t+1$ cannot be a CPNE outcome.*

Proof: We again show that if there is a NE with the SR winning, it cannot be coalition-proof.

Subcase (a). The deviation $(SP = E, RP = N)$ leads the SP to power (supported by the RP) and it is profitable, since $(1, 2) < (2, 4)$. To establish that it is also self-enforcing, note in

[47] When the SR do not enter, all groups but the RP support the RR, who win in round 1. When $SR = E$ and the sum of RR and SP is less than 50%, the RR and the RP go to round 2, and the RR wins.

Table B.1 that, since $y = 4$, the RP are ranked last by every other group and consequently can never win, in either round. Therefore, it is not profitable for them to deviate and enter against the SP; conversely, it is not optimal for the SP to let them enter alone.

Subcase (b). A profitable deviation is $(RP = N, RR = E)$, since it brings the RR to power and $(3, 1) < (4, z)$, as $z \geq 2$. The deviating coalition is also self-enforcing: if the RP deviate from it, the SP (and eventually the SR) drop out in round 1 by (15), and the RR win anyway against the RP in round 2.

Case 2: $\nu < b < \theta_H$. The preference structure, reported in Table B.2, differs from the previous one because the RR and the SR now have the same ideal policy (zero tax rate). This implies that the SP and the RP are both indifferent between RR and SR. Moreover, the SR will always rank the $RR's$ policy 2^{nd}, and vice-versa. It is easily verified that the analysis of Case 1 applies here as well (with now only subcase (a) relevant in Claim 4).

	SP	RP	RR	SR
SP	1	3	2	2
RP	2	1	3	3
RR	x	y	1	2
SR	3	4	2	1

where $(x, y) = (3, 4)$ [subcase (a)], or $(4, 3)$ [subcase (b)].

Table B.2. Fiscal preferences of each group when $\nu < b < \theta_H$.

B - Region $b^*(\nu) < b$. Table B.3 reports the preference structure for this case.

	SP	RP	RR	SR
SP	1	4	3	2
RP	3	1	2	4
RR	x	y	1	z
SR	x'	4	y'	1

where $(x, y, z) = (3, 4, 2)$ [subcase (a)], or $(4, 2, 3)$ or $(4, 3, 2)$ [subcase (b)]; $(x\prime, y\prime) = (2, 3)$ or $(3, 2)$.

Table B.3. Fiscal preferences of each group when $b^*(\nu) < b$.

Claim 1: *The RR winning at* $t + 1$ *is the unique Nash equilibrium outcome.*

Proof: We show that if the RR enter they always win, independently of all other groups' strategies; the result will immediately follow. Let the RR enter (either on or off the equilibrium path), and suppose first that RP stay out. They will then back the RR, whom they rank them second and who thus win in the first round. If the RP do enter, there are two possible subcases:

(a) If neither the SP nor the SR enter, both support the RR (whom they always prefer to the RP), who thus again win immediately.

(b) If either or both of these groups enter, no one has a majority in the first round. The RP and the RR, being the two largest contestants, make it to the second round, and here again the RR win with the support of both the SP and the SR.

Claim 2: *The RR winning at $t+1$ is a (unique) CPNE outcome.*

Proof: Let the RR enter alone: $(SP = N, RP = N, RR = E, SR = N)$. By Claim 1 no group would gain from deviating, since the RR will win anyway. To show that it is coalition-proof, note that the minimal winning coalition is (SP, RP), which obtains $(3, 2)$ when the RR win. As there is no policy vector that Pareto-dominates $(3, 2)$, there is no profitable deviating coalition, hence the result. Uniqueness follows from Claim 1.

C - Locus $b = b^*(\nu)$. The only difference with the previous case is that the RP are now indifferent between SP and RR : the preference structure is still that of Table B.3, except that the second row is now (2 1 2 4). The preceding reasoning remains unchanged since, whenever the RP have a (first- or second-round) choice between RR and SP, it is enough that they split their vote equally to ensure the latter's victory: by Assumption 4, $RR + RP/2 = r(1 + n)/2 > 1/2$. The RR winning is thus again the only NE and CPNE outcome.

D - Region $b < \nu$. The SP and RP have the same preferred policy, so either one entering, backed by the other, wins a majority. Moreover, the RR winning cannot be a CPNE outcome, as that same majority of SP plus RP could deviate (e.g., $(RP = E, SP = N)$) and win. ■

B.5 Proofs for Church's Repair Policy with Income Heterogeneity

We first show that the set of b's where $\pi(b, \nu) \geq y$ is an interval $[b^-(\nu; y), b^+(\nu; y)]$, then study its comparative statics with respect to inequality.

Lemma 6 *(1) The function $\pi(b, \nu)$ equals 0 for $b < b^*(\nu)$, then jumps up to $\pi(b^*(\nu), \nu) = R(\tau_H(b^*(\nu)))$. It is continuous and strictly increasing on $[b^*(\nu), b^*(\nu)/(1-\delta))$, then jumps down to $\pi(b^*(\nu)/(1-\delta), \nu) = R(\tau_H(b^*(\nu)/(1-\delta))) - (1-\delta) R(\tau_H(b^*(\nu)))$. Finally, it is continuous and strictly decreasing on $[b^*(\nu)/(1-\delta), +\infty)$, with $\lim_{b\to+\infty} \pi(b, \nu) = \delta R(\hat{\tau}) > 0$.*

Proof. The proof is the same as for Lemma 2, except that for $b^*(\nu)/(1-\delta) \leq b$,

$$\pi(b, \nu) = R(\tau_H(b)) - (1-\delta) R(\tau_H((1-\delta) b)) \equiv \rho(b; \theta_H), \tag{B.16}$$

$$\frac{\partial \rho(b; \theta_H)}{\partial b} = R'(\tau_H(b)) \tau'_H(b) - (1-\delta)^2 R'(\tau_H((1-\delta) b)) \tau'_H((1-\delta) b) \tag{B.17}$$

$$= \frac{\theta^H}{b^2} \left[\frac{R'(\tau_H(b))}{-R''(\tau_H(b))} - \frac{R'(\tau_H(b'))}{-R''(\tau_H(b'))} \right], \tag{B.18}$$

now replace (B.1) and (B.17) respectively, with $\tau'_H(b) = \theta_H / \left[-b^2 R''(\tau_H(b))\right] > 0$. ■

Given Lemma 6, the conditions ensuring a nonempty repairing region are readily obtained by replacing ν by $b^*(\nu)$ and $\tau^*(\cdot)$ by $\tau_H(\cdot)$ in Assumption 2, as is the case in $\pi(\cdot,\nu)$.

Assumption 8 : $\delta R(\hat{\tau}) < \eta < R(\tau_H(b^*(\nu)/(1-\delta))) - (1-\delta)R(\tau_H(b^*(\nu)))$.

These properties are illustrated by the solid curves in Figure 8b, while the dashed curve displays the next result, namely that increases in inequality shift $\pi(\cdot,\nu)$ to the right. In what follows, we make explicit the dependence of π (via $\tau_H(b)$ and $b^*(\nu)$) on θ_L and θ_H.

Lemma 7 *(1) As θ_L rises, the graph of $\pi(b,\nu;\theta_L,\theta_H)$ shifts (weakly) to the left, so that $b^-(\nu;y)$ and $b^+(\nu;y)$ both (weakly) decrease.*
(2) As θ_H rises, the graph of $\pi(b,\nu;\theta_L,\theta_H)$ shifts (weakly) to the right, so that $b^-(\nu;y)$ and $b^+(\nu;y)$ both (weakly) increase.

Proof. (1) (i) The function $\pi(b,\nu;\theta_L,\theta_H)$ depends on θ_L only trough the cutoffs $b^*(\nu)$ and $b^*(\nu)/(1-\delta)$ at which $\pi(b)$ jumps, respectively from 0 up to $(R\circ\tau_H)(b^*(\nu))$ and from $(R\circ\tau_H)(b^*(\nu)/(1-\delta))$ down to $(R\circ\tau_H)(b^*(\nu)) - (R\circ\tau_H)((1-\delta)b^*(\nu))$; note that these four values *are independent of θ_L*. Consider now an increase in θ_L to $\hat{\theta}_L \in (\theta_L,\theta_H)$; by Lemma 4.(2), the two cutoffs $b^*(\nu)$ and $b^*(\nu)/(1-\delta)$ decrease, to values which we shall denote $\hat{b}^*(\nu)$ and $\hat{b}^*(\nu)/(1-\delta)$, with

$$\hat{b}^*(\nu) < b^*(\nu) < \hat{b}^*(\nu)/(1-\delta) < b^*(\nu)/(1-\delta),$$

provided the change in θ_L is not too large. Moreover, by the property just noted, the new function $\hat{\pi}(b) \equiv \pi(b,\nu;\hat{\theta}_L,\theta_H)$ coincides with the old $\pi(b) \equiv \pi(b,\nu;\theta_L,\theta_H)$ on $[0,\hat{b}^*(\nu))$, on $[b^*(\nu),\hat{b}^*(\nu)/(1-\delta)]$ and on $[b^*(\nu)/(1-\delta),+\infty)$. They differ only on $[\hat{b}^*(\nu),b^*(\nu))$, where $\hat{\pi}(b) = R(\tau_H(b)) > 0 = \pi(b)$ and on $[\hat{b}^*(\nu)/(1-\delta), b^*(\nu)/(1-\delta))$, where $\hat{\pi}(b) = R(\tau_H(b)) - (1-\delta)R(\tau_H((1-\delta)b)) < R(\tau_H(b)) = \pi(b)$.

(ii) Omitting the dependence on y to simplify the notation, let now $b^-(\nu)$ and $b^+(\nu)$ denote the two points where, by Property (1)(i) just shown, the graph of $\pi(b)$ intersects the horizontal $\pi = y$ (we shall denote $b^-(\nu) = b^*(\nu)$ when $\pi(b^*(\nu)) = R(\tau_H(b^*(\nu))) > y$). Let $\hat{b}^-(\nu)$ and $\hat{b}^+(\nu)$ similarly denote those intersections for the graph of $\hat{\pi}$ (with $\hat{b}^-(\nu) = \hat{b}^*(\nu)$ when $\hat{\pi}(\hat{b}^*(\nu)) = R(\tau_H(\hat{b}^*(\nu))) > y$). By construction, $b^-(\nu)$ lies in the range where $\pi(b)$ is increasing (including the upward discontinuity), and by Property (1)(i) the graph of $\hat{\pi}$ is above that of π in that range –strictly when $b \in [\hat{b}^*(\nu), b^*(\nu))$. This implies that $\hat{b}^-(\nu)$ must lie to the left of $b^-(\nu)$. Similarly, $\hat{b}^+(\nu)$ lies in the range where $\hat{\pi}(b)$ is decreasing; by Property (1)(i), in that range the graph of π is either above that of $\hat{\pi}$ (for all $b \in [\hat{b}^*(\nu)/(1-\delta), b^*(\nu)/(1-\delta))$) or equal to it (for all $b \geq b^*(\nu)/(1-\delta)$), so it must be that $\hat{b}^+(\nu)$ lies to the left of $b^+(\nu)$.

(2) (i) To show that an increase in θ_H shifts (weakly) the graph of $\pi(\cdot, \nu; \theta_L, \theta_H)$ to the right, note the following three features of this function.

First, over the range $[b^*(\nu), b^*(\nu)/(1-\delta))$, the function $\pi(b, \nu; \theta_L, \theta_H) = R(\tau_H(b))$ is strictly increasing and continuous in b and is strictly decreasing in θ_H, as

$$\frac{\partial \pi(b, \nu; \theta_L, \theta_H)}{\partial \theta_H} = R'(\tau_H(b)) \frac{\partial \tau_H(b)}{\partial \theta_H} < 0,$$

given that $\partial \tau_H(b) / \partial \theta_H < 0$, by (B.13).

Second, over the range $[b^*(\nu)/(1-\delta), +\infty)$, the function $\pi(b, \nu; \theta_L, \theta_H)$ is given by (B.16), which is decreasing and continuous in b and strictly increasing in θ_H. Indeed,

$$\begin{aligned} \frac{\partial \rho(b; \theta_H)}{\partial \theta_H} &= R'(\tau_H(b)) \frac{\partial \tau_H(b)}{\partial \theta_H} - (1-\delta) R'(\tau_H((1-\delta)b)) \frac{\partial \tau_H(b)}{\partial \theta_H} \\ &= \frac{1}{b}\left[\frac{R'(\tau_H(b'))}{-R''(\tau_H(b'))} - \frac{R'(\tau_H(b))}{-R''(\tau_H(b))}\right], \end{aligned}$$

where we have used (B.13) and $b' \equiv (1-\delta)b$. This expression is positive, since $\tau_H(b)$ is increasing in b and Assumption 1 ensures that $-R'(\tau)/R''(\tau)$ is decreasing in τ.

Third, by Lemma 4.(2), the two cutoffs $b^*(\nu)$ and $b^*(\nu)/(1-\delta)$ are increasing in θ_H. Therefore, if we consider an increase in θ_H to $\hat{\theta}_H$, the two cutoffs $b^*(\nu)$ and $b^*(\nu)/(1-\delta)$ increase to values which we shall denote $\hat{b}^*(\nu)$ and $\hat{b}^*(\nu)/(1-\delta)$, with

$$b^*(\nu) < \hat{b}^*(\nu) < \frac{b^*(\nu)}{1-\delta} < \frac{\hat{b}^*(\nu)}{1-\delta},$$

provided the change in θ_H is not too large. The above three properties of $\pi(b, \nu; \theta_L, \theta_H)$ imply that an increase in θ_H shifts the graph of this function (weakly) to the right.

Summarizing, the new function $\hat{\pi}(b) \equiv \pi(b, \nu; \theta_L, \hat{\theta}_H)$ has the following shape. Over the range $[0, b^*(\nu))$, it equals zero and coincides with the old $\pi(b) \equiv \pi(b, \nu; \theta_L, \theta_H)$. Over the range $[b^*(\nu), \hat{b}^*(\nu))$, $\pi(b) = R(\tau_H(b)) > 0 = \hat{\pi}(b)$; and over $[\hat{b}^*(\nu), b^*(\nu)/(1-\delta))$, $\pi(b) = R(\tau_H(b)) > R(\hat{\tau}_H(b)) = \hat{\pi}(b)$, where $\hat{\tau}_H(b)$ denotes the optimal tax rate of the religious rich when their income is $\hat{\theta}_H$. The function $\hat{\pi}(b) = R(\hat{\tau}_H(b))$ is continuous and increasing over the range $[b^*(\nu)/(1-\delta), \hat{b}^*(\nu)/(1-\delta))$, while the function $\pi(b) = R(\tau_H(b)) - (1-\delta) R(\tau_H((1-\delta)b))$ is decreasing over this range and has a downward jump at $b^*(\nu)/(1-\delta)$. The function $\hat{\pi}(b) = R(\hat{\tau}_H(b)) - (1-\delta) R(\hat{\tau}_H((1-\delta)b))$ has a downward discontinuity at $\hat{b}^*(\nu)/(1-\delta)$, and it is decreasing over the range $[\hat{b}^*(\nu)/(1-\delta), +\infty)$ with $\hat{\pi}(b) = R(\hat{\tau}_H(b)) - (1-\delta) R(\hat{\tau}_H((1-\delta)b)) > R(\tau_H(b)) - (1-\delta) R(\tau_H((1-\delta)b)) = \pi(b)$.

(ii) By construction, $b^-(\nu)$ lies in the range where $\pi(b)$ is increasing (including the upward discontinuity), i.e. $b^-(\nu) \in [b^*(\nu), b^*(\nu)/(1-\delta))$, and by Property (2)(i) above the graph of $\hat{\pi}$ is below that of π in that range (strictly where $\hat{b}^* > 0$). This implies that $\hat{b}^-(\nu)$ must lie to the right of $b^{-}(\nu)$. Similarly, $b^{+}(\nu)$ lies in the range where $\pi(b)$ is decreasing, i.e. $b^{+}(\nu) \in [b^{*}(\nu)/(1-\delta), +\infty)$. By Property (i) above, on that range the graph of $\hat{\pi}$ is either increasing or decreasing and above that π. It can thus never be that $\hat{b}^{+}(\nu)$ lies in the range where $\hat{\pi}$ is increasing but, eventually, $\hat{b}^{-}(\nu)$ can be in this range. This means that $\hat{b}^{+}(\nu)$ belongs to the range where $\hat{\pi}$ is decreasing and above π, i.e. $\hat{b}^{+}(\nu) \in [\hat{b}^{*}(\nu)/(1-\delta), +\infty)$, which in turn implies that $\hat{b}^{+}(\nu)$ lies to the right of $b^{+}(\nu)$.

B.6 Proof of Proposition 7

We first compute below the date-t intertemporal utilities for each type of agent under blocking and no blocking, which define the payoffs of the science-policy game. We then show in Lemma 8 that: (i) the RR are *always pivotal* at date t : they want to block (weakly) less than the RP, while neither the SP nor the SR ever want to; (ii) for $q \geq 1/(1+\gamma)$, even the RP prefer not to block in the repairing region, $b \in \left[\underline{b}, \overline{b}\right]$. Consequently, the blocking-policy game has a unique CPNE outcome, which together with its unique continuation constitutes the unique PCPNE of generation t's entire two-period, three-stage game.

If all BR innovations are blocked, the RR will be in power at $t+1$, so the expected utility of any agent with income $\theta \in [\theta_L, \theta_H]$ and religiousness $\beta \in \{0,1\}$ is

$$V^{B}_{\theta,\beta} \equiv [1 - R^{-1}(\varphi(a))]\theta + [1-\lambda+\lambda(1-p_R)(1+\gamma)]\left[(1-\tau_H(b))\,\theta + \beta b R\left(\tau_H(b)\right)\right], \quad \text{(B.19)}$$

where the second term represents expected utility in old age.

Suppose now that BR innovations are not blocked, but that their damage to beliefs gets repaired with probability $\tilde{q} \in [0,1]$. While the equilibrium continuation strategy of the Church implies $\tilde{q} = \mathbf{1}_{\{b \in [\underline{b}, \bar{b}]\}} \cdot q$, for now we treat $\tilde{q}$ as a parameter. There are two cases to consider.

- **Case $\mathbf{b} \geq \mathbf{b}^{*}(\boldsymbol{\nu})/(\mathbf{1}-\boldsymbol{\delta})$.** The RR will be in power at $t+1$ even if repair fails, so the expected utility of agents in group (θ,β) is now

$$\begin{aligned} V^{NB}_{\theta,\beta} &\equiv \theta + [1-\lambda+\lambda\left(1-p_R(1-\tilde{q})\right)(1+\gamma)]\left[(1-\tau_H(b))\,\theta + \beta b R\left(\tau_H(b)\right)\right] \\ &+\lambda p_R\left(1-\tilde{q}\right)(1+\gamma)\left[\left(1-\tau_H\left(b'\right)\right)\theta + \beta b' R\left(\tau_H\left(b'\right)\right)\right], \end{aligned} \quad \text{(B.20)}$$

where $b' \equiv (1-\delta)b$. The group of (θ,β)-types therefore wants to block if and only if

$$\begin{aligned} R^{-1}(\varphi(a))\theta \quad &\leq \quad \lambda p_R\{[1-\tilde{q}\,(1+\gamma)]\left[(1-\tau_H(b))\,\theta + \beta b R\left(\tau_H(b)\right)\right] \\ &\quad - (1-\tilde{q})\,(1+\gamma)\left[(1-\tau_H(b'))\,\theta + \beta b' R\left(\tau_H(b')\right)\right]\} \equiv \Delta_I(b;\theta,\beta,\tilde{q}). \end{aligned} \quad \text{(B.21)}$$

- **Case $\mathbf{b} \in [\mathbf{b}^{*}(\boldsymbol{\nu}), \mathbf{b}^{*}(\boldsymbol{\nu})/(\mathbf{1}-\boldsymbol{\delta}))$.** When repair fails, it is now the SP who come to power at $t+1$, implementing $(T,G) = (R(\tau_L(\nu)), 0)$. The expected utility of any group (θ,β) is thus obtained by simply replacing $\beta b'$ by ν and $\tau_H(b')$ by $\tau_L(\nu)$ in (B.21). Its utility under blocking is unchanged from (B.19), so the blocking condition is given by similar substitutions in (B.21):

$$\begin{aligned} R^{-1}(\varphi(a)\theta) \quad \leq \quad & \lambda p_R \left[1-\tilde{q}\left(1+\gamma\right)\right]\left(1-\tau_H\left(b\right)\right)\theta + \beta b R\left(\tau_H\left(b\right)\right) \\ & -\left(1-\tilde{q}\right)\left(1+\gamma\right)\left[\left(1-\tau_L\left(\nu\right)\right)\theta + \nu R\left(\tau_L\left(\nu\right)\right)\right] \equiv \Delta_{II}(b,\nu;\theta,\beta,\tilde{q}). \end{aligned} \tag{B.22}$$

Lemma 8 *Let $b \geq b^*(\nu)$. Then:*

1. *For all $b \geq b^*(\nu)/(1-\delta)$ where $\Delta_I(b;\theta,1,\tilde{q}) \geq 0$, the function $\Delta_I(b;\theta,1,\tilde{q})/\theta$ is strictly decreasing in θ. Similarly, for all $b < b^*(\nu)/(1-\delta)$ where $\Delta_{II}(b;\theta,1,\tilde{q}) \geq 0$, $\Delta_{II}(b,\nu;\theta,1,\tilde{q})/\theta$ is strictly decreasing in θ. Therefore, whenever the RR want to block, so do the RP.*

2. *For all $b \geq b^*(\nu)/(1-\delta)$, $\Delta_I(b;\theta;0,\tilde{q}) < 0$, while for all $b < b^*(\nu)/(1-\delta)$, Assumption 5 implies that $\Delta_{II}(b,\nu;\theta_H;0,\tilde{q}) < 0$. In both cases, no secular agent wants to block.*

3. *For all $q \geq 1/(1+\gamma)$, $\Delta_I(b;\theta,\beta,q) < 0$ and $\Delta_{II}(b,\nu;\theta,\beta,q) < 0$. Therefore, under Assumption 7, no group finds it optimal to block in the repairing region, $b \in [\underline{b},\bar{b}]$.*

Proof. The last claim is immediate. For the other two, note that $\Delta_I(b;\theta;1,\tilde{q})/\lambda p_R$ is affine in θ, of the form $\beta b A_I + B_I\theta$, where

$$\begin{aligned} A_I \quad &\equiv \quad [1-\tilde{q}\left(1+\gamma\right)]R\left(\tau_H\left(b\right)\right) - \left(1-\tilde{q}\right)\left(1+\gamma\right)\left(1-\delta\right)R\left(\tau_H\left(b'\right)\right), \\ B_I \quad &\equiv \quad \left[1-\tilde{q}\left(1+\gamma\right)\right]\left[1-\tau_H\left(b\right)\right] - \left(1-\tilde{q}\right)\left(1+\gamma\right)\left[1-\tau_H(b')\right] < 0, \end{aligned}$$

since τ_H is weakly increasing and $\gamma > 0$. By (B.21), a minimal condition for (θ,β) types to want to block is $\Delta_I \geq 0$, which implies that $\beta b A_I \geq -B_I\theta > 0$. For $\beta = 0$ (the secular) this cannot be, while for $\beta = 1$ (the religious) this implies that $\Delta_I/\theta = bA_I/\theta + B_I$ is decreasing in θ. Similarly, $\Delta_{II}/\lambda p_R$ is of the form $A_{II}(\beta) + B_{II}\theta$, where

$$\begin{aligned} A_{II}(\beta) \quad &\equiv \quad \beta\cdot\left[1-\tilde{q}\left(1+\gamma\right)\right]bR\left(\tau_H\left(b\right)\right) - \left(1-\tilde{q}\right)\left(1+\gamma\right)\nu R\left(\tau_L\left(\nu\right)\right), \\ B_{II} \quad &\equiv \quad \left[1-\tilde{q}\left(1+\gamma\right)\right]\left[1-\tau_H\left(b\right)\right] - \left(1-\tilde{q}\right)\left(1+\gamma\right)\left[1-\tau_L\left(\nu\right)\right] < 0. \end{aligned}$$

Moreover, $A_{II}(0) < \left[1-\tilde{q}\left(1+\gamma\right)\right]\left[1-\tau_H\left(b\right)\right] - \left(1-\tilde{q}\right)\left(1+\gamma\right)\left(1-\tau_L\left(\nu\right)\right)]$ by (B.22) and $b \geq b^*(\nu)$; the rest of the proof proceeds as in the other case. ‖

Using Lemma 8, we now show that the *RR are always pivotal* at date t.

(a) Consider first the case where they want to block. Then so do the *RP*, whereas the *SP* and *SR* never want to. At least one (or both) of *RR* or *RP* then finds optimal to enter: indeed, if only one of them does it is supported by the other and thus wins in the first round; if both do and it leads to anything else than their common preferred outcome, i.e., blocking, it is optimal for one of them to deviate and back the other. Thus, in any Nash equilibrium, blocking must occur. Furthermore, the profiles $(SP = N, RP = N, RR = E, SR = N)$ $(SP = N, RP = E, RR = N, SR = N)$ are both $CPNE$'s (with the same outcome): for a deviation to be profitable it would need to result in a different outcome, and this can occur only if the RR or RP, or both, deviate(s); they could only lose, however, and so never will.

(b) Suppose now that the RR do not want to block. The RP is the only group that might want to. They will never win, however, as it would be optimal for at least one the other three groups to enter, beating the RP with the support of the other two. Thus, in any Nash equilibrium, blocking cannot occur. Finally, it is easy to verify that $(SP = N, RP = E, RR = N, SR = N)$ is again a CPNE.

This concludes the proof of the first claim in Proposition 7. We now turn to the second one, concerning the monotonicity of the equilibrium blocking locus, i.e. that of the RR. Since their type is $(\theta, \beta) = (\theta_H, 1)$, this boundary (for any given $\tilde{q}$) is given by $R^{-1}(\varphi(a))\,\theta_H = \Delta_{RR}(b)$, where we define

$$\Delta_{RR}(b) \equiv \begin{cases} \Delta_I(b; \theta_H, 1, \tilde{q}) & \text{for} \quad b \geq b^*(\nu)/(1-\delta), \\ \Delta_{II}(b; \theta_H, 1, \tilde{q}) & \text{for} \quad b \in [b^*(\nu), b^*(\nu)/(1-\delta). \end{cases} \tag{B.23}$$

Let us now show that $\partial \Delta_{RR}(b)/\partial b > 0$, implying that $B(a) \equiv (R \circ \Delta_{RR})^{-1}(\varphi(a))\,\theta_H$ is well-defined and increasing in a. Setting $\beta = 1$ and $\theta = \theta_H$ in (B.21) and (B.22), and recalling that Δ_{RR} is a difference of value functions optimized over τ_R, the envelope theorem implies

$$\begin{aligned} \frac{1}{\lambda p_R} \cdot \frac{\partial \Delta_I}{\partial b}(b; \theta_H, 1, \tilde{q}) &= [1 - \tilde{q}(1+\gamma)]\, R(\tau_H(b))] - (1-\tilde{q})(1+\gamma)(1-\delta) R\left(\tau_H\left(b'\right)\right) = A_I, \\ \frac{1}{\lambda p_R} \cdot \frac{\partial \Delta_{II}}{\partial b}(b, \nu; \theta_H, 1, \tilde{q}) &= [1 - \tilde{q}(1+\gamma)]\, R(\tau_H(b)) > 0, \end{aligned}$$

with $A_I > 0$ whenever $\Delta_I \geq 0$, as shown earlier. This is true in particular for $\tilde{q} = 0$ (no-repairing regions), proving the desired results. ∎

B.7 Proof of Proposition 8

• **Case $\mathbf{b} > \bar{\mathbf{b}}$**. *No repairing and no power reallocation.* Since $\bar{b} > b^*(\nu)/(1-\delta)$, the relevant case in (B.23) is the first one, so the blocking condition is $\Delta_{RR}(b) - R^{-1}(\varphi(a))\,\theta_H \geq 0$ with $\Delta_{RR}(b) = \Delta_I(b; \theta_H, 1, 0)$. Using again the envelope theorem then yields

$$\frac{\partial \Delta_{RR}(b)}{\partial \theta_H} - R^{-1}(\varphi(a)) = \lambda p_R \left[1 - \tau_H(b) - (1+\gamma)\left(1 - \tau_H\left(b'\right)\right)\right] - R^{-1}(\varphi(a)) < 0, \tag{B.24}$$

since $\tau_H(b') < \tau_H(b)$.

• **Case $\mathbf{b}^*(\nu) \leq \mathbf{b} < \underline{\mathbf{b}}$**. *No repairing, leading to a power reallocation.* Since $\underline{b} < b^*(\nu)/(1-$

δ), the relevant case in (B.23) is the second one, so in the blocking condition $\Delta_{RR}(b) - R^{-1}(\varphi(a))\,\theta_H \geq 0$ we now have $\Delta_{RR}(b) = \Delta_{II}(b; \theta_H, 1, 0)$. Differentiating with respect to θ_H and using the first-order condition $\nu R'(\tau_L(\nu)) = \theta_L$ then yields

$$\begin{aligned}
&\frac{\partial \Delta^2_{RR}(b)}{\partial \theta_H} - R^{-1}(\varphi(a)) \\
=\ &\lambda p_R \left\{ 1 - \tau_H(b) - (1+\gamma)\left[1 - \tau_L(\nu)\right] + (1+\gamma)(\theta_H - \theta_L)\frac{\partial \tau_L(\nu)}{\partial \theta_H} \right\} - R^{-1}(\varphi(a)).
\end{aligned}$$

Greater inequality thus leads to more blocking if

$$1 - \tau_H(b) - (1+\gamma)(1 - \tau_L(\nu)) + (1+\gamma)(\theta_H - \theta_L)\frac{\partial \tau_L(\nu)}{\partial \theta_H} > \frac{R^{-1}(\varphi(a))}{\lambda p_R}. \tag{B.25}$$

Since $\max\{\tau_H(b), \tau_L(\nu)\} < 1$, a sufficient condition for (B.25) to hold is

$$(\theta_H - \theta_L)\frac{\partial \tau_L(\nu)}{\partial \theta_H} > 1 + \frac{R^{-1}(\varphi(a))}{\lambda p_R(1+\gamma)}. \tag{B.26}$$

Differentiating implicitly the first order condition $\nu R'(\tau_L(\nu)) = \theta_L$ with respect to θ_L, and taking into account that $\partial\theta_L/\partial\theta_H = -n/(1-n)$, we have

$$\frac{\partial \tau_L(\nu)}{\partial \theta_H} = \left(\frac{n}{1-n}\right)\frac{1}{\nu\left[-R''(\tau_L(\nu))\right]} > 0. \tag{B.27}$$

Substituting (B.27) into (B.26), the latter can be rewritten as

$$\theta_H > 1 + \frac{(1-n)^2}{n}\nu\left[-R''(\tau_L(\nu))\right]\left(1 + \frac{R^{-1}(\varphi(a))}{\lambda p_R(1+\gamma)}\right). \tag{B.28}$$

Since $R(\tau_L(\nu))$ is $\mathcal{C}^3$ and $R''(\tau_L(\nu))$ is nonincreasing (by Assumption 1, $R''' \leq 0$), $-R''(\tau_L(\nu))$ is positive, nondecreasing and bounded above by $-R''(\hat{\tau})$, while $\varphi(a)$ has an upper bound at $\bar{\varphi}$. Therefore, condition (B.28) holds under Assumption 6. In this region, greater income inequality thus leads, ceteris paribus, to more blocking. ■

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TABLE 1

Knowledge Blocking, Doctrinal Repair, and Consequences

Context	Blocking	Repairing	Consequences	References
Establishment (380 A.D.) and consolidation of Christianity as official religion of Roman Empire	Hellenistic traditions of free inquiry and debate in science and philosophy increasingly repressed. Knowledge made subservient to dogma	Late Middle Ages, Renaissance	"Long Sleep of Reason" in the Western World: intellectual and scientific stagnation	Freeman (2005)
Europe, 12th Century	Aristotle's "lost works": (Physics, On the Soul, On Generation and Corruption, Metaphysics, Meteorology, On the Heavens): banned, penalty of excommunication	13-14th Century, "Aquinian Synthesis" of faith and reason. Becomes new Church dogma		Deming (2010)
Europe, 15th Century	Copernican revolution, heliocentrism, atomism, infinitesimals…: banned as heretical. Inquisition trials of scientists (Galileo, Bruno), self-censorship by others (Descartes)	Enlightenment (18th century). Church allows heliocentrism to be taught in 1822, concedes it in 1992	Decline of innovation in Catholic lands. Shift of Scientific Revolution to Northern Europe , Protestant countries	Trevor-Roper (1967), Gusdorf (1969), Landes (1998), Young (2009), Mokyr (2016)
Europe, 17th -19th Century	Newtonism, Scientific Revolution, "mechanical" laws of nature, technical education in primary schools, vaccines: opposed by Catholic Church	Newtonism accepted relatively quickly by Church of England	Long-lasting delays in technology adoption, especially for Industrial Revolution (France, Italy, Spain)	Jacob and Stewart (2004) Vidal-Robert (2011), Squicciarini (2020)
Consolidation of Islam following its conquests, starting in 11th Century, "Sunni Revival"	Greek "rational sciences" no longer taught, become extinct. Growing intolerance to "foreign" sciences, ideas		Earlier Islamic "Golden Age" gives place to centuries of stagnation. Falling behind the West	Lewis (2003), Deming (2010), Chaney (2011), McClellan & Dorn (2006), Rubin (2017)
Muslim World, 16th-21st Centuries	Printing: banned soon after Gutenberg's invention, upon penalty of death (1515). Constantinople observatory destroyed soon after completion (1580)	Significant printing starts only in early 19th century (part of defensive modernization)	Extremely low rates of book publication, translation, scientific productivity, innovation	Arab Human Dev. Report (2002), Hoodboy (2007), Diner (2009), Muslim World Science Initiative (2015)
Worldwide, modern era Contemporary US is notable	Darwinism, Human Evolution: teaching forbidden in many US states until 1960's, creationism taught today in 15-20% of US schools. Non-belief in most Muslim countries	Allowed as "possible" by Catholic Church in 1950. Tennessee's 1925 Butler Act repealed in 1967	Scientific illiteracy. Restrictions on research on stem cell research. Public funds for Creation Museum, "creation science" teaching	NSF Survey (2001), GSS (2006), Sherkat (2011)
Countries with avowedly conservative religious leaders (US, Brazil, Turkey, Russia)	Scientific denialism: climate change, epidemiological risks, antivax. Promotion of alternative pseudo-sciences	Unresolved	Major cuts in Earth and Life Sciences. Policy dismissal of expertise: climate, sea levels, Covid-19	Mooney (2005), Science News (2017), Columbia University "Silencing Science Tracker"

TABLE 2: Religiosity and Innovation: Cross−Country Estimates

Dep. var.: *Residents' patents per capita (log)*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Religiosity	–4.668***			–2.377***			–2.280***			–1.871***		
	(1.103)			(0.573)			(0.597)			(0.656)		
Belief in God		–5.309***			–2.493***			–2.319***			–1.826***	
		(1.307)			(0.728)			(0.742)			(0.679)	
Church attendance			–5.468***			–2.305***			–1.917***			–1.129
			(0.962)			(0.717)			(0.684)			(0.798)
Religious freedom				0.005	0.015*	0.015	–0.005	0.005	0.004	–0.003	0.008	–0.001
				(0.009)	(0.009)	(0.010)	(0.009)	(0.009)	(0.009)	(0.012)	(0.011)	(0.013)
GDP per capita (log)				1.082***	1.143***	1.056***	0.754***	0.853***	0.771***	0.875***	0.986***	0.867***
				(0.171)	(0.177)	(0.160)	(0.182)	(0.184)	(0.154)	(0.187)	(0.180)	(0.180)
Population (log)				0.128	0.107	0.188**	0.068	0.052	0.129	0.103	0.081	0.121
				(0.077)	(0.077)	(0.086)	(0.076)	(0.075)	(0.083)	(0.081)	(0.069)	(0.083)
Protection intellectual property				0.105	0.034	0.044	0.608***	0.474***	0.535***	0.536***	0.406***	0.541***
				(0.120)	(0.124)	(0.123)	(0.173)	(0.159)	(0.151)	(0.177)	(0.150)	(0.161)
Tertiary education (years)				0.930**	0.813*	0.806*	1.309***	1.171***	1.187***	0.850*	0.581	0.844*
				(0.457)	(0.436)	(0.427)	(0.435)	(0.409)	(0.447)	(0.455)	(0.382)	(0.491)
Foreign direct investment				–0.019*	–0.020*	–0.014	–0.010	–0.011	–0.005	0.009	–0.011	–0.006
				(0.010)	(0.012)	(0.012)	(0.009)	(0.010)	(0.011)	(0.010)	(0.012)	(0.011)
Protestant (pred.)										–0.068	–0.089	–0.275
										(0.286)	(0.322)	(0.314)
Catholic (pred.)										–0.451	–0.515*	–0.689**
										(0.282)	(0.271)	(0.295)
Muslim (pred.)										–0.414	–0.495	–0.642
										(0.536)	(0.542)	(0.588)
Orthodox (pred.)										0.589	0.730	0.179
										(0.546)	(0.545)	(0.545)
Year fixed effects							YES	YES	YES	YES	YES	YES
Constant	–6.916***	–5.611***	–8.599***	–21.956***	–22.191***	–24.198***	–17.769***	–18.479***	–20.335***	–19.391***	–20.291***	–21.591***
	(0.786)	(1.095)	(0.273)	(2.231)	(2.410)	(2.253)	(2.414)	(2.496)	(2.235)	(2.734)	(2.678)	(2.585)
Observations	278	220	281	221	172	224	221	172	224	220	171	222
Adjusted R−squared	0.198	0.234	0.324	0.698	0.720	0.690	0.743	0.757	0.728	0.756	0.777	0.739

Notes: OLS estimates. Standard errors (in parentheses) are clustered by country. *Significant at 10%; **significant at 5%; ***significant at 1%.

TABLE 3: Religiosity and Innovation in the US: Cross-State Estimates

Dep. var.: *Patents per capita (log)*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Importance of religion	-3.226^{***}			-3.015^{***}			-3.913^{***}		
	(1.057)			(0.787)			(0.625)		
Belief in God		-12.977^{***}			-8.688^{**}			-10.290^{***}	
		(3.287)			(3.536)			(3.385)	
Church attendance			-2.737^{**}			-2.373^{**}			-3.181^{***}
			(1.289)			(1.111)			(1.067)
GSP per capita (log)				-1.125^{*}	-1.061	-1.222^{*}	-0.477	-0.569	-0.709
				(0.588)	(0.663)	(0.617)	(0.489)	(0.673)	(0.618)
Population (log)				0.260^{***}	0.199^{**}	0.237^{***}	0.218^{***}	0.154	0.200^{**}
				(0.078)	(0.090)	(0.085)	(0.079)	(0.094)	(0.089)
Tertiary education				0.074^{***}	0.078^{**}	0.086^{***}	0.035^{*}	0.050	0.054^{**}
				(0.025)	(0.032)	(0.026)	(0.021)	(0.032)	(0.024)
Foreign direct investment							-3.017^{***}	-2.232^{***}	-2.545^{***}
							(0.574)	(0.733)	(0.619)
Constant	-6.681^{***}	3.718	-7.422^{***}	-0.551	6.065	-0.227	-5.075	3.886	-3.803
	(0.647)	(3.128)	(0.550)	(5.907)	(7.258)	(6.420)	(5.267)	(7.887)	(6.559)
Observations	51	51	51	51	51	51	51	51	51
Adjusted R-squared	0.198	0.206	0.101	0.463	0.396	0.386	0.567	0.451	0.456

Notes: OLS estimates. Robust standard errors in parentheses. *Significant at 10%; **significant at 5%; ***significant at 1%.

(a) Without controls

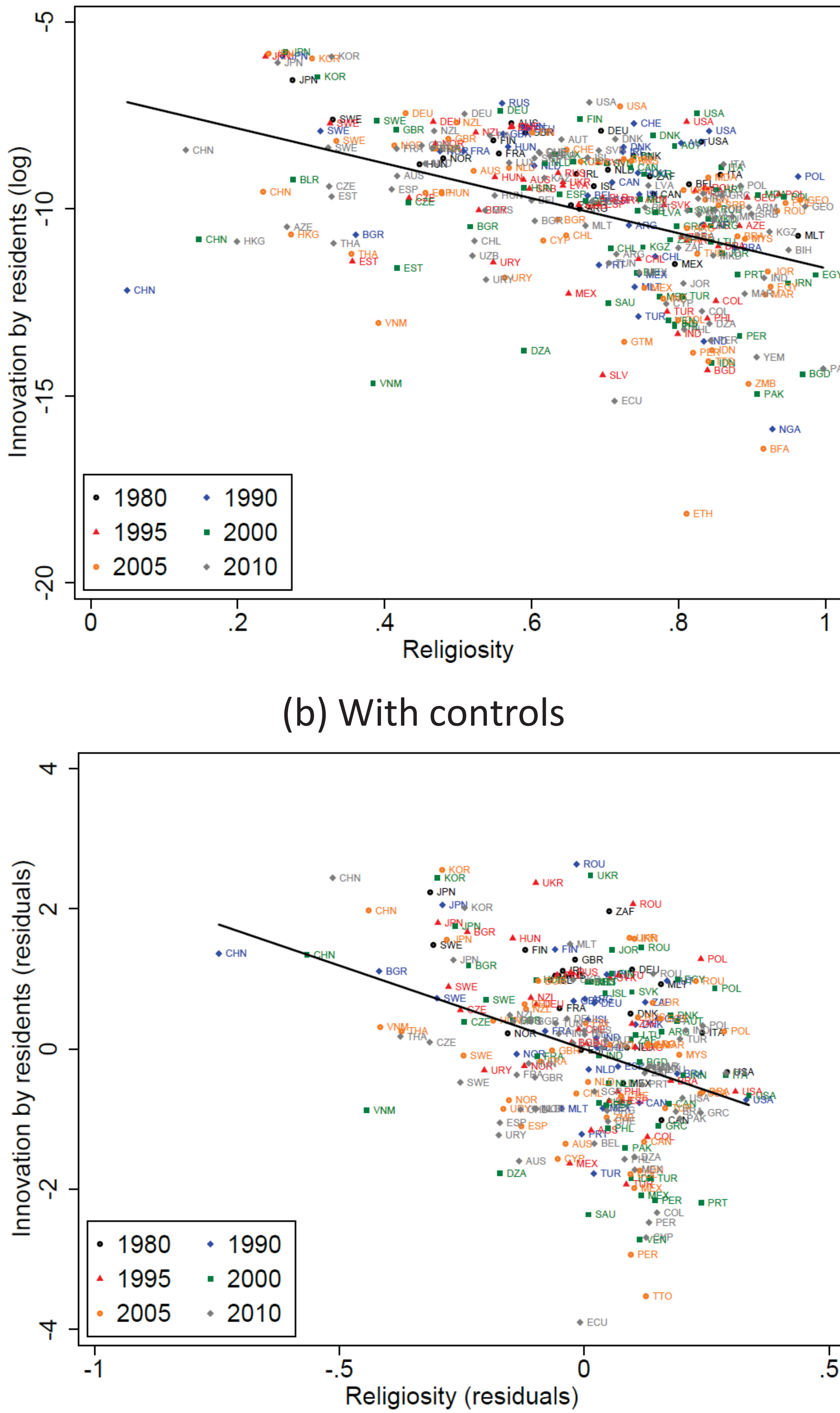
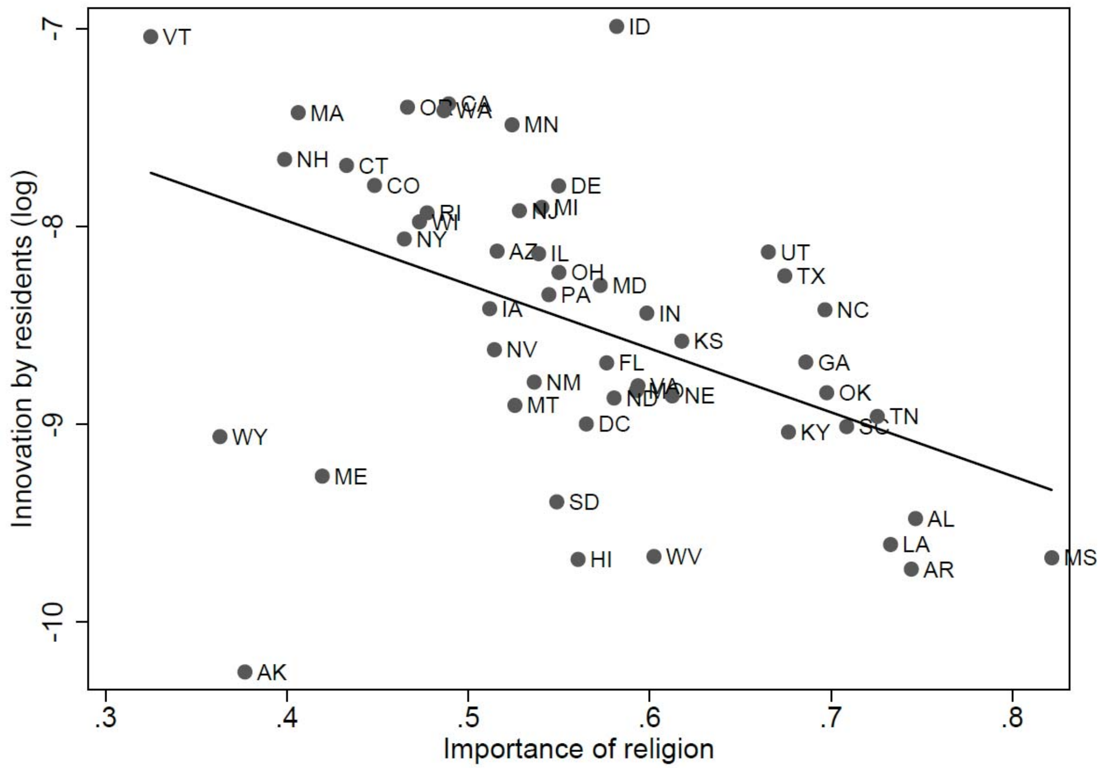


FIGURE 1

Religiosity and innovation across countries

(a) Without controls



(b) With controls

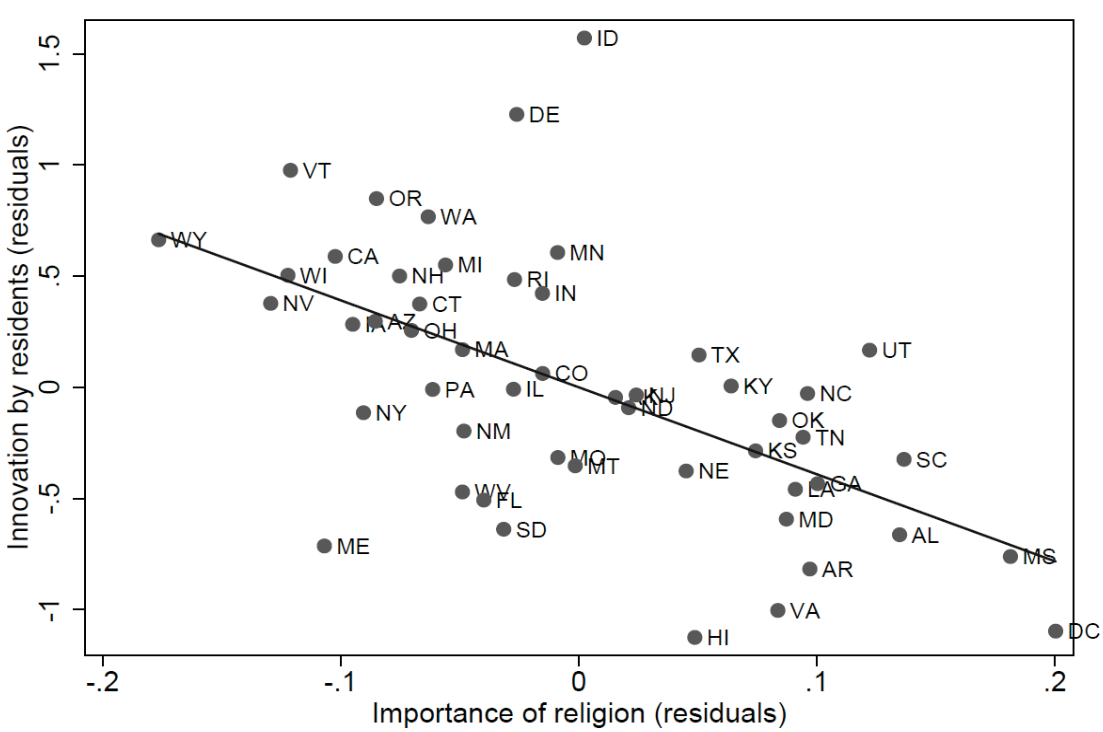


FIGURE 2

Religiosity and innovation across US states

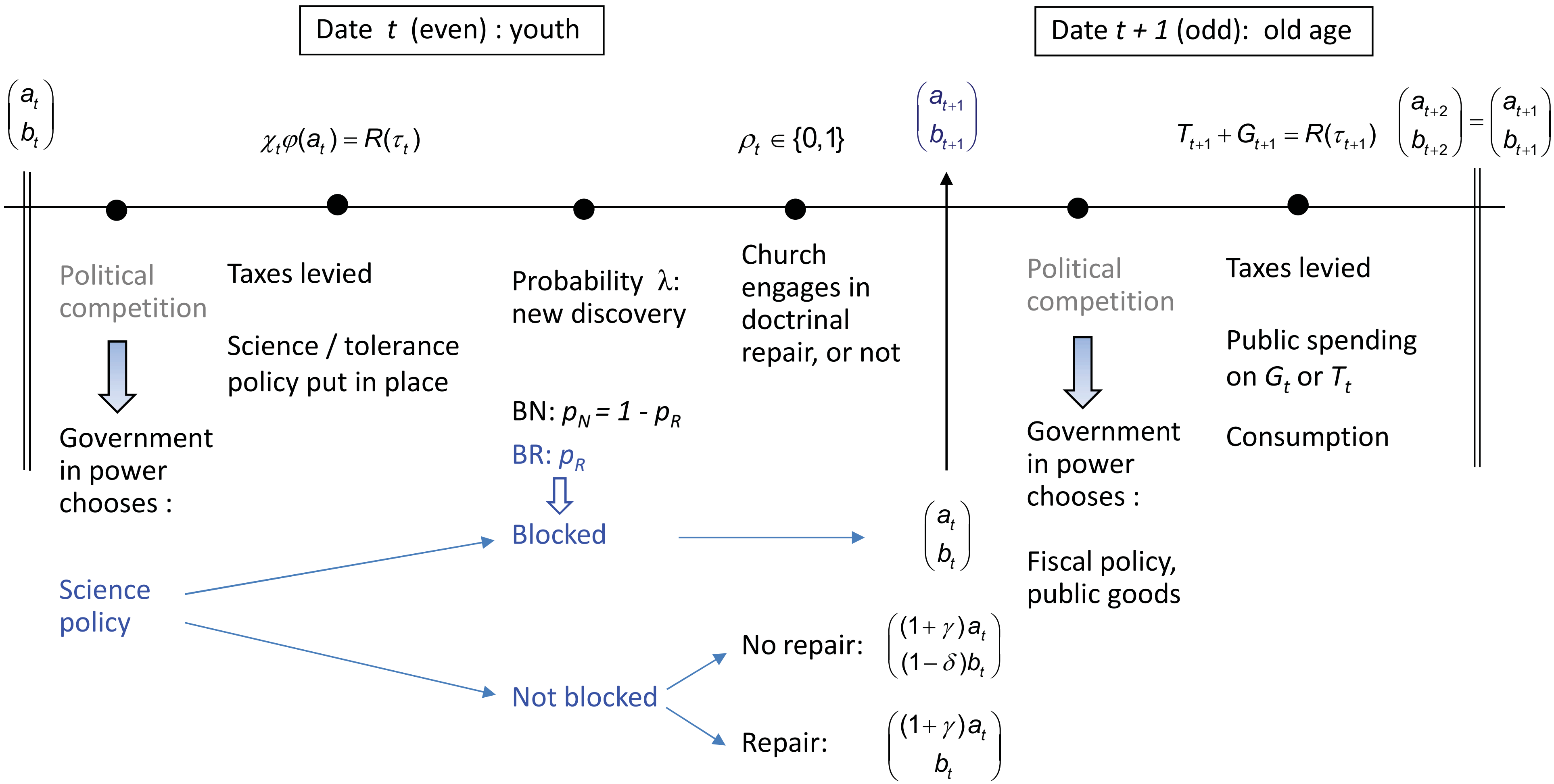


FIGURE 3

Timing of actions and events

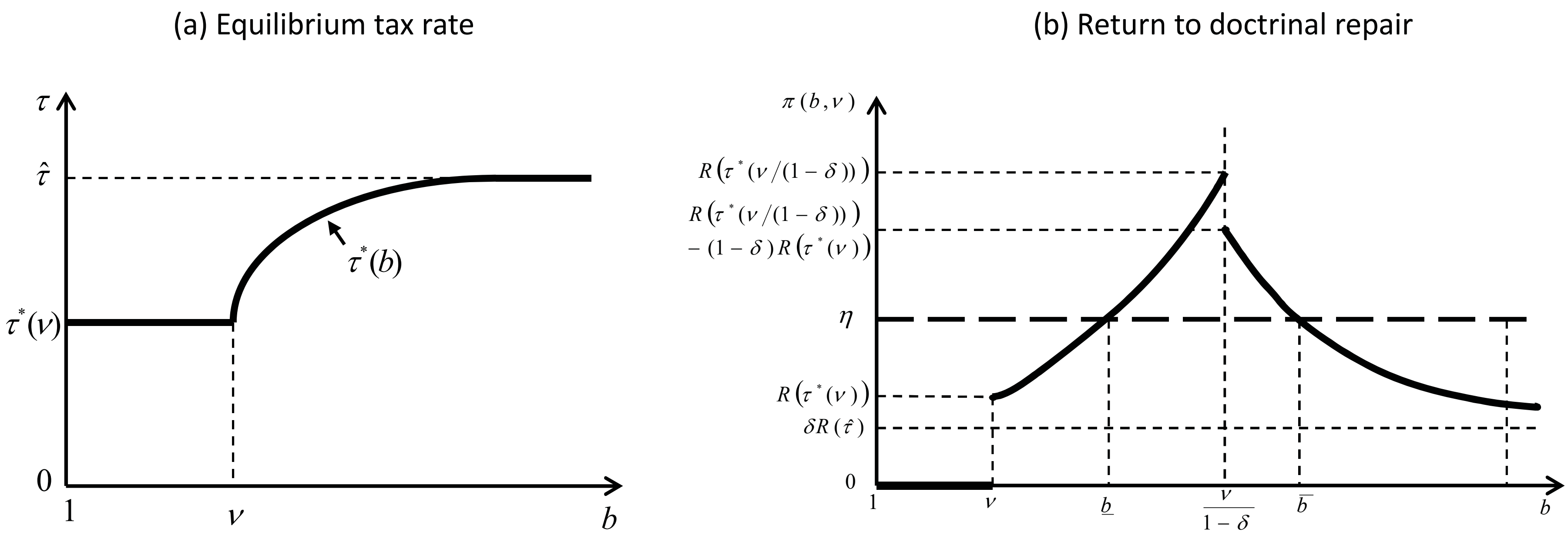


FIGURE 4

Effects of religiosity on taxation and doctrinal repair

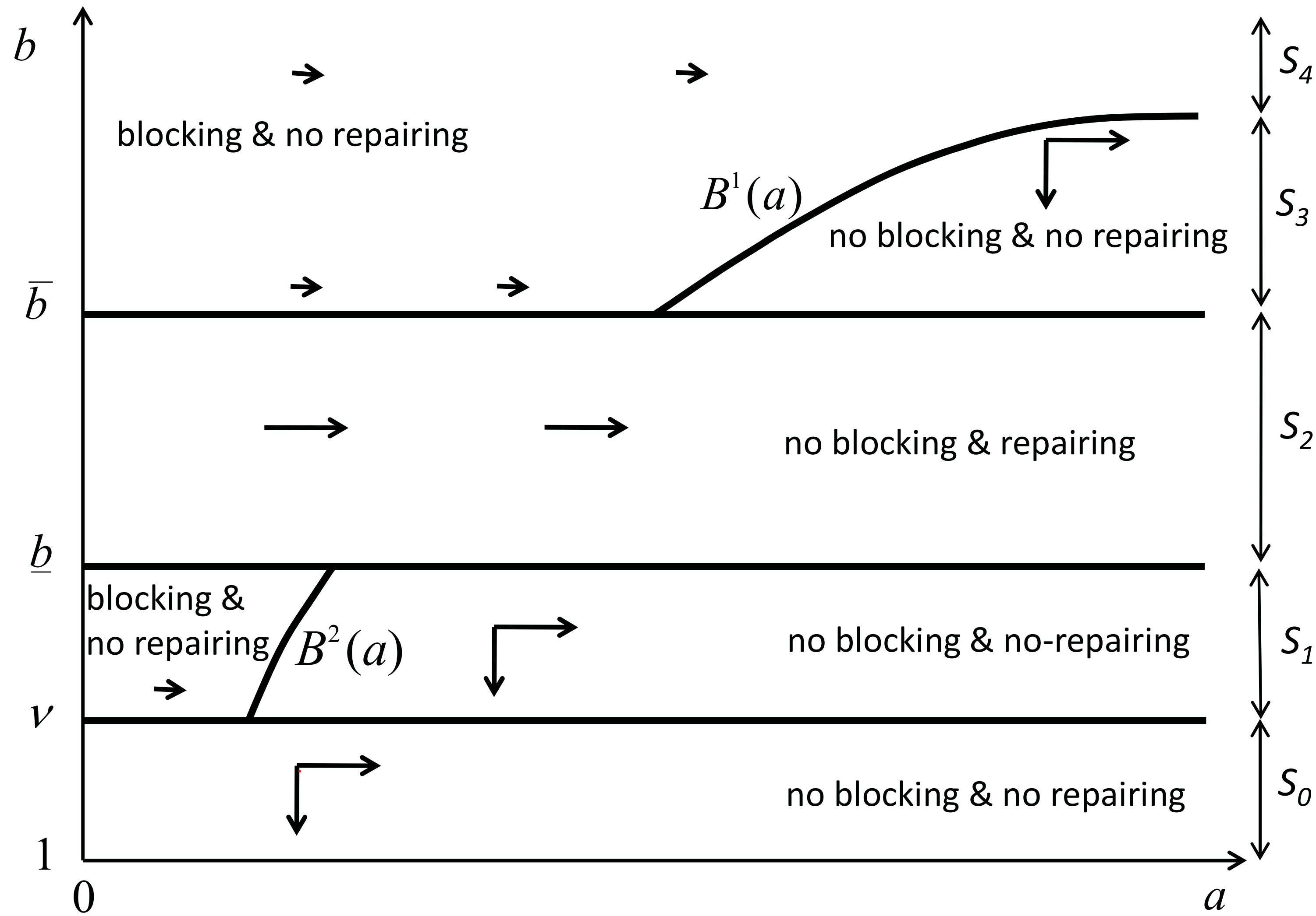


FIGURE 5

Dynamics with absorbing states.

Notes: The length of the horizontal arrows denotes the economy's average rate of innovation and growth. The five key ranges are: S_0 = Strongly Secular, S_1 = Mildly Secular, S_2 = Adaptive-US, S_3 = Mildly Theocratic, and S_4 = Strongly Theocratic; among these, the even-numbered ones are absorbing.

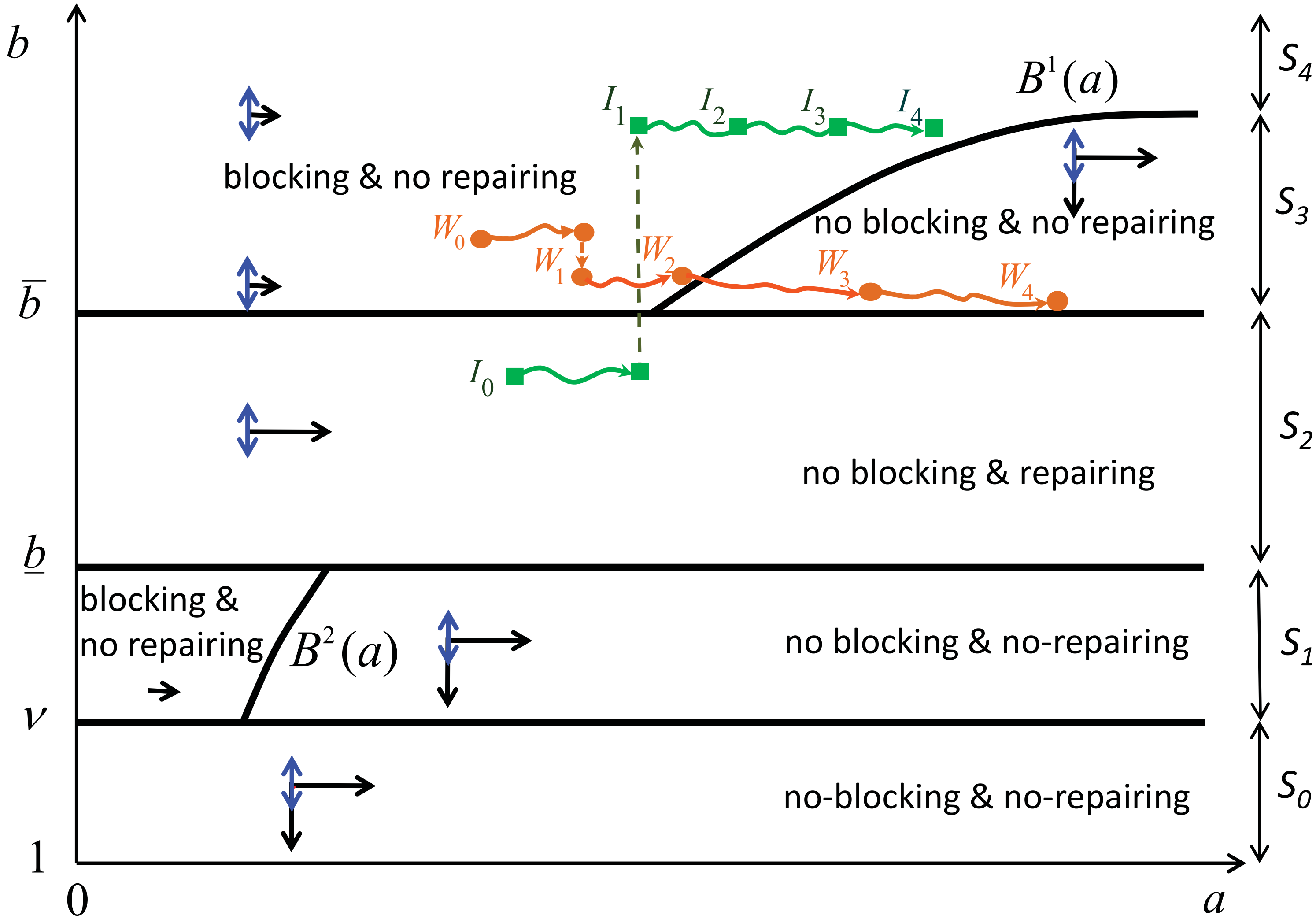


FIGURE 6

Ergodic dynamics

Notes: The length of the horizontal arrows denotes the economy's average rate of innovation. With shocks to religiosity, figured by the vertical blue arrows, the system is ergodic over the five regimes: S_0 = Strongly Secular, S_1 = Mildly Secular, S_2 = Adaptive-US, S_3 = Mildly Theocratic, and S_4 = Strongly Theocratic. The paths I_t and W_t are the "historical" ones discussed in the text for the Islamic and Western worlds.

(a) Transition matrix (per generation)

$$P^{25} = \begin{bmatrix} .79 & .16 & .04 & .05 & .07 \\ .56 & .21 & .16 & .03 & .05 \\ .09 & .08 & .63 & .15 & ..05 \\ .03 & .05 & .51 & .21 & .19 \\ 0 & .01 & .09 & .10 & .81 \end{bmatrix}$$

(b) Invariant distribution

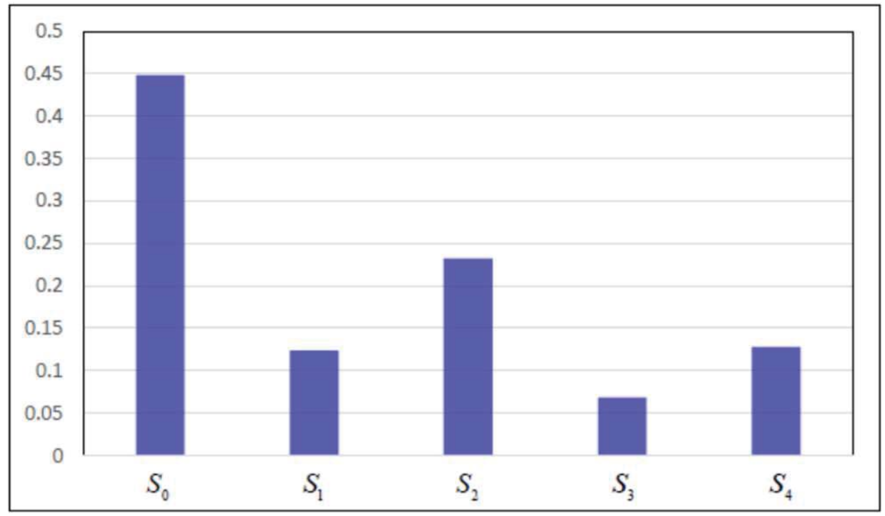


FIGURE 7

Transition matrix and invariant distribution

Notes: (a) Transition matrix, per generation. (b) Invariant distribution. The five belief states are S_0 = Strongly Secular, S_1 = Mildly Secular, S_2 = Adaptive-US, S_3 = Mildly Theocratic, and S_4 = Strongly Theocratic.

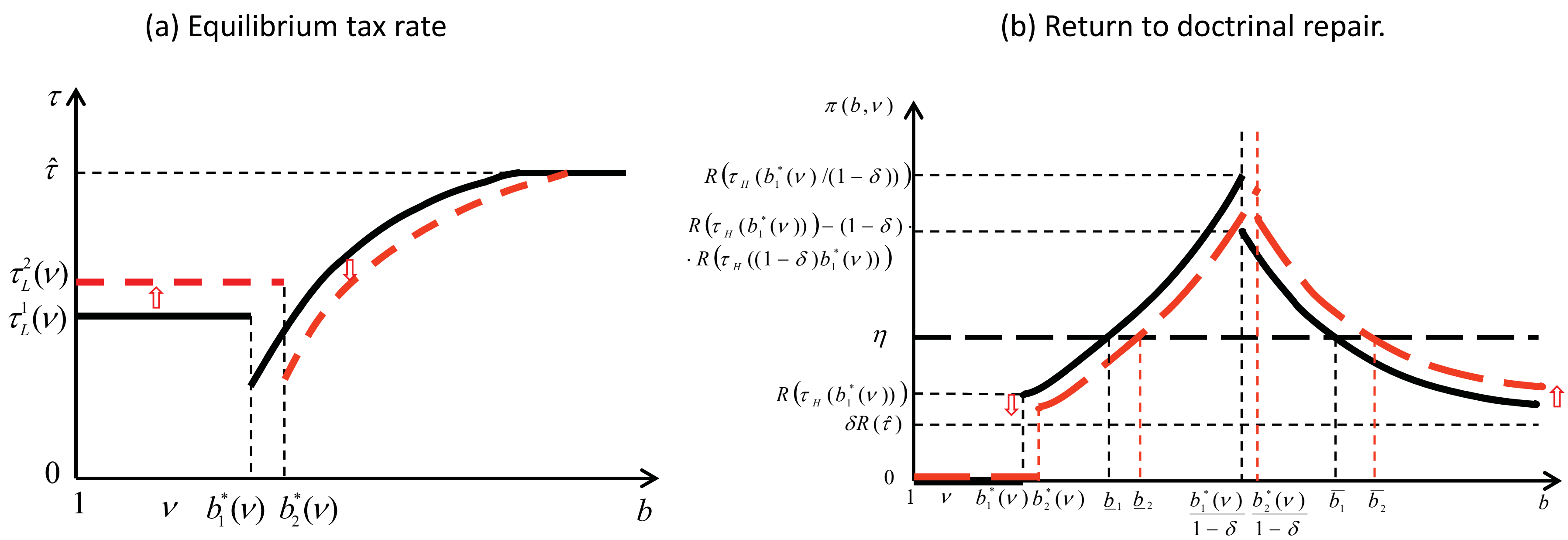


FIGURE 8

Effects of inequality and religiosity on taxation and doctrinal repair

Notes: The shifts from the solid black to the dashed red lines show the effects of increased income inequality.

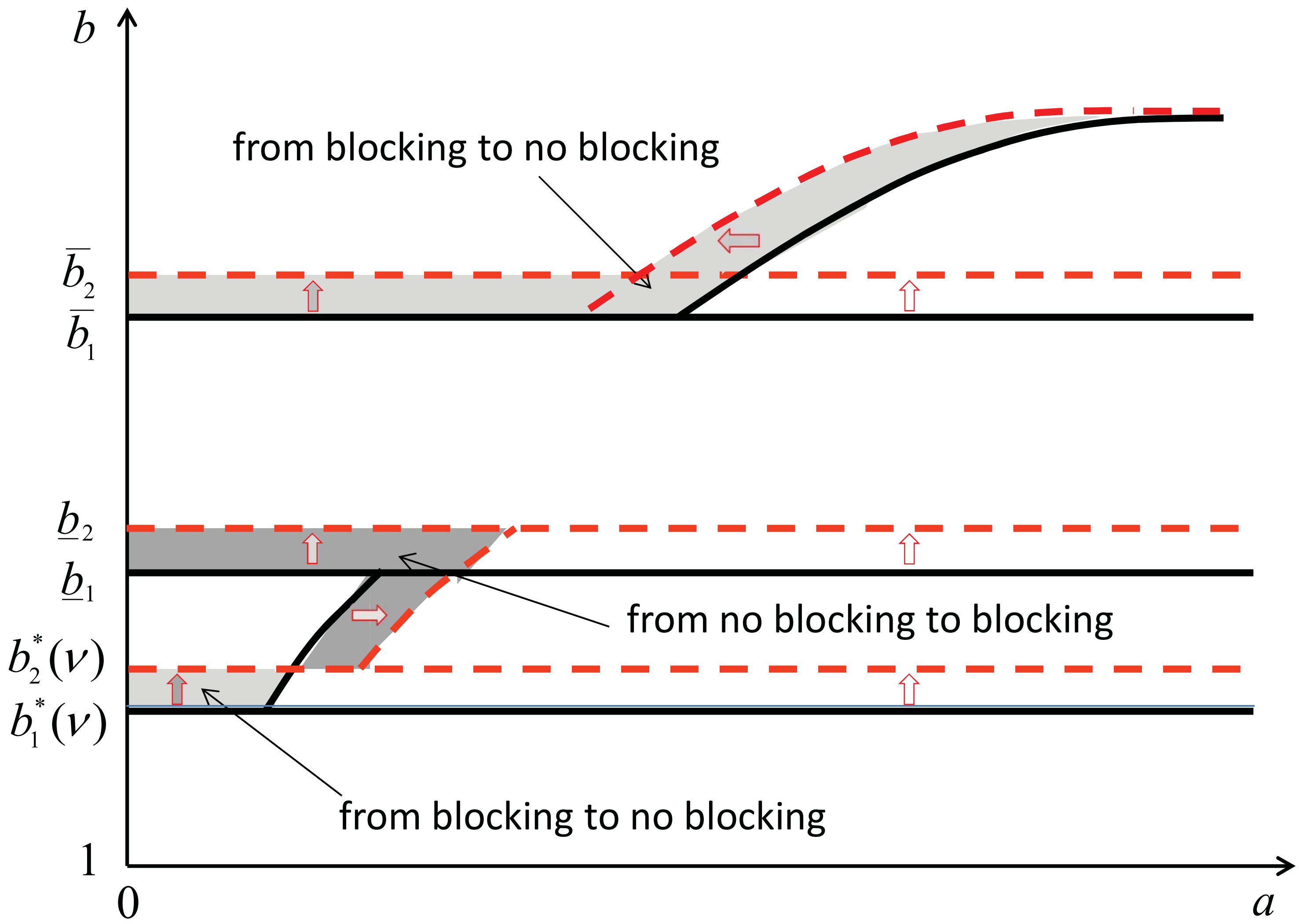


FIGURE 9

Effects of inequality on redistribution, doctrinal repair, and science policy

Notes: The shift from the solid black to the dashed red lines (blocking and repairing boundaries) shows the effects of an increase in income inequality.

Online Appendix C: Religious Conformity of Societal Laws

We extend here our framework to the case where the policies that religious agents value are not fiscal ones (subsidies, tax exemptions) but the conformity of society's laws to religious precepts and proscriptions. Let $\tilde{\tau} \leq 1$ measure how strictly these are enforced, resulting in an income loss of $\tilde{\tau}\theta$ for any individual with productivity θ (per unit of contemporary TFP). These losses may reflect the reduced time and talent available for production, the costs of unplanned pregnancies, the resources consumed by rituals or spent on circumventing the restrictions (black market, bribes, trips abroad, etc.), or all of the above. For religious agents and the Church, these societal strictures also represent a public good which they value at bG, where G is now equal to $G = \tilde{R}(\tilde{\tau})$ and the technology $\tilde{R}$ for producing it has the following properties.

Assumption 9 *The function $\tilde{R}$ is $\mathcal{C}^3$, strictly increasing and strictly concave, with $\tilde{R}(0) = 0$, $\tilde{R}'(0) = 1$ and $\tilde{R}'(1) > 0$. Furthermore, $\tilde{R}'''(\tilde{\tau}) \leq 0$ for all $\tilde{\tau} \in [0, 1]$.*

These properties are very similar to those of the tax revenue function $R(\tau)$, except that the latter is maximized at $\hat{\tau} < 1$ whereas $\tilde{R}(\tilde{\tau})$ is maximized above 1. The only fiscal public good provided by the government during agents' old age is now T, and the budget constraint (2) is replaced by $T = (1 - \tilde{\tau})R(\tau)$. The preferred policy of an agent with relative productivity θ and religious type $\beta \in \{0, 1\}$ is consequently given by

$$\max_{\tau,\tilde{\tau}} \left\{ (1 - \tilde{\tau}) \left[(1 - \tau)\theta + \nu R(\tau) \right] + \beta b \tilde{R}\left(\tilde{\tau}\right) \right\}. \tag{C.1}$$

Clearly, secular agents always want $\tilde{\tau} = 0$ and their fiscal preferences are unchanged. Religious agents are examined below.

C.1 Economy without income differences

• *Second-period policy outcome.* The unique distinction is between secular and religious agents so the latter, being in the majority, maximize (C.1) with $\theta = \beta = 1$, leading to:

$$\tau^*(\nu) = (R')^{-1}(1/\nu), \tag{C.2}$$

$$\tilde{\tau}^*(b) = \begin{cases} 0 & \text{for} \quad b < \tilde{\nu} \\ (\tilde{R}')^{-1}\left(\tilde{\nu}/b\right) & \text{for} \quad \tilde{\nu} \leq b \leq 1/\tilde{R}'\left(1\right) \\ 1 & \text{for} \quad 1/\tilde{R}'\left(1\right) < b, \end{cases} \tag{C.3}$$

where we define

$$\tilde{\nu} \equiv 1 - \tau^*(\nu) + \nu R(\tau^*(\nu)). \tag{C.4}$$

There are three differences with respect to the baseline model. First, G is now provided for all $b \geq \tilde{\nu}$ rather than for $b \geq \nu$. Second, T is always provided (funded by the same tax rate $\tau^*(\nu)$ as before), whereas before it was equal to zero for $b < \nu$. Third, agents' lower incomes due to the religious restrictions $\tilde{\tau} > 0$ imposed when $b \geq \tilde{\nu}$ reduce the tax base, so that for any given value of τ, T is also lower. Proposition 1 thus becomes:

Proposition 10 *The fiscal and legal policies implemented in the second period are:*
(1) If $b < \tilde{\nu}$*, then* $(\tau, \tilde{\tau}, T, G) = (\tau^*(\nu), 0, R(\tau^*(\nu)), 0)$; $\tau^*(\nu))$*, so that* τ *and* T *increase in* ν*.*
(2) If $b \geq \tilde{\nu}$*, then* $(\tau, \tilde{\tau}, T, G) = (\tau^*(\nu), \tilde{\tau}^*(b), (1 - \tilde{\tau}^*(b))R(\tau^*(\nu)), \tilde{R}(\tilde{\tau}^*(b)))$*, so that so that* $\tilde{\tau}$ *and* G *increase in* b*.*

For any b and ν, we denote again the second-period equilibrium level of G as

$$G(b, \nu) \equiv \begin{cases} 0 & \text{if } b < \tilde{\nu} \\ \tilde{R}(\tilde{\tau}^*(b)) & \text{if } b \geq \tilde{\nu}. \end{cases} \tag{C.5}$$

• *Doctrinal repair.* With similar substitutions, the analysis is unchanged from that of Section 5.2. Indeed, the value of repairing, $\tilde{\pi}(b, \nu)$, has the same single-peaked shape as $\pi(b, \nu)$, due to the fact that $\tilde{R}$ has similar properties to those of R (see Lemma 10 in Online Appendix D). The analogue to Assumption 2 is obtained similarly:

Assumption 10 $\delta \tilde{R}(1) < \eta/q < \tilde{R}\left(\tilde{\tau}^*\left(\tilde{\nu}/\left(1-\delta\right)\right)\right) - \left(1-\delta\right)\tilde{R}\left(\tilde{\tau}^*\left(\tilde{\nu}\right)\right).$

We thus obtain a parallel to Proposition 2, with ν simply replaced by $\tilde{\nu}$.

• *Science policy.* The analysis in Section 5.3 is also essentially unchanged: the blocking loci remain $R^{-1}(\varphi(a)) \leq \Delta^1(b)$ in region 1 ($b > \bar{b} > \tilde{\nu}/(1-\delta)$), and $R^{-1}(\varphi(a)) \leq \Delta^2(b)$ in Region 2 ($\tilde{\nu} \leq b < \underline{b}$), but now with

$$\Delta^1(b) = \lambda p_R \left\{[1 - \tilde{\tau}^*(b)]\tilde{\nu} + b\tilde{R}(\tilde{\tau}^*(b)) - (1+\gamma)\left[\left(1 - \tilde{\tau}^*(b')\right)\tilde{\nu} + b'\tilde{R}\left(\tilde{\tau}^*(b')\right)\right]\right\} \tag{C.6}$$

$$\Delta^2(b) = \lambda p_R \left\{[1 - \tilde{\tau}^*(b)]\tilde{\nu} + b\tilde{R}(\tilde{\tau}^*(b)) - (1+\gamma)\tilde{\nu}\right\}. \tag{C.7}$$

Both functions are again increasing wherever they are non-negative (see Online Appendix D.2.3), therefore Proposition 3 still applies.

C.2 Economy with unequal incomes

C.2.1 Preferred societal and fiscal policies

As observed earlier, the fiscal preferences of secular agents remain unchanged. For the religious poor, maximizing (C.1) yields $\tau = \tau_L(\nu/\theta_L)$ as in the original specification, while $\tilde{\tau} = \tilde{\tau}_L(b) \equiv$

$\tilde{\tau}^*(b/\tilde{\theta}_L)$, where $\tilde{\tau}^*(\cdot)$ is given by (C.2) and we define

$$\tilde{\theta}_L \equiv \; [1 - \tau_L(\nu)]\theta_L + \nu R(\tau_L(\nu)). \tag{C.8}$$

The problem for the religious rich is similar, except that $\tau_H(\nu) \equiv 0$, hence $\tilde{\theta}_H \equiv \theta_H$ and $\tilde{\tau}_H(b) = \tilde{\tau}^*(b/\theta_H)$. The reason why $\tilde{\theta}_L$ exceeds θ_L, and increases in ν, is that the RP face an additional tradeoff: the tax-base losses generated by religious restrictions imply that the same optimal tax rate $\tau_L(\nu)$ yields a lower level of T, leading them to choose positive levels of G and $\tilde{\tau}$ only when $b \geq \tilde{\theta}_L > \theta_L$. For further reference, let us also define

$$\check{b}_j \equiv \tilde{\theta}_j / \tilde{R}'(1), \text{ for } \; j = L, H. \tag{C.9}$$

Thus $\tilde{\tau}_j(b) = 0$ for $b \leq \tilde{\theta}_j$, solves $b\tilde{R}'(\tilde{\tau}) = \tilde{\theta}_j$ for $\tilde{\theta}_L < b \leq \check{b}_j$, and $\tilde{\tau}_j(b) = 1$ for $b > \check{b}_j$.

Lemma 9 *(1) The ideal policies of the SP and the SR are the same as in Proposition 1.*
(2) The ideal policy of the RR coincides with that of the SR (i.e., $T = G = 0$) for $b < \theta_H$, while for $b \geq \theta_H$ it is $(\tau, \tilde{\tau}, T, G) = (0, \tilde{\tau}_H(b), 0, \tilde{R}(\tilde{\tau}_H(b)))$, where $\tilde{\tau}_H(b) \equiv \tilde{\tau}^*(b/\theta_H) > 0$.
(3) The ideal policy of the RP is $(\tau, \tilde{\tau}, T, G) = (\tau_L(\nu), \tilde{\tau}_L(b), (1 - \tilde{\tau}_L(b))R(\tau_L(\nu)), \tilde{R}(\tilde{\tau}_L(b)))$. They always tax income at the same rate $\tau_L(\nu)$ as the SP, but legislate the religious public good G only when $b \geq \tilde{\theta}_L$, setting $\tau_L(b) \equiv \tilde{\tau}^*(b/\tilde{\theta}_L) > 0$.

C.2.2 Political coalitions at $t + 1$

In the benchmark model, Lemma 1 showed the existence of a belief threshold b^* above which the religious poor abandoned their "class interests", siding with the religious rich rather than the secular poor. It also showed $b^*(\nu; \theta_H, \theta_L)$ to be increasing in ν and θ_H, and decreasing in θ_L. The very same intuition and results obtain here provided that $\tilde{R}$ is everywhere less concave than R', or more generally has the following property.

Assumption 11 *For any $s \leq 1$, $\tilde{R}'(s) \geq R'(s)$. Consequently, $\tau^*(x) \leq \tilde{\tau}^*(x)$, for all x.*

The (redefined) $b^*(\nu)$ tells us how the RP rank the RR versus the SP, but a CPNE at date $t + 1$ involves more than that: all possible coalitions, deviating subcoalitions, etc., must be checked for deviation-proofness. In particular, since the RP now implement redistribution $T > 0$ even when they impose $G > 0$, the SP might prefer such a policy to that of the RR (who set a lower G, but $T = 0$). This, in turn, could lead to winning coalitions different from those of the baseline model, with the RP emerging as victor. To rule out this case and ensure that the political outcome remains unchanged, additional assumptions are required.

Assumption 12

$$\frac{-\tilde{R}''(1)}{\tilde{R}'(1)} \leq \min\left\{\frac{(1-\hat{\tau})(\theta_H-\theta_L)}{\theta_L+\nu R(\hat{\tau})}\frac{\tilde{R}'(1)}{\tilde{R}(1)},\ \frac{\tilde{\theta}_L}{\theta_L}\left[-\tilde{R}''(0)\right]\right\}.$$

This is of the same nature as Assumption 6, in that it requires the presence of enough income inequality in society, as both terms on the right-hand side are easily seen to increase with θ_H and decrease with θ_L.

Assumption 13

$$\frac{\tilde{R}(1)}{\tilde{R}'(1)} < (1-\tau_L(\nu)) + \frac{\nu R(\tau_L(\nu))}{\theta_H}.$$

A smaller value of $\tilde{R}(1)/\tilde{R}'(1)$ makes Assumptions 12 and 13 both more likely to hold.[48]

The unique CPNE outcome at date $t+1$, paralleling that in Proposition 5, is then characterized below (see Online Appendix D for proofs).

Proposition 11 *Under Assumptions 11-12, and if $\tilde{\tau}_L(b^*(\nu))$ is relatively high, the equilibrium societal and fiscal policy in the second period is unique and characterized by a religiosity threshold $b^*(\nu;\theta_H,\theta_L) > \theta_H > \nu$, or $b^*(\nu)$ for short, such that:*

(1) If $b < b^*(\nu)$, the religious poor back the secular poor, who thus come to power and implement their preferred policy, $(\tau,\tilde{\tau},T,G) = (\tau_L(\nu),0,R(\tau_L(\nu)),0)$.

(2) If $b \geq b^*(\nu)$, the religious poor back the religious rich, who thus come to power and implement their preferred policy, $(\tau,\tilde{\tau},T,G) = (0,\tilde{\tau}^*_H(b),0,\tilde{R}(\tilde{\tau}^*_H(b)))$.

(3) The threshold b^* is strictly increasing in ν and θ_H, and strictly decreasing in θ_L.

C.2.3 Church's Behavior, Blocking Equilibrium, and Comparative Statics

The remaining analysis is essentially unchanged from that of the benchmark model, since:

(i) The policy outcome at $t+1$ hinges in the same manner on whether the SP or the RR are in power, namely on b being below or above (the redefined) $b^*(\nu;\theta_H,\theta_L)$.

(ii) The SP and the RR's policies are the same as in the baseline, except that for the latter $\tau_H(b)$ and $R(\tau_H(b))$ are replaced by the similarly-behaved $\tilde{\tau}^*_H(b)$ and $\tilde{R}(\tilde{\tau}^*_H(b))$.

(iii) The same is therefore true for the Church's repairing decision, with Assumption 8 becoming:

[48] Since the right-hand side of Assumption 13 is bounded below by $1-\hat{\tau}$, sufficient (and simpler) conditions for both assumptions to hold are that $\frac{\tilde{R}(1)}{\tilde{R}'(1)} \leq 1-\hat{\tau}$ and $\frac{-\tilde{R}''(1)}{\tilde{R}'(1)} \leq \min\left\{\frac{\theta_H-\theta_L}{\theta_L+\nu R(\hat{\tau})},\ \frac{\tilde{\theta}_L}{\theta_L}\left[-\tilde{R}''(0)\right]\right\}$.

Assumption 14 *:* $\delta\tilde{R}(1) < \eta/q < \tilde{R}\left(\tilde{\tau}_H(b^*(\nu)/(1-\delta))\right) - (1-\delta)\tilde{R}\left(\tilde{\tau}_H(b^*(\nu))\right).$

(iv) Continuing the backward induction, the four groups' preferences with respect to blocking (value functions and resulting coalition formation) are also unchanged, up to the same substitutions, resulting in the same monotonicities and comparative statics. ■

Online Appendix D: Proofs for Appendix C

D.1 Economy without Income Differences

The only result not proved in Appendix C concerns the behavior of the religious sector.

Lemma 10 *The function $\pi(b,\nu)$ equals 0 for $b < \tilde{\nu}$, then jumps up to $\pi(\tilde{\nu},\nu) = \tilde{R}(\tilde{\tau}^*(\tilde{\nu}))$. It is continuous and increasing on $[\tilde{\nu}, \tilde{\nu}/(1-\delta))$, then jumps down to $\pi(\tilde{\nu}/(1-\delta),\nu) = \tilde{R}(\tilde{\tau}^*(\tilde{\nu}/(1-\delta))) - (1-\delta)\tilde{R}(\tilde{\tau}^*(\tilde{\nu}))$. Finally, it is continuous and strictly decreasing on $[\tilde{\nu}/(1-\delta), +\infty)$, with $\lim_{b\to+\infty}\pi(b,\nu) = \delta\tilde{R}(1) > 0$.*

Proof. The proof is identical to that of Lemma 2, as $\tilde{R}$ has similar properties to those of R. Together with Assumption 10, this yields the optimal-repairing interval. ■

Let us now turn to the State's blocking loci. In Region 1, differentiating (C.6) and using the envelope theorem gives

$$\frac{\partial\Delta^1(b)}{\partial b} = \lambda p_R\left[\tilde{R}(\tilde{\tau}^*(b)) - (1+\gamma)(1-\delta)\tilde{R}\left(\tilde{\tau}^*\left(b'\right)\right)\right]. \tag{D.1}$$

Blocking BR innovations requires that $\Delta^1(b) \geq 0$, which by (C.6) takes the form

$$\tilde{R}(\tilde{\tau}^*(b)) - (1+\gamma)(1-\delta)\tilde{R}\left(\tilde{\tau}^*\left(b'\right)\right) \geq (\tilde{\nu}/b)\left[(1+\gamma)\left(1-\tilde{\tau}^*\left(b'\right)\right) - (1-\tilde{\tau}^*(b))\right]. \tag{D.2}$$

Since $\tilde{\tau}^*(b)$ is nondecreasing and $b' \equiv (1-\delta)b$, the right-hand side of (D.2) is strictly positive. Therefore, $\Delta^1(b) \geq 0$ implies that $\partial\Delta^1(b)/\partial b > 0$ in (D.1). Similarly, from (C.7) we obtain $\partial\Delta^2(b)/\partial b = \lambda p_R\tilde{R}(\tilde{\tau}^*(b))$, which is always positive. Finally, we omit the proof that there is no blocking when $b \in [\underline{b}, \bar{b}]$ as it closely follows the one in Appendix B.2.

D.2 Economy with Unequal Incomes

To prove Proposition 11, we again solve the game backwards from $t+1$.

D.2.1 Political preferences at $t+1$

Recall the definitions of $\tilde{\tau}_L(b)$ and $\tilde{\tau}_H(b)$ from Appendix C.2.1. The proofs establishing the existence and uniqueness of $b^*(\nu)$ in Lemma 4 of Appendix B go through unchanged, by simply replacing everywhere $\tau_H(b)$ and $R(\tau_H(b))$ with $\tilde{\tau}_H(b)$ and $\tilde{R}(\tilde{\tau}_H(b))$. In particular, the RP's indifference condition (between SP and RR) defining $b^*(\nu)$ is now

$$[1-\tilde{\tau}_H(b^*(\nu))]\,\theta_L + b^*(\nu)\,\tilde{R}(\tilde{\tau}_H(b^*(\nu))) = [1-\tau_L(\nu)]\theta_L + \nu R(\tau_L(\nu)). \tag{D.3}$$

For any $b \geq \check{b}_H > \check{b}_L$ defined by (C.9), we have $\tilde{\tau}_H(b) = \tilde{\tau}_L(b) = 1$: the RR and RP's ideal policies coincide ($\tilde{\tau} = 1$, making τ irrelevant), so the RP must prefer the RR to the SP. By definition of b^* this means that $b^*(\nu) < \check{b}_H$, therefore

$$\forall\ b \leq b^*(\nu),\ \tilde{\tau}_H(b) < 1 \text{ and } b\tilde{R}'(\tilde{\tau}_H(b)) = \theta_H. \tag{D.4}$$

The proofs for the comparative statics of $b^*(\nu)$ with respect to ν and θ_H also remain unchanged. For monotonicity in θ_L, however, under the benchmark specification we made use of the fact that $\tau_L(\nu) > \tau_H(b^*(\nu))$; see Lemma 5 in Appendix B. In the present case, we show a similar inequality, which in turns makes the same proof of monotonicity go through.

Lemma 11 *Under Assumption 11,* $\tau_L(\nu) > \tilde{\tau}_H(b^*(\nu))$.

Proof. Suppose, by contradiction, that $\tau_L(\nu) \leq \tilde{\tau}_H(b^*(\nu))$. Let us rewrite (D.3) as

$$\begin{aligned}
\tilde{\tau}_H(b^*(\nu)) - \tau_L(\nu) &= \frac{b^*(\nu)\tilde{R}(\tilde{\tau}_H(b^*(\nu)))}{\theta_L} - \frac{\nu R(\tau_L(\nu))}{\theta_L} \\
&= \frac{b^*(\nu)}{\theta_L}\left[\tilde{R}(\tilde{\tau}_H(b^*(\nu))) - \tilde{R}(\tau_L(\nu))\right] \\
&\quad + \frac{b^*(\nu)}{\theta_L}\left[\tilde{R}(\tau_L(\nu)) - R(\tau_L(\nu))\right] + \frac{b^*(\nu)-\nu}{\theta_L}R(\tau_L(\nu)).
\end{aligned} \tag{D.5}$$

Since $R(0) = \tilde{R}(0) = 0$ and $\tilde{R}'(x) \geq R'(x)$ for all x, $\tilde{R}$ lies everywhere above R. Together with $b^*(\nu) > \nu$, this implies that the last line in (D.5) is strictly positive. Turning to the second line, the Mean-Value Theorem implies that

$$\tilde{R}(\tilde{\tau}_H(b^*(\nu)) - \tilde{R}(\tau_L(\nu)) = [\tilde{\tau}_H(b^*(\nu)) - \tau_L(\nu)] \cdot \tilde{R}'(c),$$

for some $c \in [\tau_L(\nu),\ \tilde{\tau}_H(b^*(\nu))]$. We can then rewrite (D.5) as

$$\begin{aligned}
&[\tilde{\tau}_H(b^*(\nu)) - \tau_L(\nu)]\left[1 - \frac{b^*(\nu)}{\theta_L}\tilde{R}'(c)\right] \\
=\ & \frac{b^*(\nu)}{\theta_L}\left[\tilde{R}(\tau_L(\nu)) - R(\tau_L(\nu))\right] + \frac{b^*(\nu)-\nu}{\theta_L}R(\tau_L(\nu)) > 0.
\end{aligned} \tag{D.6}$$

This clearly rules out $\tilde{\tau}_H(b^*(\nu)) = \tau_L(\nu)$, but also $\tilde{\tau}_H(b^*(\nu)) > \tau_L(\nu)$, which would imply $b^*(\nu)\tilde{R}'(c) < \theta_L$, hence $b^*(\nu)\tilde{R}'(\tilde{\tau}_H(b^*(\nu))) < \theta_L$, by concavity of $\tilde{R}'$. Recall, however, that by

(D.4) we have $b\tilde{R}'(\tilde{\tau}_H(b)) = \theta_L$, implying a contradiction for $b = b^*(\nu)$. ■

D.2.2 Coalition formation and CPNE at $t+1$

A - Region $b < b^*(\nu)$

Case 1: $b < \tilde{\theta}_L \equiv (1 - \tau_L(\nu))\theta_L + \nu R(\tau_L(\nu))$. The RP's ideal policy coincides with that of the SP, which is therefore always implemented.

Case 2: $\tilde{\theta}_L \leq b < \theta_H$. In this case the RP desire $G > 0$, but the RR do not. Table D.1 reports the corresponding preference structure.

	SP	RP	RR	SR
SP	1	y	x	x
RP	2	1	3	3
RR	3	4	1	2
SR	3	4	2	1

where $(x, y) = (2, 3)$ [subcase (a)], or $(3, 2)$ [subcase (b)].

Table D.1. Fiscal preferences of each group when $(1 - \tau_L(\nu))\theta_L + \nu R(\tau_L(\nu)) \leq b < \theta_H$.

The RR have the same ideal policy as the SR ($G = T = 0$), so the SP and RP are indifferent between them (as in Region A, Case 2 of the baseline model, where $\nu < b < \theta_H$; see Table B.2). The RR and SR prefer the SP to the RP, because both these groups redistribute income at the rate $\tau_L(\nu)$ but latter also impose positive levels of G.

The RP rank the SP in 2^{nd} place, by Lemma 4.(1) and the fact that $b < b^*(\nu)$. The SP, in turn, rank the RP as 2^{nd} for values of b close to θ_L, as the latter then impose only a low level of G (subcase (b)). As b increases (and eventually approaches θ_H), it is possible that the SP switch to preferring the ideal policy of the SR (and RR) to that the RP, because the losses generated by $\tilde{\tau}_L(b)$ more than compensate their gains from redistribution. The RP will then be ranked last (subcase (a)).

In either subcase, the SP winning is the unique CPNE, as they are preferred to the RR by both the SP and the RP. Formally, subcase (a) in Table D.1 is identical to that in Table B.2; that the equilibrium is also unchanged in subcase (b) is immediate to verify.[49]

Case 3: $\theta_H \leq b < b^*(\nu)$. Table D.2 reports the preference structure for this case.

[49] First note that the RP winning is not a CPNE. Indeed, assume that $RP = E$ is a NE. A profitable deviation is ($RR = N$, $SP = E$) since it brings the SP to power and $(3, 1) < (4, z)$ as $z \in \{2, 3\}$. The deviation is also self-enforcing: if the RR deviate and enter, they go to round 2 with the RP and lose. Similarly, it is immediate to show that the SP winning is a CPNE.

	SP	RP	RR	SR
SP	1	y	x	z
RP	2	1	3	4
RR	3	4	1	2
SR	x'	4	y'	1

where $(x, y, z) = (3, 4, 2)$ or $(4, 3, 2)$ [subcase (a)], or $(4, 2, 3)$ [subcase (b)]; $(x\prime, y\prime) = (2, 3)$ or $(3, 2)$.

Table D.2. Fiscal preferences of each group when $\theta_H \leq b < b^*(\nu)$.

This case differs from the previous one, since the RR now choose $G > 0$. The SP, however, may still prefer the RP to the SR because of the income redistribution which the former provide, but not the latter. In this case the SP rank the RR last, as they are a just as source of losses, by imposing $G > 0$ (subcase (b)). Alternatively, the SP may rank the SR as 2^{nd}; they could then prefer the RR to the RP, or vice versa (subcase (a)).[50] By definition of $b^*(\nu)$, the RP still continue to prefer the SP to the RR, and always rank the SR last. The preferences of the SR are the same as in Region A, Case 1 of the baseline framework (see Table B.1).

Consider, finally, the RR. A priori, they could now prefer (when b is high relative to θ_H) prefer the RP's policy to that of the SP, and this in turn may prevent the SP from winning. The reason is that, in this case, the SP may rank 2^{nd} the RP's ideal policy (this was not the case in the baseline framework). And if both the SP and the RR rank the RP in second place, they will be the winner. The first part of Assumption 12 serves to rule out this scenario and ensure that the preferences of the RR remain the same as in subcase (a) of Table B.1. Indeed, the RR prefer the SP to the RP if:[51]

$$[1 - \tau_L(\nu)]\,\theta_H + \nu R(\tau_L(\nu)) > [1 - \tilde{\tau}_L(b)]\,[(1 - \tau_L(\nu))\theta_H + \nu R(\tau_L(\nu))] + b\tilde{R}(\tilde{\tau}_L(b)).$$

This expression simplifies to

$$\Gamma(b) \equiv -\tilde{\tau}_L(b)\,[(1 - \tau_L(\nu))\theta_H + \nu R(\tau_L(\nu))] + b\tilde{R}(\tilde{\tau}_L(b)) < 0. \tag{D.7}$$

This condition always holds for b equal or close to θ_H, since in this case the RR's preferred societal policy is $\tilde{\tau}_H(\theta_H) \approx 0$, whereas the RP impose on them not only the same redistribution $\tau_L(\nu)$ as the SP, but also a strictly positive $\tilde{\tau}_L(B)$. Hence, (D.7) is always satisfied if $\partial\Gamma/\partial b \leq 0$ for all $\theta_H \leq b < b^*(\nu)$. Differentiating (D.7), we obtain

[50] The religious component of the RR's policy package imposes lower losses (a lower $\tilde{\tau}$) on the SP than that of the RP. However, the RP provide some income redistribution that may compensate for such losses.

[51] Both SP and RP tax and redistribute income at the same rate $\tau_L(\nu)$, but transfers T under the SP are higher, as there are no income losses from a positive $\tilde{\tau}$.

$$\frac{\partial \Gamma}{\partial b} = -\frac{\partial \tilde{\tau}_L(b)}{\partial b}\left[(1-\tau_L(\nu))\theta_H + \nu R(\tau_L(\nu))\right] + b\tilde{R}'(\tilde{\tau}_L(b))\frac{\partial \tilde{\tau}_L(b)}{\partial b} + \tilde{R}(\tilde{\tau}_L(b)). \tag{D.8}$$

• *Interior solution for* $\tilde{\tau}_L(b)$. Suppose first that $b^*(\nu) \leq \check{b}_L$, so that for all $b \leq b^*(\nu)$, $\tilde{\tau}_L(b)$ is defined by the first-order condition $b\tilde{R}'(\tilde{\tau}_L(b)) = \tilde{\theta}_L$. This also implies that $\partial\tilde{\tau}_L(b)/\partial b = \tilde{\theta}_L/[-b^2\tilde{R}''(\tilde{\tau}_L(b))] > 0$, therefore $\partial\Gamma/\partial b \leq 0$ if and only if

$$\begin{aligned}
\frac{(\tilde{\theta}_L)^2}{-b^2\tilde{R}''(\tilde{\tau}_L(b))} + \tilde{R}(\tilde{\tau}_L(b)) &\leq \frac{\tilde{\theta}_L}{-b^2\tilde{R}''(\tilde{\tau}_L(b))}\left[\tilde{\theta}_L + (1-\tau_L(\nu))(\theta_H - \theta_L)\right] \iff \\
-\frac{\tilde{R}''(\tilde{\tau}_L(b))}{[\tilde{R}'(\tilde{\tau}_L(b))]^2}\tilde{R}(\tilde{\tau}_L(b)) &\leq \frac{(1-\tau_L(\nu))(\theta_H - \theta_L)}{(1-\tau_L(\nu))\theta_L + \nu R(\tau_L(\nu))}.
\end{aligned} \tag{D.9}$$

The left-hand-side is increasing in $\tilde{\tau}_L(b)$, and therefore reaches its maximum at $-\tilde{R}''(1)\tilde{R}(1)/[\tilde{R}'(1)]^2$.[52] On the right-hand side, the numerator is minimized when $\tau_L(\nu) = \hat{\tau}$, while the denominator is always less than $\theta_L + \nu R(\hat{\tau})$. Therefore, (D.9) will hold provided that

$$-\frac{\tilde{R}''(1)\tilde{R}(1)}{[\tilde{R}'(1)]^2} \leq \frac{(1-\hat{\tau})(\theta_H - \theta_L)}{\theta_L + \nu R(\hat{\tau})}.$$

Rearranging terms, this is exactly the first part of Assumption 12. Thus $\Gamma(b) < 0$, meaning that the *RR* prefer the *SP* to the *RP*, holds for all $b \leq \check{b}_L$.

• *Corner solution for* $\tilde{\tau}_L(b)$. Suppose now that $b^*(\nu) > \check{b}_L$ meaning that $\tilde{\tau}_L(b) = 1$ for all $b \in [\check{b}_L, b^*(\nu)]$; for $\tilde{\tau}_H(b)$, in contrast, we have (D.4). Over that range, (D.8) now yields $\partial\Gamma/\partial b = \tilde{R}(1) > 0$, so (D.7) will hold if it is satisfied at $b = b^*(\nu)$, i.e.

$$b^*(\nu)\tilde{R}(1) < (1-\tau_L(\nu))\theta_H + \nu R(\tau_L(\nu)). \tag{D.10}$$

Since $\tilde{\tau}_L(b) = 1$, it follows from $b^*(\nu) < \check{b}_H$ and the definition of $\check{b}_H \equiv \theta_H/\tilde{R}'(1)$ in (C.9) that $b^*(\nu) < \theta_H/\tilde{R}'(1)$. Therefore, a sufficient condition is

$$\frac{\tilde{R}(1)}{\tilde{R}'(1)} \leq \frac{(1-\tau_L(\nu))\theta_H + \nu R(\tau_L(\nu))}{\theta_H}, \tag{D.11}$$

which is Assumption 13. Thus $\Gamma(b) < 0$ for $b \in [\check{b}_L, b^*(\nu)]$ as well, and again the *RR* prefer the *SP* to the *RP*.

Clearly, the *RR* also always prefer the *SR* to the *SP* (who tax). The rest of the proof that the *SP* winning is the unique CPNE is then similar to that of the baseline model.

[52] Indeed, $S(x) \equiv -\tilde{R}''(x)\tilde{R}(x)/[\tilde{R}'(x)]^2$ is increasing in x (hence maximized at $x = 1$), since $S'(x)\left[\tilde{R}'(x)\right]^2 = -[\tilde{R}'''(x)\tilde{R}(x) + \tilde{R}''(x)\tilde{R}'(x)]\tilde{R}'(x) - [\tilde{R}''(x)]^2\tilde{R}(x) > 0$.

B - Region $b^*(\nu) < b$.

The RP now prefer the RR to the SP. If the SP prefer the RR to the RP, the entire structure of preferences is the same as in the baseline's Table B.3, leading to the RR winning as the unique CPNE. The SP indeed prefer the RR's policy package to that of the RP if

$$[1-\tilde{\tau}_H(b)]\theta_L > [1-\tilde{\tau}_L(b)]\left[(1-\tau_L(\nu))\theta_L + \nu R(\tau_L(\nu))\right] \equiv [1-\tilde{\tau}_L(b)]\tilde{\theta}_L. \tag{D.12}$$

As b increases, $\tilde{\tau}_L(b)$ and $\tilde{\tau}_H(b)$ reach 1 at finite levels $\check{b}_L$ and $\check{b}_H$ defined in (C.9); since there is no income to left redistribute, the fiscal component of the RP's policy becomes irrelevant. When $b \in [\check{b}_L, \check{b}_H)$, the SP prefer the RR to the RP, and when $b \geq \check{b}_H$ they are indifferent between them. We now need to check that (D.12) is satisfied for all $b \in [b^*(\nu), \check{b}_L)$, when this interval is nonempty. At $b = b^*(\nu)$, by definition,

$$[1-\tau_L(\nu)]\,\theta_L + \nu R(\tau_L(\nu)) = [1-\tilde{\tau}_H(b^*(\nu))]\,\theta_L + b^*(\nu)\tilde{R}(\tilde{\tau}_H(b^*(\nu))). \tag{D.13}$$

Substituting (D.13) into (D.12) evaluated at $b^*(\nu)$, the latter can be rewritten as

$$\tilde{\tau}_L(b^*(\nu))[1-\tilde{\tau}_H(b^*(\nu))]\theta_L - [1-\tilde{\tau}_L(b^*(\nu))]b^*(\nu)\tilde{R}(\tilde{\tau}_H(b^*(\nu))) > 0. \tag{D.14}$$

Lemma 12 *Condition (D.14) is satisfied when $\tilde{\tau}_L(b^*(\nu))$ is high enough, namely*

$$\tilde{\tau}_L(b^*(\nu)) > \frac{\Phi\theta_L + \nu R(\tau_L(\nu))}{[1-\tau_L(\nu)]\,\theta_L + \nu R(\tau_L(\nu))}, \tag{D.15}$$

where $\Phi \equiv (\theta_H - \theta_L)^{-1}\left\{\theta_H\left[\tilde{R}(\tau_L(\nu)) - R(\tau_L(\nu))\right] + (\theta_H - \nu)\,R(\tau_L(\nu))\right\}$.

Proof. The proof proceeds in three steps.

Step 1. From the definition of $b^*(\nu)$ in (D.13), we obtain

$$b^*(\nu)\,\tilde{R}(\tilde{\tau}_H(b^*(\nu))) = [\tilde{\tau}_H(b^*(\nu)) - \tau_L(\nu)]\,\theta_L + \nu R(\tau_L(\nu)). \tag{D.16}$$

Substituting (D.16) into equation (D.14) yields

$$0 < \tilde{\tau}_L(b^*(\nu))\,[1-\tilde{\tau}_H(b^*(\nu))]\,\theta_L - [1-\tilde{\tau}_L(b^*(\nu))]\left\{[\tilde{\tau}_H(b^*(\nu)) - \tau_L(\nu)]\,\theta_L + \nu R(\tau_L(\nu))\right\}$$

or, after some simple manipulations,

$$\tilde{\tau}_L(b^*(\nu))\theta_L - \left\{[\tilde{\tau}_H(b^*(\nu)) - \tau_L(\nu)]\,\theta_L + \nu R(\tau_L(\nu))\right\} + \tilde{\tau}_L(b^*(\nu))\left[-\tau_L(\nu)\theta_L + \nu R(\tau_L(\nu))\right] > 0.$$

Isolating the terms in $\tilde{\tau}_L(b^*(\nu))$, this is equivalent to

$$\tilde{\tau}_L(b^*(\nu))\left\{[1-\tau_L(\nu)]\,\theta_L+\nu R(\tau_L(\nu))\right\} > [\tilde{\tau}_H(b^*(\nu))-\tau_L(\nu)]\,\theta_L+\nu R(\tau_L(\nu)).$$

Since the term in curly brackets is strictly positive, (D.14) becomes

$$\tilde{\tau}_L(b^*(\nu)) > \frac{[\tilde{\tau}_H(b^*(\nu))-\tau_L(\nu)]\,\theta_L+\nu R(\tau_L(\nu))}{[1-\tau_L(\nu)]\,\theta_L+\nu R(\tau_L(\nu))}. \tag{D.17}$$

Step 2. In the remaining part of the proof, we look for a lower bound on $\tilde{\tau}_H(b^*(\nu))-\tau_L(\nu)$ that does not depend on $b^*(\nu)$. Recalling the definition of $b^*(\nu)$ as rewritten in (D.6), we have

$$\tilde{\tau}_H(b^*(\nu))-\tau_L(\nu) = -\frac{\frac{b^*(\nu)}{\theta_L}\left[\tilde{R}(\tau_L(\nu))-R(\tau_L(\nu))\right]+\frac{b^*(\nu)-\nu}{\theta_L}R(\tau_L(\nu))}{\frac{b^*(\nu)}{\theta_L}\tilde{R}'(c)-1},$$

for some $c\in(\tilde{\tau}_H(b^*(\nu)),\tau_L(\nu))$. Since R' is decreasing, this implies

$$\tilde{\tau}_H(b^*(\nu))-\tau_L(\nu) < -\frac{\frac{b^*(\nu)}{\theta_L}\left[\tilde{R}(\tau_L(\nu))-R(\tau_L(\nu))\right]+\frac{b^*(\nu)-\nu}{\theta_L}R(\tau_L(\nu))}{\frac{b^*(\nu)}{\theta_L}\tilde{R}'(\tilde{\tau}_H(b^*(\nu)))-1}. \tag{D.18}$$

Recalling next that $b^*(\nu)\tilde{R}'(\tilde{\tau}_H(b^*(\nu)))\equiv\theta_H<b^*(\nu)$, (D.18) in turn implies

$$\tilde{\tau}_H(b^*(\nu))-\tau_L(\nu) < -\frac{\theta_H\left[\tilde{R}(\tau_L(\nu))-R(\tau_L(\nu))\right]+(\theta_H-\nu)\,R(\tau_L(\nu))}{\theta_H-\theta_L}\equiv\Phi. \tag{D.19}$$

Step 3. Condition (D.17) provides an upper bound, Φ, which does not depend on $b^*(\nu)$, for the term $\tilde{\tau}_H(b^*(\nu))-\tau_L(\nu)$. Together with (D.17), this implies *a fortiori:*

$$\tilde{\tau}_L(b^*(\nu)) > \frac{\Phi\theta_L+\nu R(\tau_L(\nu))}{[1-\tau_L(\nu)]\,\theta_L+\nu R(\tau_L(\nu))},$$

which is exactly (D.15). Finally, since the right-hand-side does not depend on $b^*(\nu)$, it provides a lower bound for $\tilde{\tau}_L(b^*(\nu))$ above which (D.14) holds. ■

From here on we shall assume that $\tilde{\tau}_L(b^*(\nu))$ satisfies (D.15), so that (D.12) holds at $b=b^*(\nu)$. To show that it also holds for $b>b^*(\nu)$, we rewrite it as

$$[1-\tilde{\tau}_H(b)]\,\theta_L-[1-\tilde{\tau}_L(b)]\,\tilde{\theta}_L>0. \tag{D.20}$$

Under (D.14), a sufficient condition for (D.12) to hold for $b>b^*(\nu)$ is that the left-hand side of (D.20) be nondecreasing in b. From the first order conditions of the RR's and RP's, we have

$$\frac{\partial\tilde{\tau}_H(b)}{\partial b}=-\frac{\tilde{R}'(\tilde{\tau}_H(b))}{b\tilde{R}''(\tilde{\tau}_H(b))},\quad \frac{\partial\tilde{\tau}_L(b)}{\partial b}=-\frac{\tilde{R}'(\tilde{\tau}_L(b))}{b\tilde{R}''(\tilde{\tau}_L(b))}.$$

Using these expressions, $[1-\tilde{\tau}_H(b)]\,\theta_L - [1-\tilde{\tau}_L(b)]\,\tilde{\theta}_L$ weakly increases in b if

$$\frac{\tilde{\theta}_L}{\theta_L} \geq \frac{\tilde{R}'\left(\tilde{\tau}_H(b)\right)}{-\tilde{R}''\left(\tilde{\tau}_H(b)\right)} \cdot \frac{-\tilde{R}''\left(\tilde{\tau}_L(b)\right)}{\tilde{R}'\left(\tilde{\tau}_L(b)\right)}, \tag{D.21}$$

By Assumption 9, we have: (i) $\tilde{R}'\left(\tilde{\tau}_H\right) < 1$, since $\tilde{R}'\left(0\right) = 1 \geq \tilde{R}'\left(x\right)$ for any x as $\tilde{R}''\left(x\right) < 0$; (ii) $-\tilde{R}''\left(\tilde{\tau}_L(b)\right)/\tilde{R}'\left(\tilde{\tau}_L(b)\right) \leq -\tilde{R}''\left(1\right)/\tilde{R}'\left(1\right)$, since $-\tilde{R}''\left(x\right)/\tilde{R}'\left(x\right)$ is increasing in x and $\tilde{R}'\left(1\right) > 0$; (iii) $-\tilde{R}''\left(\tilde{\tau}_H(b)\right) \geq -\tilde{R}''\left(0\right)$, since $\tilde{R}'''\left(x\right) \leq 0$ and $\tilde{R}''\left(x\right) < 0$. These three facts imply that

$$\frac{1}{-\tilde{R}''\left(0\right)}\frac{-\tilde{R}''\left(1\right)}{\tilde{R}'\left(1\right)} \geq \frac{\tilde{R}'\left(\tilde{\tau}_H(b)\right)}{-\tilde{R}''\left(\tilde{\tau}_H(b)\right)}\frac{-\tilde{R}''\left(\tilde{\tau}_L(b)\right)}{\tilde{R}'\left(\tilde{\tau}_L(b)\right)},$$

so that (D.21) is always satisfied under Assumption 12, the second part of which is $\tilde{\theta}_L/\theta_L \geq \tilde{R}''\left(1\right)/[\tilde{R}''\left(0\right)\tilde{R}'\left(1\right)]$. This completes the proof that (D.12) is satisfied for all $b \in [b^*(\nu), \check{b}_L)$ and, therefore, that the SP prefer the ideal policy of the RR to that of the RP in this range.

Table D.3 reports the preference structure for this case.

	SP	RP	RR	SR
SP	1	4	3	2
RP	3	1	2	4
RR	x	y	1	z
SR	x'	4	y'	1

where $(x, y, z) = (3, 4, 2)$ [subcase(a)], or $(4, 2, 3)$ or $(4, 3, 2)$ [subcase b]; $(x\prime, y\prime) = (2, 3)$ or $(3, 2)$.

Table D.3. Fiscal preferences of each group when $b^*(\nu) < b$.

It is the same as in the baseline's Table B.3, so the RR winning is the unique CPNE.

D.2.3 Behavior of the Religious Sector and Science Policy

Replacing $\tau_H(b)$ and $R(\tau_H(b))$ by $\tilde{\tau}_H^*(b)$ and $\tilde{R}(\tilde{\tau}_H^*(b))$ in Lemma 6 and Assumption 8 (which then becomes Assumption 14), the same proofs lead to the same characterization and comparative statics of the Church's repairing policy.

As stated at the end of Appendix C, with these same substitutions the four groups' blocking preferences (value functions at t) inherit, from the later stages of the game, the same properties as in the core model, and therefore does the equilibrium coalition formation (PCPNE) and its comparative statics. ■

Online Appendix E: Further Variants and Extensions

E.1 Parents and Children

Instead of their own religious beliefs and scientific-technical knowledge, adults may want to shape those of their offspring, through similar channels of tolerance versus blocking of new ideas, or doctrinal adaptation. We outline here a reinterpretation of the basic model corresponding to this timing, in which adults internalize the young's material and spiritual utility.

As before, all variables are normalized by current TFP. Agents are now young adults in odd periods $(t-1, t+1)$, and old in even ones $(t, t+2)$. When young, they derive utility from consumption and possibly religion,

$$U_{t+1}^i = c_{t+1}^i + \beta^i b_{t+1} G_{t+1} = 1 - \tau_{t+1} + \nu T_{t+1} + \beta^i b_{t+1} G_{t+1}, \tag{E.1}$$

where (a_{t+1}, b_{t+1}) are determined by the science-religion tradeoffs made at time t by their parents, $(\tau_{t+1}, G_{t+1}, T_{t+1})$ by their own generation's choices over public goods and their financing, and β^i indicates whether an agent belongs to a religious or secular "dynasty". Young adults either do not yet have the opportunity (time, knowledge, political power) to invest in blocking or, equivalently, youth is myopic: they do not anticipate how, once older, they will start worrying about the religious values and welfare of their children.[53] That is what their own parents did in as older adults, however, maximizing

$$\begin{aligned} U_t^i &= c_t^i + \mathbb{E}_t[U_{t+1}^i\,(a_{t+1}/a_t)] = 1 - \tau_t + \mathbb{E}_t[(c_{t+1}^i + \beta^i b_{t+1} G_{t+1})\,(a_{t+1}/a_t) \;\mid\; (a_t, b_t)] \\ &= 1 - \chi_t R(\varphi(a_t)) + \mathbb{E}_t[(1 - \tau_{t+1} + \nu T_{t+1} + \beta^i b_{t+1} G_{t+1})\,(a_{t+1}/a_t) \;\mid\; (a_t, b_t)] \end{aligned} \tag{E.2}$$

over the blocking-investment decision $\chi_t = 0, 1$, which can protect the transmission of their beliefs b_t to their children (and the latter's resulting maximized utility U_{t+1}^i), but may also deprive them of productive new knowledge. Keeping the objective function of the Church and the fact that it acts between period t and $t+1$ unchanged, the above formulation is *isomorphic* to the one in the paper, leading to identical results.

Remarks.

1. Old parents internalize the utility of their children in youth U_{t+1}^i, but not in the children's old age: since U_{t+2}^i includes concerns about the grandchildren's generation (U_{t+3}^i), this would transform the model into one with infinite-horizon dynasties.

2. We can equivalently think of *individuals living three periods:* (i) as a child as date t, whose parents are currently old; (ii) as a young adult without children nor living parents

[53] This can be see as a form of "projection bias", which is well documented in many realms. In particular, the young do not anticipate how they typically will become more "conservative" once they age, have families, etc.

date $t + 1$; (iii) as an older adult with a young child at $t + 2$. As above, blocking-investment decisions made by parents' generation at date t apply to the innovations (if any) that arrive between then and $t+1$. Thus, instead of inheriting their parents' (a_t, b_t), children's beliefs and productivity will be (a_{t+1}, b_{t+1}) once they become young adults, and remain the same with age: $(a_{t+2}, b_{t+2}) = (a_{t+1}, b_{t+1})$. If BR innovations are not blocked by $\chi_t = 1$, they will thus erode *the next generation's religiosity* to $b_{t+1} = (1 - \delta)b_t$, unless these beliefs are "repaired" by the Church at the start of $t + 1$, by adapting the doctrine to the new knowledge.

3. In the extended (ergodic) version of the model of Section 6, the exogenous shocks to religiosity (natural disasters, etc.) still occur between periods $t + 1$ and $t + 2$, but this now corresponds to them "hitting" agents between youth and old age.

4. The above model is (intentionally) restrictive in some ways, in that young and old *adults* do not "overlap": (i) when the former make decisions, their parents are dead, or more generally economically and politically inactive; (ii) when the latter make decisions, the latter are still passive children. Together with the assumption that young adults do not "think though" the (different) preferences they will have when they become parents, or if they do cannot yet act upon it, these assumptions "break" the additional interactions that would arise in a standard OLG model, on top of the ones already present. In such a model, young and old adults would vote simultaneously, therefore on blocking and public-goods policies at the same time, leading to a single government budget constraint (hence, crowding out between the costs of blocking and those of public goods). Moreover, the political-competition game determining who gets to set (χ, G, T) would feature *not just four but eight* social groups, each with different preferences: *(old/young, religious/secular, rich/poor).* Such a model would be intractable, leading to opacity rather than additional insights.

E.2 Integration of State and Church

We analyze here the case where there is no State-Church separation. Clearly, this requires that religious agents be in power. We therefore take this as given, or more simply focus on the case of homogenous incomes, which delivers this outcome. In the baseline model, religious citizens and the Church had the same value bG for religious public goods (or laws); their payoffs differed because citizens also have an income endowment from which they consume and pay taxes, while only the Church paid the cost ηb for doctrinal repairing. A natural unitary objective function merges (1) and (3), so that the unified State-Church body now maximizes

$$U_t^i = \mathbb{E}_t[c_t^i - \rho_t \eta b_t + c_{t+1}^i + b_{t+1}G_{t+1}]. \tag{E.3}$$

Up to a renormalization, this is equivalent to summing (1) and (3), which corresponds to the case where Church and State are nominally distinct but can make compensating lump-sum transfers to each other. The political game is the same as before, except that now the unified State-Church player decides sequentially: (i) whether to block belief-eroding innovations ex ante; (ii) if it hasn't, whether to repair the doctrine ex post when one occurs, or do nothing; (iii) its preferred provision of both secular and religious public good; this last aspect is unchanged, and still described by Proposition 1.

Naturally, when Church-State is an integrated actor it will choose, between blocking and repair, the one instrument that is the most efficient, weighing all the (direct and opportunity) costs and benefits of each option according to (E.3). Intuition suggests, and we shall verify, that the outcome will depend in the same straightforward way as before on the cost η and effectiveness q of repair, and on the setup cost for blocking, $\varphi(a)$. How the decision varies with the level of religiosity b, on the other hand, now leads to a richer set of possibilities. We shall both: (i) provide intuitive conditions for the blocking locus to remain upward-sloping everywhere, demonstrating the robustness to State-Church merging of the whole dynamical system, and in particular of the feature that increased religiosity makes blocking more likely, generating an absorbing basin of attraction; (b) show that, absent such conditions, parts of the blocking locus may now be downward-sloping, reversing this last feature; a sufficiently strong and coordinated religious state will then find reform more efficient than blocking.

E.2.1 State-Church's Belief-Repairing Strategy

The State-Church entity will now invest in doctrinal adaptation if

$$q\left[1-\tau^*(b)+bR(\tau^*(b))\right]+(1-q)\left[1-\tau^*\left(b'\right)+b'R(\tau^*\left(b'\right))\right]-\eta b\geq 1-\tau^*\left(b'\right)+b'R(\tau^*\left(b'\right)), \tag{E.4}$$

with $b'=(1-\delta)\,b$ when $b\geq\nu/(1-\delta)$. When $b\in(\nu,\nu/(1-\delta))$ the condition is unchanged except that b' is replaced by ν.

1. For $b\geq\nu/(1-\delta)$, we can rewrite (E.4) as:

$$\pi(b,\nu)\equiv\frac{-\tau^*(b)+bR(\tau^*(b))+\tau^*(b')-b'R(\tau^*(b'))}{b}\geq\frac{\eta}{q}. \tag{E.5}$$

Using the first-order conditions (5) defining $\tau^*(b)$ and $\tau^*(b')$, we have

$$\frac{\partial\pi(b,\nu)}{\partial b}\equiv\frac{\tau^*(b)-\tau^*(b')}{b^2}>0,$$

since $b'<b$ and $\tau^*(b)$ is increasing in b.

2. For $b\in(\nu,\nu/(1-\delta))$, the repairing condition can be rewritten as

$$\pi(b,\nu)\equiv\frac{-\tau^*(b)+bR(\tau^*(b))+\tau^*(\nu)-\nu R(\tau^*(\nu))}{b}\geq\frac{\eta}{q}. \tag{E.6}$$

Using again the first order condition for $\tau^*(b)$, we have in this range

$$\frac{\partial \pi(b,\nu)}{\partial b} \equiv \frac{\tau^*(b) - \tau^*(\nu) + \nu R(\tau^*(\nu))}{b^2} \geq 0,$$

since the optimality of fiscal decisions requires that $\tau^*(\nu) \leq \nu R(\tau^*(\nu))$. Thus, $\pi(b,\nu)$ is increasing in b over $\mathbb{R}_+$ (whereas in the baseline case it was hill-shaped), up to the point where it reaches its maximal value of $\delta R(\hat{\tau})$; $\pi(b,\nu)$ is also continuous everywhere, and it is equal zero to for $b \leq \nu$; see Figure E.1.

Proposition 12 *When $\eta/q < \delta R(\hat{\tau})$, there exists a unique threshold $\hat{b} > \nu$, defined as $\pi(\hat{b},\nu) = \eta/q$, such that the State-Church entity attempts doctrinal repair following unblocked belief-eroding innovations if and only if $b \geq \hat{b}$. If $\eta/q > \delta R(\hat{\tau})$, repairing is never optimal.*

E.2.2 State-Church Policy Toward Science

The analysis of blocking when there is no repairing (i.e., $b < \hat{b}$) is exactly the same as in the baseline framework. In particular, there is no blocking when $b < \nu$, and for $\nu \leq b < \hat{b}$ Proposition 3 applies. The State-Church entity thus blocks BR discoveries if and only if (a,b) lies above the *upward-sloping locus* $b = B^1(a)$ in the first case, or $b = B^2(a)$ in the second.

• **Characterization of the blocking region for** $b \geq \hat{b}$. It remains to examine the choice of the State-Church entity between blocking and repairing when $b \geq \hat{b}$. Its value from blocking BR discoveries is the same as in (9), i.e.

$$V^B(a,b) = 1 - R^{-1}(\varphi(a)) + [1 - \lambda + \lambda p_R + \lambda(1-p_R)(1+\gamma)]\, V(b), \tag{E.7}$$

where $V(b) = 1 - \tau^*(b) + bR(\tau^*(b))$ is its second-period utility, defined by (8) in Section 5.3. As to the value of repairing, it is

$$\begin{aligned} V^R(a,b) \quad = \quad & 1 + [1 - \lambda + \lambda(1-p_R)(1+\gamma) + \lambda p_R q(1+\gamma)]\, V(b) \\ & + \lambda p_R (1-q)(1+\gamma)\, V(b') - \lambda p_R \eta b, \end{aligned} \tag{E.8}$$

where $V(b')$ is defined as follows:

(1) High religiosity: when $b \geq \max\{\hat{b},\ \nu/(1-\delta)\}$, we have $V(b') = 1 - \tau^*(b') + b'R(\tau^*(b'))$, with $b' \equiv (1-\delta)b$.

(2) Intermediate religiosity: when $\hat{b} \leq b < \nu/(1-\delta)$, we have $V(b') = V(\nu) = 1 - \tau^*(\nu) + \nu R(\tau^*(\nu))$.

Using (9) and (E.8) and rearranging terms, it follows that blocking is preferred to repairing, $V^B(a,b) \geq V^R(a,b)$, when

$$R^{-1}\left(\varphi\left(a\right)\right) \leq \lambda p_R \left\{\eta b - \left[q\left(1+\gamma\right)-1\right]V\left(b\right) - \left(1-q\right)\left(1+\gamma\right)V\left(b'\right)\right\} \equiv \Delta^1(b). \tag{E.9}$$

As the term on the left is positive (and increasing in TFP a), the occurrence of blocking requires that $\Delta^1(b) > 0$. From (E.9), note that Assumption 7, which in the baseline framework ensures that there is never blocking ($\Delta^1(b) \leq 0$) when the Church is willing to attempt repair, no longer guarantees this recursivity. This is because the single State-Church entity now making both choices internalizes the cost of repairing ηb, which, other things equal, makes blocking relatively more attractive than under State-Church separation.

We also observe, intuitively, that the possibility of blocking ($\Delta^1(b) > 0$) is greater, the higher is the cost of repairing η, and the lower its probability of success q or/and the TFP gains γ forsaken by blocking.

We next provide explicit conditions for blocking to occur over a nonempty region, while Assumption 7 continues to hold. If $\eta/q < \delta R(\hat{\tau})$, then by Proposition 12 $\hat{b} < +\infty$ and for all $b \geq \hat{b}$, repairing is preferred to doing nothing. Since blocking is preferred to repairing for some positive range of a's if and only if $\Delta^1(b) > 0$, it will actually occur for all (a,b) with a in that range and $b \geq \hat{b}$ if and only if

$$\left[q\left(1+\gamma\right)-1\right]V\left(b\right) + \left(1-q\right)\left(1+\gamma\right)V\left(b'\right) < \eta b \leq q\delta b R(\hat{\tau}). \tag{E.10}$$

As the leftmost term is increasing in b, this condition becomes, for b large enough (so that $\tau^*(b) = \hat{\tau}$ and hence $V\left(b\right) = 1 - \hat{\tau} + bR\left(\hat{\tau}\right)$ and $V\left(b'\right) = 1 - \hat{\tau} + \left(1-\delta\right)bR\left(\hat{\tau}\right))$:

$$[\gamma - \delta\left(1-q\right)\left(1+\gamma\right)]R(\hat{\tau}) < \eta < q\delta R(\hat{\tau}),$$

which defines a non-empty interval for η if and only if $\gamma - \delta\left(1-q\right)\left(1+\gamma\right) < q\delta$, or equivalently:

$$\delta > \frac{\gamma}{1+\gamma\left(1-q\right)}. \tag{E.11}$$

This requires that $q\gamma < 1$, but the latter is compatible with $q\left(1+\gamma\right) \geq 1$. Suppose, finally, that $\eta/q \geq \delta R(\hat{\tau})$, so that $\hat{b} = +\infty$, i.e. repairing is never optimal. Blocking will occur when $V^B(a,b) > 0$, which by (E.7) defines for any b a nonempty interval for a, and conversely for any a will hold for all b large enough, as $V(b) \approx bR(\hat{\tau}))$ also becomes arbitrarily large.

• **Shape of the blocking locus** $B^1(a)$. If this boundary is increasing, as in the benchmark model, then once again as a country becomes more religious, blocking becomes more likely (in particular, relative to repairing). If it is decreasing, or non-monotonic, on the other hand, the reverse may happen. In what follows, we provide conditions, and intuitions, for both cases.

Since the left-hand side of (E.9) is increasing in a (a more scientifically advanced country is still always less likely to block), the blocking boundary will be upward-sloping if and only if

$\Delta^1(b)$ is increasing in b. The same two cases as in (E.8) must be distinguished.

(1) High religiosity: $b \geq \max\{\hat{b}, \nu/(1-\delta)\}$. We have

$$\frac{\partial \Delta^1(b)}{\partial b} = \lambda p_R \left\{\eta - [q(1+\gamma)-1] R(\tau^*(b)) - (1-q)(1+\gamma)(1-\delta) R\left(\tau^*\left(b'\right)\right)\right\}, \tag{E.12}$$

as the first order conditions for $\tau^*(b)$ and $\tau^*(b')$ imply respectively that $\partial V(b)/\partial b = R(\tau^*(b))$ and $\partial V(b')/\partial b = (1-\delta) R(\tau^*(b'))$. From (E.12) it is immediate that $\partial^2 \Delta^1(b)/\partial b^2 \leq 0$ for all b, so $\partial \Delta^1(b)/\partial b$ is monotonically decreasing in b. Its minimum value is thus achieved at all b above the threshold $\breve{b}$ defined by $\tau^*(\breve{b}/(1-\delta)) = \hat{\tau}$, and equal to

$$\min_b \left\{\frac{\partial \Delta^1(b)}{\partial b}\right\} = \left.\frac{\partial \Delta^1(b)}{\partial b}\right|_{b \geq \breve{b}} = \lambda p_R \left\{\eta - [q(1+\gamma)-1] R(\hat{\tau}) - (1-q)(1+\gamma)(1-\delta) R(\hat{\tau})\right\}, \tag{E.13}$$

which is positive when[54]

$$\eta > [\gamma - \delta(1-q)(1+\gamma)] R(\hat{\tau}). \tag{E.14}$$

In particular, if

$$\delta(1-q) > \frac{\gamma}{1+\gamma}, \tag{E.15}$$

condition (E.14) is automatically satisfied, and it is easy to see that (E.11) is also implied.

When (E.14) holds, so that the minimum value of $\partial \Delta^1(b)/\partial b$ in (E.13) is positive, equation (E.9) with the equality sign defines an *upward-sloping* blocking locus, $b = B^1(a)$; see Figure E.2a. Blocking will take place when (a, b) is above (equivalently, to the left of) this schedule, and repairing (or, for b low enough, neither) when it is below. Moreover, as a becomes large, $\varphi(a)$ tends to $\overline{\varphi} < R(\hat{\tau})$, implying that $B^1(a)$ tends to the horizontal asymptote $\Delta^1(b) = R(\bar{\varphi})$, as illustrated in Figure E.2a.

Note, finally, that the condition (E.13) for an upward-sloping locus (or the stronger E.15) is quite intuitive: as b rises, the cost of repairing ηb must increase faster than the *opportunity cost* of blocking (i.e., leaving aside the fixed cost $\varphi(a)$), which is the difference between religious consumption $bG \precapprox bR(\hat{\tau})$ lost due to foregone TFP growth γ and that lost due to eroded faith following a failed repair attempt.

When (E.13) is reversed, conversely, the blocking locus $B^1(a)$ will not be positively sloped everywhere: since $\partial \Delta^1(b)/\partial b$ is monotonically decreasing in b, its sign may become negative when religiosity exceeds a certain threshold; formally, if $\partial \Delta^1(b)/\partial b\big|_{b=\hat{b}} > 0$ but $\partial \Delta^1(b)/\partial b\big|_{b=\breve{b}} <$ 0, the blocking locus $B^1(a)$ has first a positive and then a negative slope as b rises, as illustrated in Figure E.2b. If instead $\Delta^1(b) > 0$ but $\partial \Delta^1(b)/\partial b\big|_{b=\hat{b}} < 0$, we have $\partial \Delta^1(b)/\partial b < 0$

[54] Recall also that the maximal value of $\pi(b, \nu)$ is $\delta R(\hat{\tau})$, so the only restriction on η follows from $\delta R(\hat{\tau}) \geq \eta/q$. Therefore, substituting $\eta = q\delta R(\hat{\tau})$ into (E.14), the parameter space satisfying (E.14) is non-empty as long as $\delta > \gamma/[1+\gamma(1-q)]$, which is again condition (E.11).

for all $b \geq \hat{b}$, so the blocking locus $B^1(a)$ will be decreasing everywhere, as in Figure E.2c. In particular, we can provide a sufficient condition for $B^1(a)$ to be negatively sloped (at least over some range): combining equation (E.11), which ensures a non-empty blocking region above $\hat{b}$, with the opposite of (E.15), which ensures that, for some nonempty range of η, (E.14) is reversed, so that $\min_b\{\partial\Delta^1/\partial b\} < 0$, yields:

$$\frac{\gamma}{1+(1-q)\gamma} < \delta < \frac{\gamma}{(1-q)(1+\gamma)}. \tag{E.16}$$

(2) Intermediate religiosity: $\hat{b} \leq b < \nu/(1-\delta)$. In this range, the blocking locus is defined by equation (E.9) with the equality sign and $V(b') \equiv V(\nu)$.[55] Its slope, (E.12) now becomes

$$\frac{\partial\Delta^1(b)}{\partial b} = \lambda p_R \left\{\eta - [q(1+\gamma)-1] R(\tau^*(b))\right\}. \tag{E.17}$$

From Assumption 7, i.e. $q(1+\gamma) > 1$, and $R(\tau^*(b)) \leq R(\hat{\tau})$, it follows that

$$\eta > [q(1+\gamma)-1] R(\hat{\tau}) = [\gamma - (1-q)(1+\gamma)] R(\hat{\tau}) \tag{E.18}$$

ensures that $\partial\Delta^1(b)/\partial b$ is always positive, and therefore the $b = B^1(a)$ locus is upward-sloping in this range; see again Figure E.2a. The interpretation is similar to the previous case, except that now if repair fails the entire value of religious consumption is lost, as the secular public good will be preferred.

As before, absent (E.18) $B^1(a)$ could be nonmonotonic (first increasing, then decreasing), or monotonically decreasing in b, in this region as well. This occurs, for some nonempty range of η, when the right-hand-side of (E.18) is positive (which, in turn, ensures that (E.11) holds), that is:

$$\delta > \frac{\gamma}{(1-q)(1+\gamma)}. \tag{E.19}$$

Finally, comparing (E.12) and (E.17) shows that $\partial\Delta^1(b)/\partial b$ is larger in absolute value in case (1) than in case (2), which implies that the blocking locus is steeper when $\hat{b} \leq b < \nu/(1-\delta)$ than when $\nu/(1-\delta) \leq \hat{b} \leq b$; see again Figure E.2c.

E.2.3 Dynamics of Scientific Progress and Religiosity: Summary

As established above and illustrated by Figures E.2a and E.2c, we see that, in countries where there is no separation between State and Church (presumably requiring a relatively high level of religiosity to start with):

[55] The earlier analysis on the non-emptiness of the parameter space for blocking remains unchanged in this region, now simply setting $V(b') = V(\nu)$.

(a) As before, it remains the case that belief-eroding innovations are likely to be blocked when the economy is not well developed in terms of scientific and technical knowledge, whereas religious doctrines becomes more likely to adapt as the economy grows.

(b) It also remains the case that, when religiosity is higher than a certain threshold $\hat{b}$, there is always either blocking of BR innovations or repairing of beliefs –both ways of preserving valuable religious capital.

(c) Under a simple and intuitive condition, it remains the case that higher religiosity makes blocking relatively more likely than repairing, leading again to stagnating theocracies, and more generally leaving all results from the benchmark model qualitatively unchanged. Under alternative parameter configurations, which we also provide, this particular ranking of policies can be reversed in part of the phase diagram, making it easier for even slow knowledge growth (e.g., due only to neutral innovations) to ultimately move the economy outside of the stagnation region.

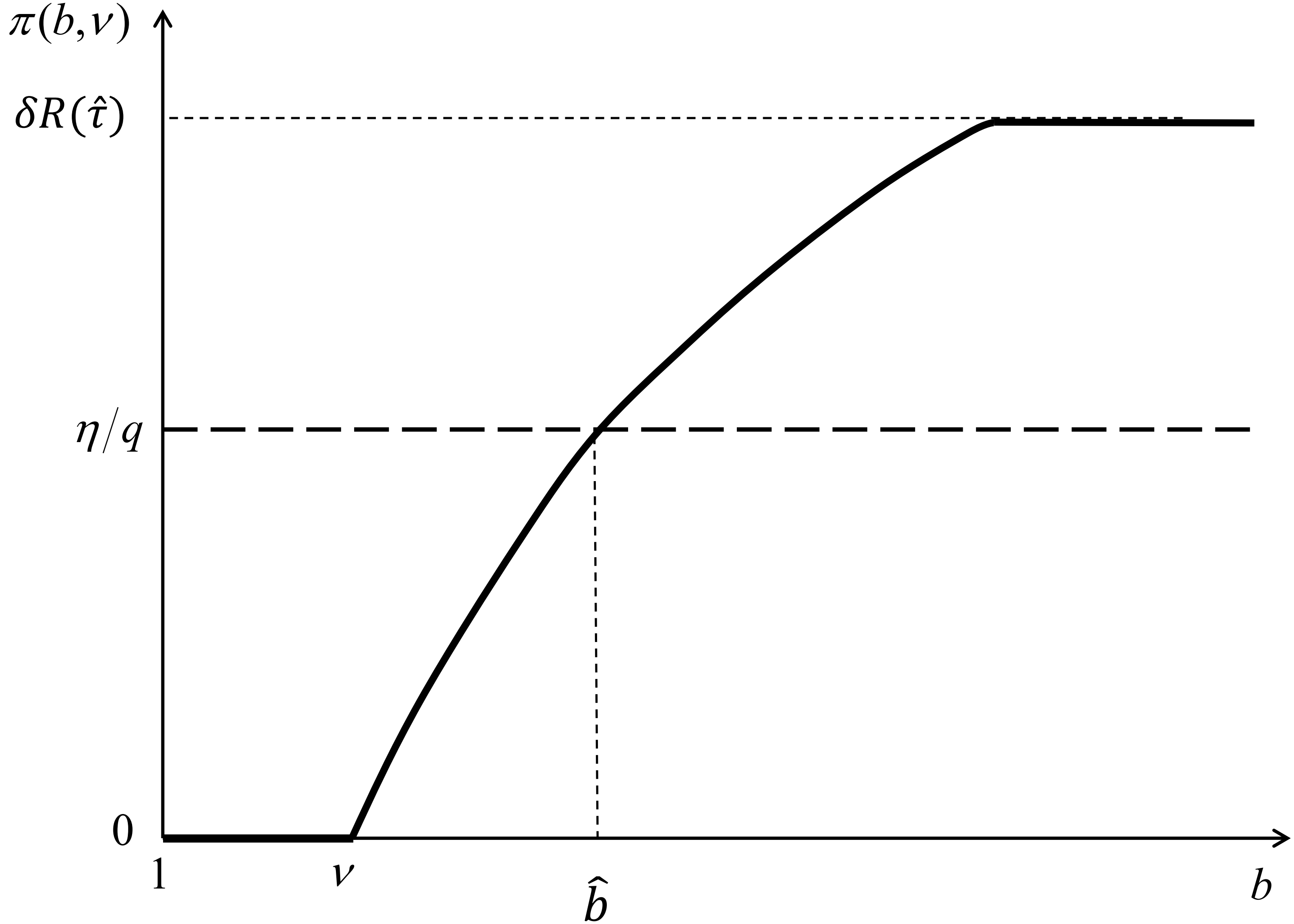


Figure E.1: Return to doctrinal repair for an integrated State-Church entity

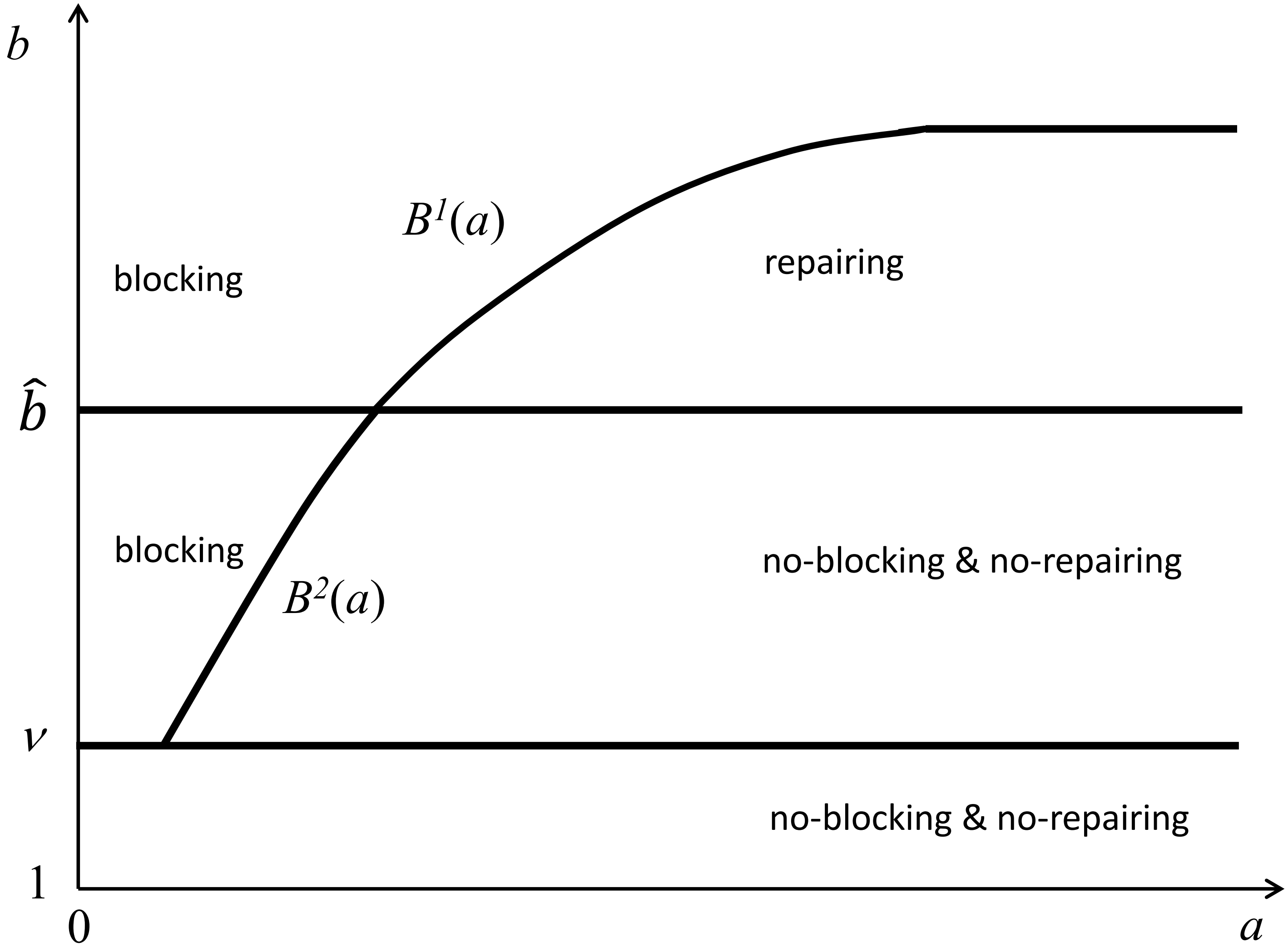


Figure E.2a: Repairing and blocking regions, with increasing locus *B(a)*

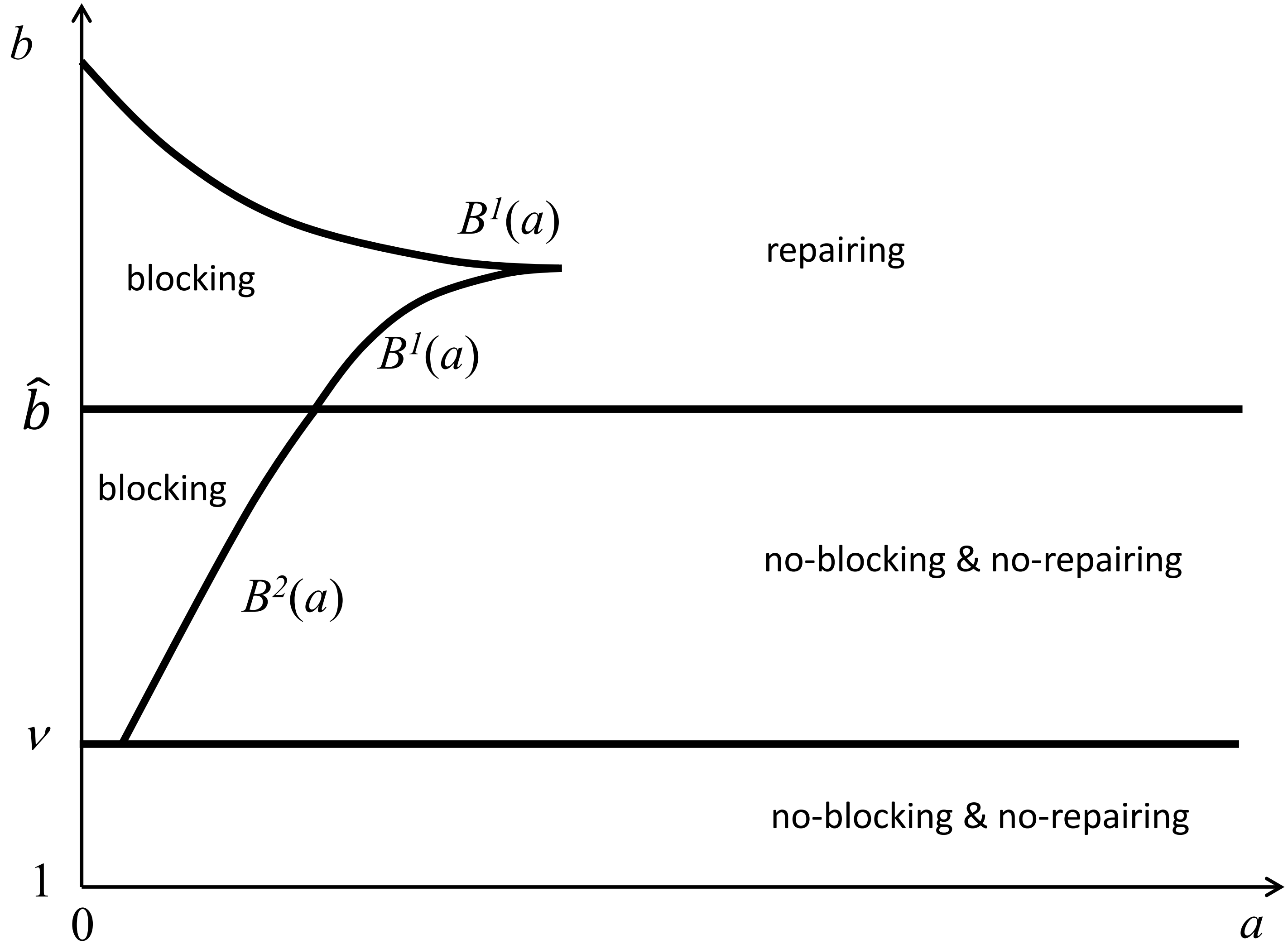


Figure E.2b: Repairing and blocking regions, with nonmonotonic locus $B^1(a)$

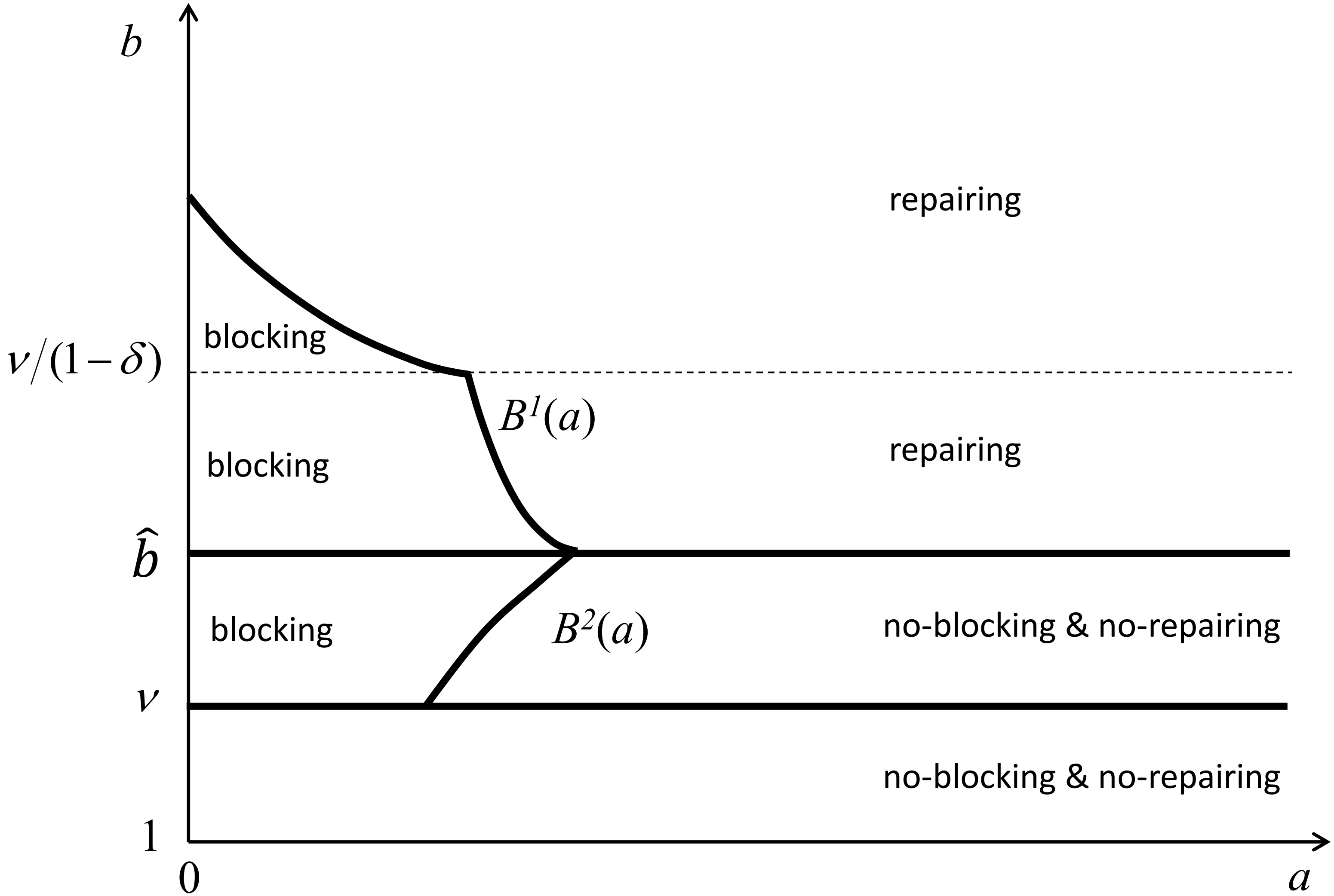


Figure E.2c: Repairing and blocking regions, with decreasing locus *$B^1(a)$*; shown here for $\hat{b} < \nu/(1-\delta)$

APPENDIX F: Innovation and Religiosity Across Countries and States – Robustness Checks

Section F.1 presents the robustness checks for the international cross-country analysis, and Section F.2 those for the U.S. cross-state analysis.

F.1 Cross-Country Patterns: Robustness Checks

Subsection F.1.1 contains the estimates and scatterplots for the relationship between religiosity and innovation with all five measures of religiosity not shown in the main text (Table F.1, Figures F.1-F.4).

Subsection F.1.2 reports the material for the robustness checks when:

- using total patents per capita, namely those filed in a country by both residents and foreigners, in place of patents per capita by residents (Table F.2);
- the control set includes dummies for current and formerly Communist countries, as well their interactions with religiosity measures (Table F.3, Figures F.5a-5b);
- using controls for the population shares of major religions, rather than which one is dominant (Table F.4).

F.1.1 Robustness checks with other measures of religiosity

We first reproduce Table 2 (also included in the main text), which contains the estimates for the three main measures of religiosity—*Religious person*, *Belief in God*, *Church attendance.* Table F.1 next provides the estimates for all specifications using the other two indexes—*Importance of religion*, *God very important*. We then show the scatterplots displaying the unconditional and conditional relationships between all five measures of religiosity and the level of innovation (Figures 1a-1b, contained also in the main text, followed by Figures F.1-F.4).

For each of the five religiosity variables, we list below the corresponding figures showing the unconditional and the conditional relationships (baseline specification), as well as the table and column containing the corresponding estimate:

(i) *Religious person*: Figures 1a, 1b (Table 2: Columns 1, 4).
(ii) *Belief in God*: Figures F.1a, F.1b (Table 2: Columns 2, 5).
(iii) *Church attendance*: Figures F.2a, F.2b (Table 2: Columns 3, 6).
(iv) *Importance of religion*: Figures F.3a, F.3b (Table F.1: Columns 1, 3).
(v) *God very important*: Figures F.4a, F.4b (Table F.1: Columns 2, 4).

TABLE 2: Religiosity and Innovation: Cross−Country Estimates

Dep. var.: *Residents' patents per capita (log)*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Religiosity	–4.668***			–2.377***			–2.280***			–1.871***		
	(1.103)			(0.573)			(0.597)			(0.656)		
Belief in God		–5.309***			–2.493***			–2.319***			–1.826***	
		(1.307)			(0.728)			(0.742)			(0.679)	
Church attendance			–5.468***			–2.305***			–1.917***			–1.129
			(0.962)			(0.717)			(0.684)			(0.798)
Religious freedom				0.005	0.015*	0.015	–0.005	0.005	0.004	–0.003	0.008	–0.001
				(0.009)	(0.009)	(0.010)	(0.009)	(0.009)	(0.009)	(0.012)	(0.011)	(0.013)
GDP per capita (log)				1.082***	1.143***	1.056***	0.754***	0.853***	0.771***	0.875***	0.986***	0.867***
				(0.171)	(0.177)	(0.160)	(0.182)	(0.184)	(0.154)	(0.187)	(0.180)	(0.180)
Population (log)				0.128	0.107	0.188**	0.068	0.052	0.129	0.103	0.081	0.121
				(0.077)	(0.077)	(0.086)	(0.076)	(0.075)	(0.083)	(0.081)	(0.069)	(0.083)
Protection intellectual property				0.105	0.034	0.044	0.608***	0.474***	0.535***	0.536***	0.406***	0.541***
				(0.120)	(0.124)	(0.123)	(0.173)	(0.159)	(0.151)	(0.177)	(0.150)	(0.161)
Tertiary education (years)				0.930**	0.813*	0.806*	1.309***	1.171***	1.187***	0.850*	0.581	0.844*
				(0.457)	(0.436)	(0.427)	(0.435)	(0.409)	(0.447)	(0.455)	(0.382)	(0.491)
Foreign direct investment				–0.019*	–0.020*	–0.014	–0.010	–0.011	–0.005	0.009	–0.011	–0.006
				(0.010)	(0.012)	(0.012)	(0.009)	(0.010)	(0.011)	(0.010)	(0.012)	(0.011)
Protestant (pred.)										–0.068	–0.089	–0.275
										(0.286)	(0.322)	(0.314)
Catholic (pred.)										–0.451	–0.515*	–0.689**
										(0.282)	(0.271)	(0.295)
Muslim (pred.)										–0.414	–0.495	–0.642
										(0.536)	(0.542)	(0.588)
Orthodox (pred.)										0.589	0.730	0.179
										(0.546)	(0.545)	(0.545)
Year fixed effects							YES	YES	YES	YES	YES	YES
Constant	–6.916***	–5.611***	–8.599***	–21.956***	–22.191***	–24.198***	–17.769***	–18.479***	–20.335***	–19.391***	–20.291***	–21.591***
	(0.786)	(1.095)	(0.273)	(2.231)	(2.410)	(2.253)	(2.414)	(2.496)	(2.235)	(2.734)	(2.678)	(2.585)
Observations	278	220	281	221	172	224	221	172	224	220	171	222
Adjusted R−squared	0.198	0.234	0.324	0.698	0.720	0.690	0.743	0.757	0.728	0.756	0.777	0.739

Notes: OLS estimates. Standard errors (in parentheses) are clustered by country. *Significant at 10%; **significant at 5%; ***significant at 1%.

TABLE F.1

Religiosity and Innovation: Cross−Country Estimates. *Robustness with other measures of religiosity*

Dep. var.: *Residents' patents per capita (log)*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Importance of religion	–5.140***		–2.368***		–2.018***		–1.833***	
	(0.809)		(0.434)		(0.425)		(0.518)	
God very important		–5.017***		–2.517***		–2.198***		–2.236***
		(0.513)		(0.432)		(0.427)		(0.544)
Religious freedom			0.003	0.004	–0.004	–0.002	0.001	0.008
			(0.009)	(0.009)	(0.010)	(0.009)	(0.012)	(0.012)
GDP per capita (log)			0.906***	0.952***	0.732***	0.752***	0.844***	0.852***
			(0.160)	(0.151)	(0.164)	(0.163)	(0.179)	(0.178)
Population (log)			0.152**	0.154**	0.115	0.111	0.136	0.126
			(0.069)	(0.076)	(0.072)	(0.079)	(0.083)	(0.081)
Protection intellectual property			0.196	0.062	0.581**	0.424**	0.530***	0.380**
			(0.119)	(0.112)	(0.164)	(0.166)	(0.169)	(0.170)
Tertiary education (years)			1.093**	0.889**	1.297***	1.185***	0.874*	0.851*
			(0.432)	(0.384)	(0.438)	(0.386)	(0.482)	(0.446)
Foreign direct investment			–0.013	–0.014	–0.007	–0.008	–0.006	–0.008
			(0.011)	(0.011)	(0.010)	(0.010)	(0.011)	(0.011)
Protestant (pred.)							–0.101	–0.030
							(0.321)	(0.285)
Catholic (pred.)							–0.509	–0.355
							(0.307)	(0.279)
Muslim (pred.)							–0.125	0.412
							(0.564)	(0.591)
Orthodox (pred.)							0.513	0.522
							(0.548)	(0.548)
Year fixed effects					YES	YES	YES	YES
Constant	–6.941***	–8.131***	–21.135***	–21.560***	–19.163***	–18.975***	–20.625***	–20.668***
	(0.563)	(0.261)	(2.171)	(2.145)	(2.283)	(2.389)	(2.751)	(2.733)
Observations	262	281	207	224	207	224	205	222
Adjusted *R*−squared	0.376	0.471	0.731	0.757	0.752	0.777	0.764	0.786

Notes: OLS estimates. Standard errors (in parentheses) are clustered by country. *Significant at 10%; **significant at 5%; ***significant at 1%.

(i) *Religious person*: Figures 1a, 1b (Table 2: Columns 1, 4).

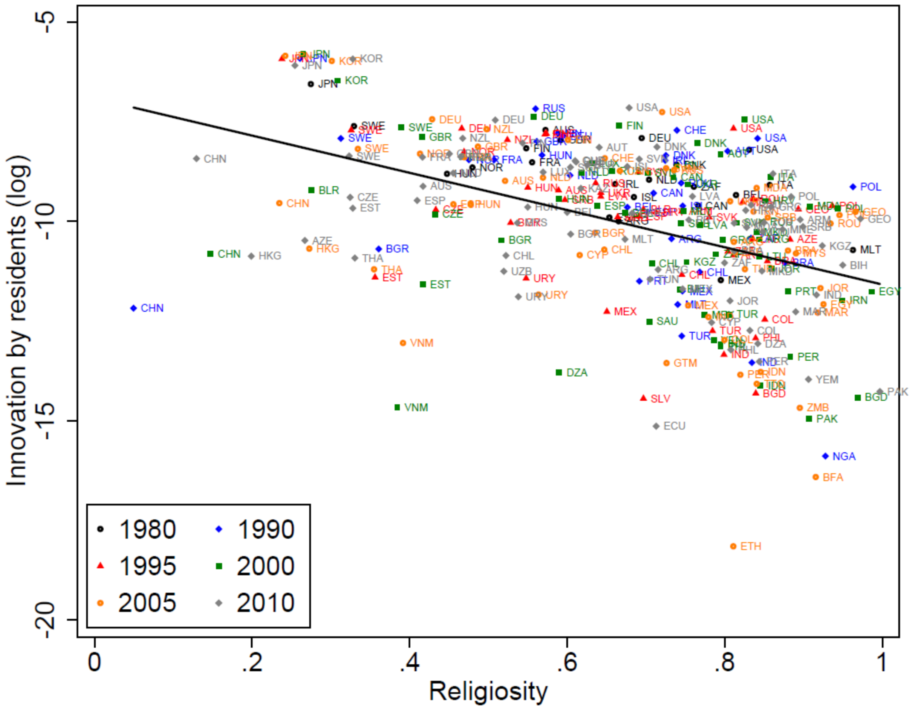


FIGURE 1a: Unconditional relationship

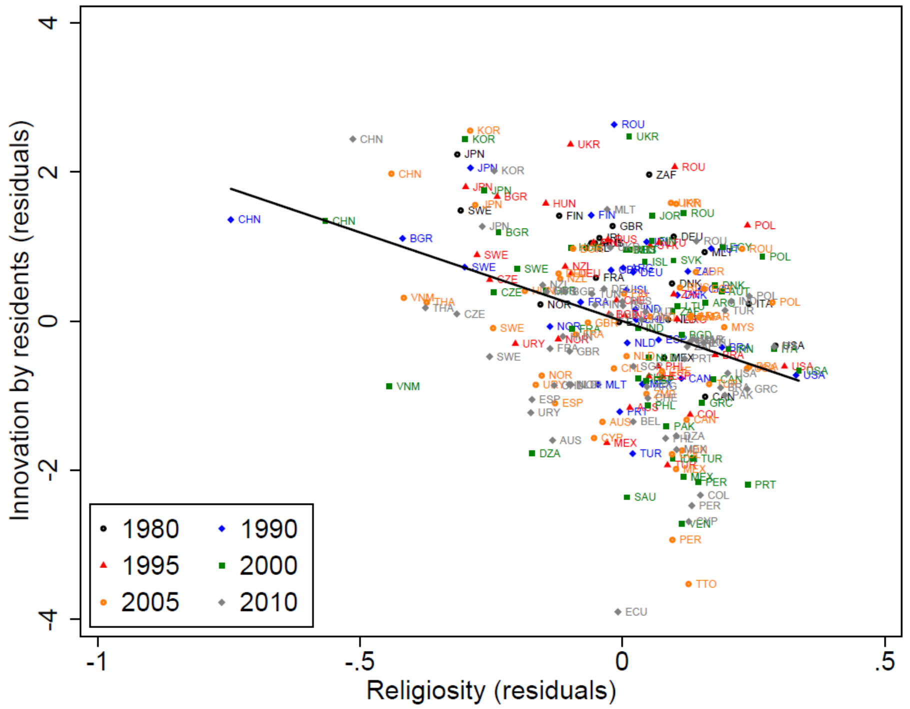


FIGURE 1b: Conditional relationship

(ii) *Belief in God*: Figures F.1a, F.1b (Table 2: Columns 2, 5).

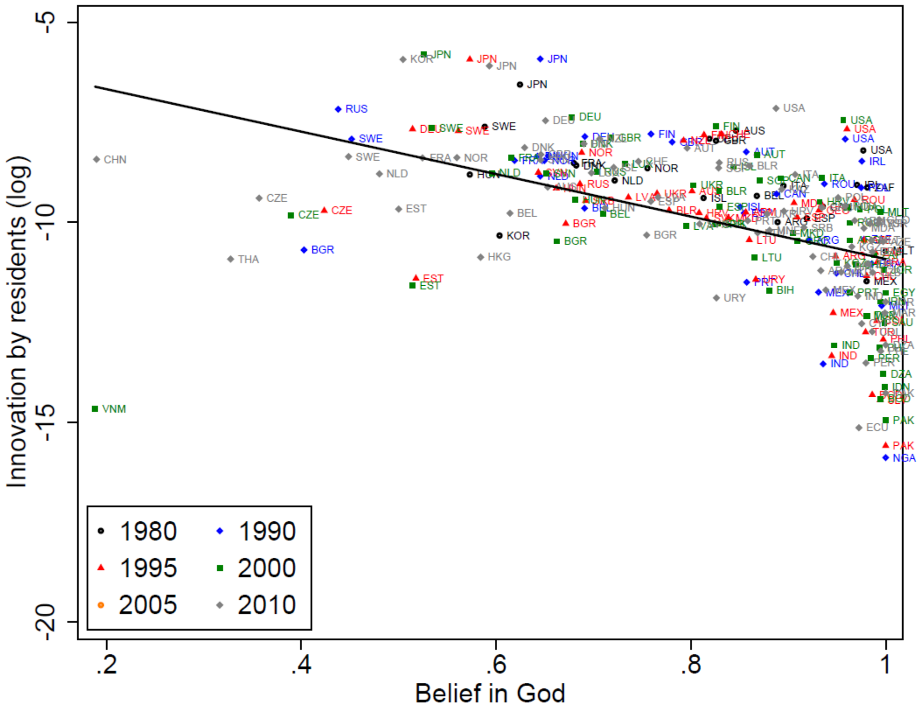


FIGURE F.1a: Unconditional relationship

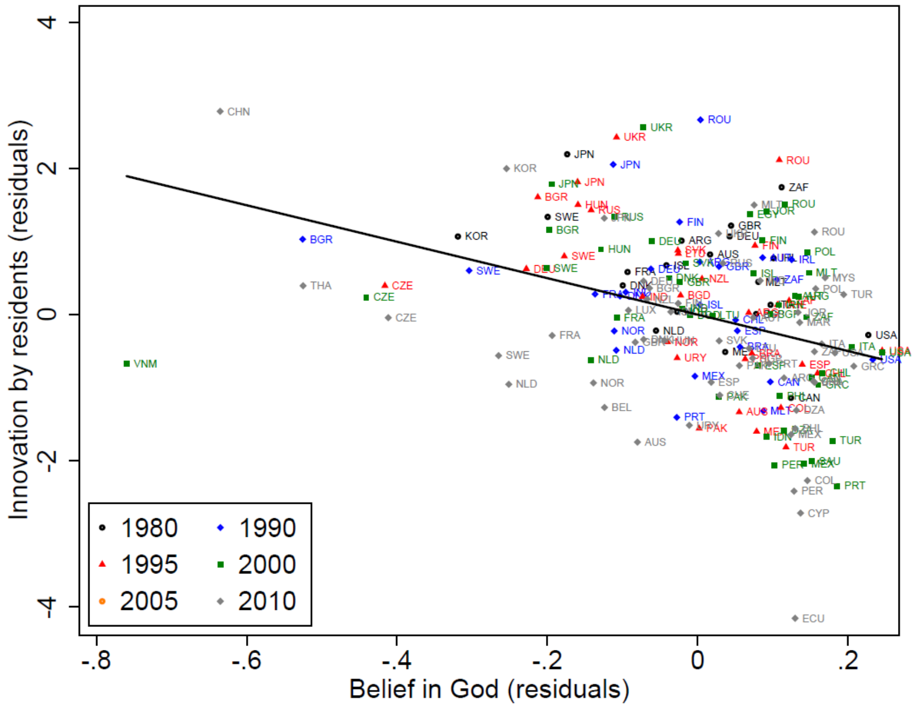


FIGURE F.1b: Conditional relationship

(iii) *Church attendance*: Figures F.2a, F.2b (Table 2: Columns 3, 6).

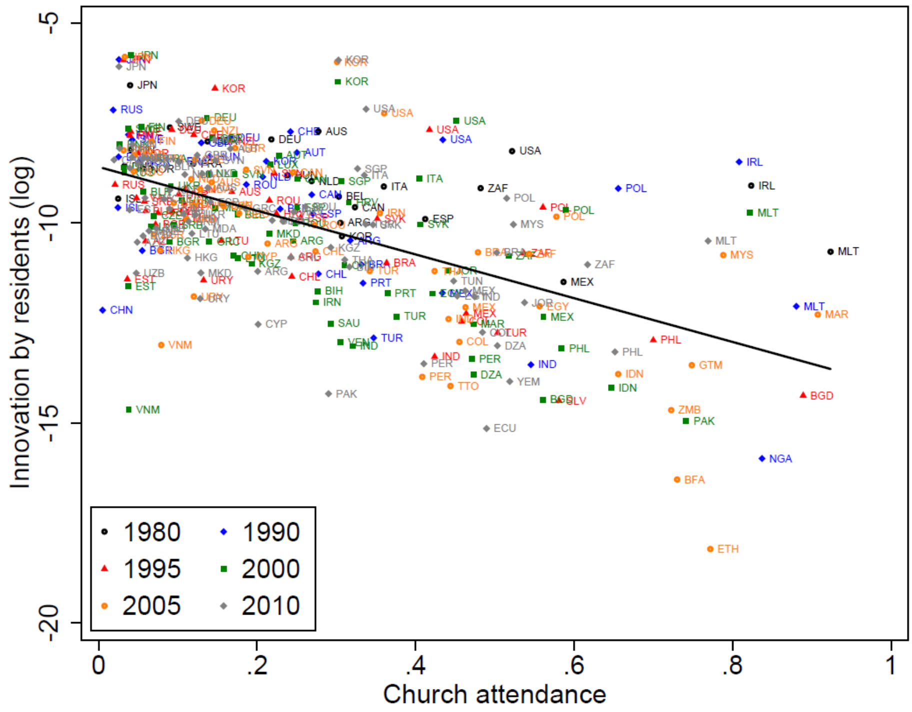


FIGURE F.2a: Unconditional relationship

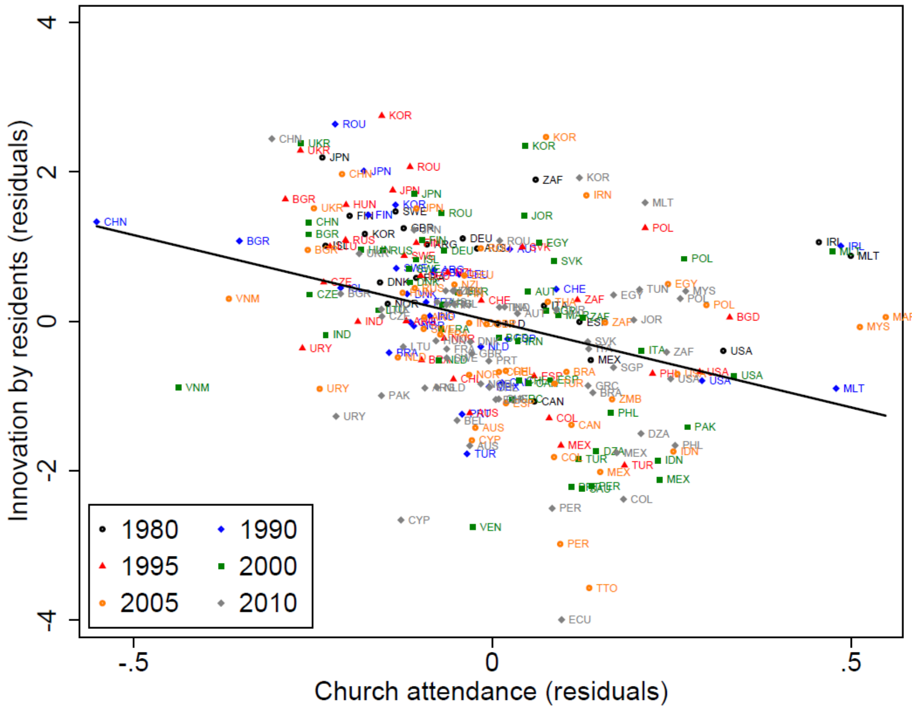


FIGURE F.2b: Conditional relationship

(iv) *Importance of religion*: Figures F.3a, F.3b (Table F.1: Columns 1, 3).

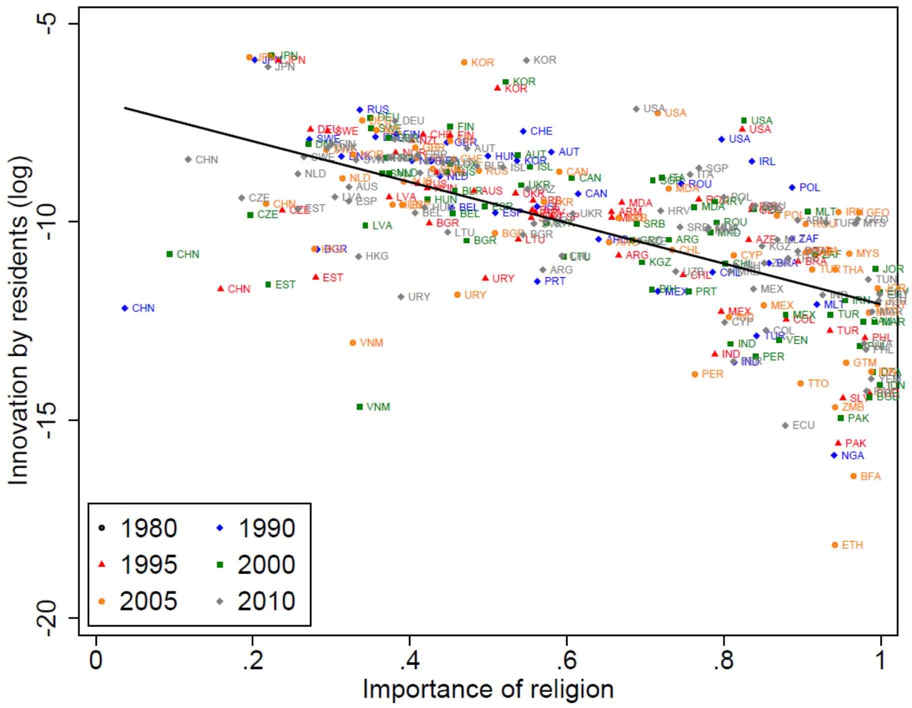


FIGURE F.3a: Unconditional relationship

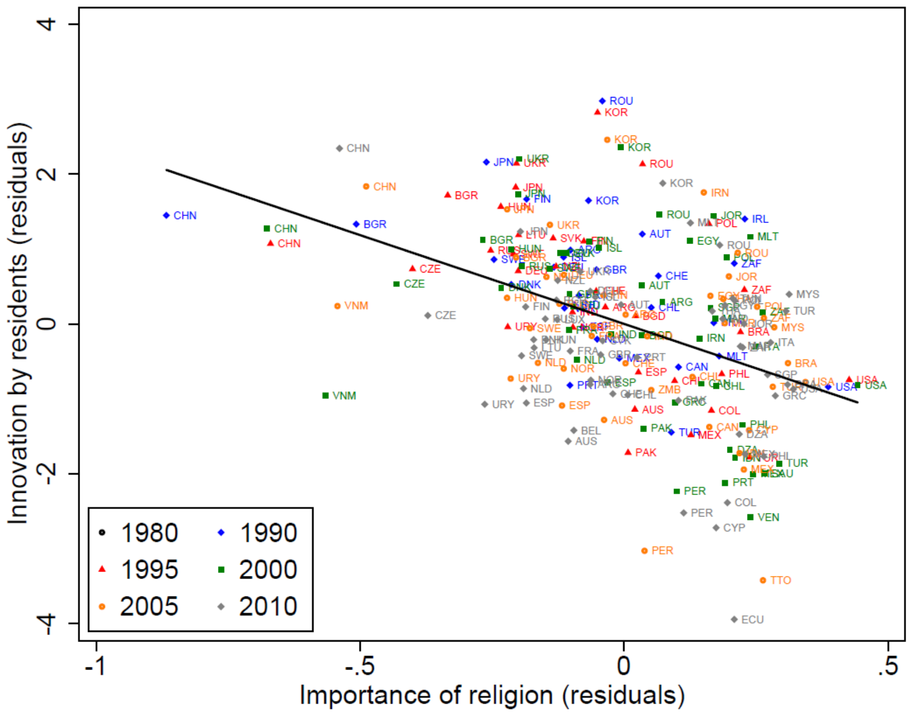


FIGURE F.3b: Conditional relationship

(v) *God very important*: Figures F.4a, F.4b (Table F.1: Columns 2, 4).

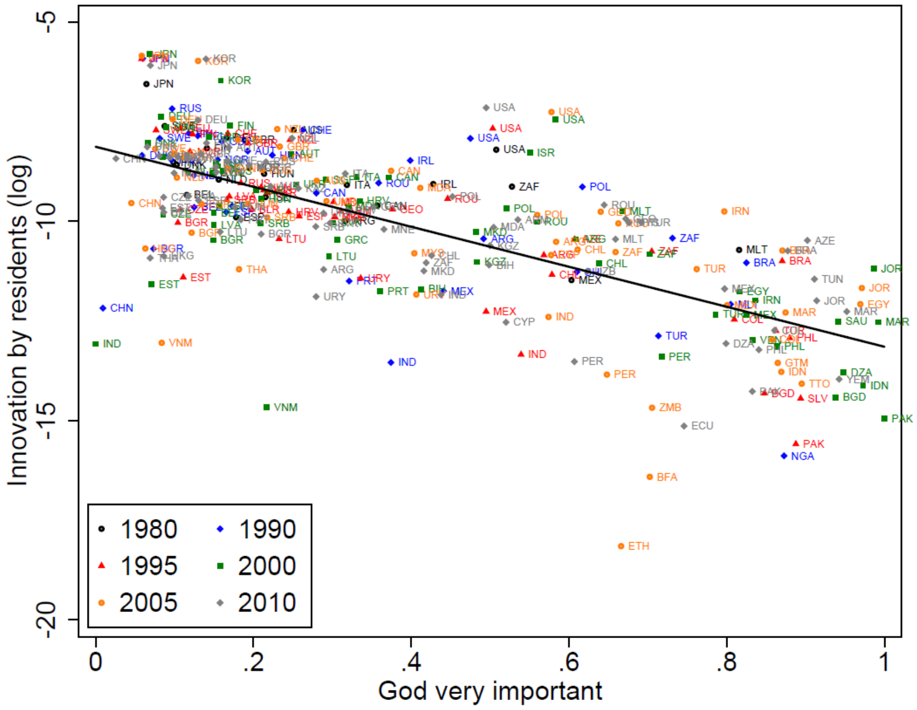


FIGURE F.4a: Unconditional relationship

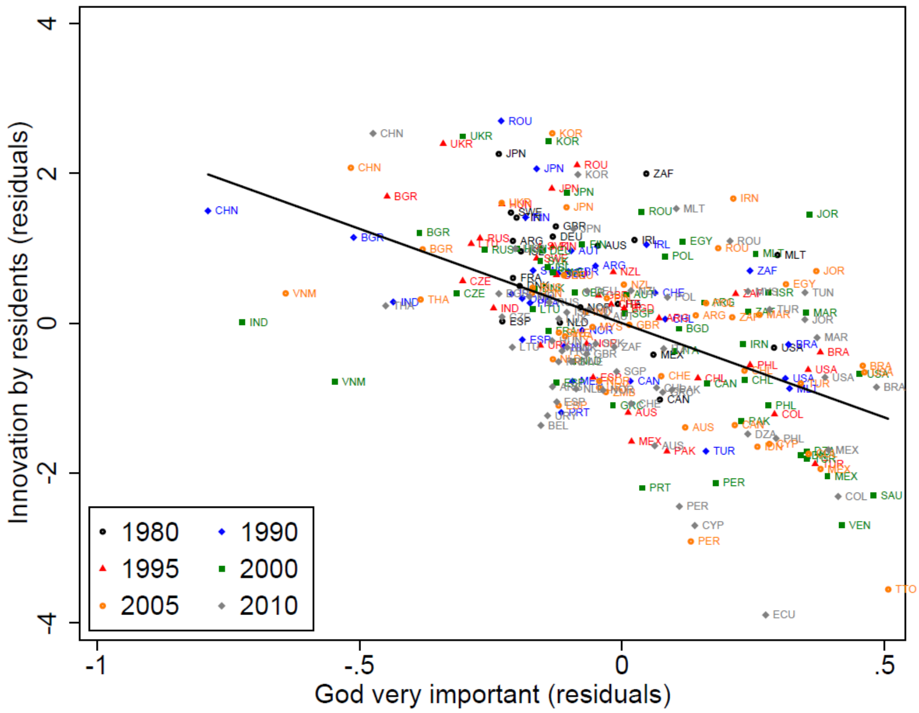


FIGURE F.4b: Conditional relationship

F.1.2 Robustness checks with total patents per capita, controlling for Communist countries, and for the population shares of major religions

In this subsection, we report the robustness checks for the international cross-country analysis when:

- using total patents per capita, namely those filed in a country by both residents and foreigners (Table F.2);
- using dummies for current and formerly Communist countries, as well their interactions with religiosity measures (Table F.3 and Figures F.5a-5b);
- controlling for the population shares of major religions, rather than which one is dominant (Table F.4).

TABLE F.2: Religiosity and Innovation: Cross−Country Estimates. *Robustness with Total patents per capita*

Dep. var.: *Total patents per capita (log)*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Religiosity	–3.909***			–1.678***			–1.681***			–1.385***		
	(0.901)			(0.367)			(0.364)			(0.449)		
Belief in God		–3.785***			–1.344***			–1.296**			–0.814	
		(0.890)			(0.472)			(0.490)			(0.530)	
Church attendance			–3.380***			–0.866**			–0.698			–0.285
			(0.792)			(0.419)			(0.444)			(0.546)
Religious freedom				0.023***	0.028***	0.027***	0.018***	0.023***	0.021***	0.017**	0.020**	0.014*
				(0.006)	(0.006)	(0.007)	(0.006)	(0.006)	(0.007)	(0.007)	(0.008)	(0.008)
GDP per capita (log)				0.795***	0.882***	0.846***	0.623***	0.712***	0.692***	0.594***	0.684***	0.643***
				(0.086)	(0.098)	(0.098)	(0.079)	(0.090)	(0.090)	(0.100)	(0.106)	(0.112)
Population (log)				0.006	0.009	0.048	–0.029	–0.025	0.014	–0.049	–0.055	–0.034
				(0.054)	(0.069)	(0.067)	(0.050)	(0.065)	(0.064)	(0.048)	(0.060)	(0.057)
Protection intellectual property				–0.091	–0.158	–0.108	0.163	0.097	0.152	0.177	0.129	0.189
				(0.097)	(0.116)	(0.111)	(0.100)	(0.116)	(0.121)	(0.109)	(0.118)	(0.118)
Tertiary education (years)				0.704***	0.656**	0.689**	0.957***	0.939***	0.950***	0.970***	0.770**	0.957***
				(0.248)	(0.288)	(0.269)	(0.228)	(0.270)	(0.288)	(0.275)	(0.290)	(0.308)
Foreign direct investment				–0.028***	–0.026**	–0.025**	–0.023**	–0.021**	–0.020**	–0.022**	–0.020**	–0.020**
				(0.009)	(0.010)	(0.011)	(0.009)	(0.010)	(0.010)	(0.009)	(0.010)	(0.009)
Protestant (pred.)										–0.086	–0.226	–0.278
										(0.221)	(0.262)	(0.237)
Catholic (pred.)										–0.370*	–0.625**	–0.643***
										(0.207)	(0.242)	(0.229)
Muslim (pred.)										–0.186	–0.481	–0.681
										(0.434)	(0.492)	(0.471)
Orthodox (pred.)										–0.420	–0.448	–0.717*
										(0.395)	(0.417)	(0.394)
Year fixed effects							YES	YES	YES	YES	YES	YES
Constant	–6.296***	–5.762***	–8.024***	–16.965***	–18.048***	–19.334***	–14.509***	–15.779***	–17.080***	–13.878***	–14.863***	–15.091***
	(0.647)	(0.742)	(0.234)	(1.375)	(1.648)	(1.663)	(1.294)	(1.541)	(1.599)	(1.459)	(1.578)	(1.577)
Observations	278	220	281	221	172	224	221	172	224	220	171	222
Adjusted R−squared	0.215	0.191	0.185	0.704	0.679	0.674	0.739	0.716	0.703	0.742	0.726	0.721

Notes: OLS estimates. Standard errors (in parentheses) are clustered by country. *Significant at 10%; **significant at 5%; ***significant at 1%

Table F.3 reports the estimates of the relationship between religiosity and innovation for all five measures of religiosity when we include a dummy for *current and former Communist countries* and its interaction term with the religiosity variable. This allows us to estimate the impact of religiosity on innovation in communist and non-communist countries.

The unconditional estimated marginal effects of religiosity on innovation in Communist and non-Communist countries are shown in Figure F.5a; they are obtained from the estimates reported in Columns 1-5 of Table F.3. The figure shows that the estimated effect of religiosity on innovation is always significantly negative in never-Communist countries, while it is always insignificant in countries that are or that experienced a Communist regime.

Figure F.5b reports the estimated marginal effects of religiosity on innovation when we include the full set of controls, corresponding to the estimates in Columns 6-10 of Table F.3. The results of the unconditional estimates are confirmed; the only exception is the estimated coefficient of Church attendance in never-Communist countries that is still negative, but no longer statistically significant at standard levels.

TABLE F.3: Religiosity and Innovation: Cross−Country Estimates. *Robustness with current and former Communist countries*

Dep. var.: *Residents' patents per capita (log)*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Religiosity	–7.772***					–2.324***				
	(1.081)					(0.835)				
Belief in God		–8.978***					–2.069**			
		(1.402)					(0.788)			
Church attendance			–6.721***					–0.667		
			(1.110)					(0.958)		
Importance of religion				–7.085***					–1.734**	
				(0.650)					(0.785)	
God very important					–5.726***					–1.997***
					(0.535)					(0.656)
Communist	–5.274***	–7.280***	–1.567***	–4.000***	–1.651***	–0.705	–1.290	1.017**	–0.310	0.298
	(0.934)	(1.608)	(0.533)	(0.790)	(0.509)	(0.731)	(1.056)	(0.484)	(0.691)	(0.461)
Religiosity x *Communist*	7.979***					3.016***				
	(1.326)					(0.992)				
Belief in God x *Communist*		8.912***					3.348**			
		(1.925)					(1.268)			
Church attendance x *Communist*			4.016					1.453		
			(2.861)					(1.248)		
Importance of religion x *Communist*				6.246***					2.722***	
				(1.255)					(0.953)	
God very important x *Communist*					3.485**					2.655***
					(1.360)					(0.996)
Religious freedom						0.002	0.010	0.005	0.005	0.011
						(0.011)	(0.010)	(0.012)	(0.012)	(0.012)
GDP per capita (log)						1.033***	1.118***	1.090***	0.985***	0.986***
						(0.173)	(0.144)	(0.183)	(0.190)	(0.184)
Population (log)						0.172**	0.150**	0.167**	0.187**	0.161*
						(0.081)	(0.070)	(0.079)	(0.084)	(0.081)
Protection intellectual property						0.379**	0.297**	0.403***	0.406**	0.286*
						(0.159)	(0.137)	(0.143)	(0.156)	(0.162)
Tertiary education (years)						0.704*	0.433	0.856*	0.897**	0.902**
						(0.367)	(0.297)	(0.465)	(0.429)	(0.406)
Foreign direct investment						–0.003	–0.004	–0.004	–0.002	–0.005
						(0.008)	(0.009)	(0.010)	(0.010)	(0.010)
Protestant (pred.)						0.024	–0.062	–0.134	–0.046	0.026
						(0.282)	(0.303)	(0.326)	(0.337)	(0.283)
Catholic (pred.)						–0.627**	–0.717***	–0.853***	–0.724**	–0.504*
						(0.254)	(0.241)	(0.277)	(0.289)	(0.268)
Muslim (pred.)						–0.065	–0.310	–0.265	0.068	0.572
						(0.538)	(0.490)	(0.571)	(0.562)	(0.585)
Orthodox (pred.)						–0.190	–0.170	–0.343	–0.339	–0.145
						(0.411)	(0.412)	(0.466)	(0.427)	(0.418)
Year fixed effects						YES	YES	YES	YES	YES
Constant	–4.877***	–2.501**	–7.990***	–5.566***	–7.675***	–21.722***	–22.301***	–23.782***	–22.810***	–22.628***
	(0.718)	(1.141)	(0.345)	(0.442)	(0.302)	(2.735)	(2.188)	(2.645)	(3.064)	(2.854)
Observations	278	220	281	262	281	220	171	222	205	222
Adjusted R−squared	0.334	0.387	0.373	0.490	0.510	0.799	0.818	0.774	0.796	0.807

Notes: OLS estimates. Standard errors (in parentheses) are clustered by country. *Significant at 10%; **significant at 5%; ***significant at 1%.

Estimated marginal effects of religiosity on innovation in Communist and non-Communist countries:

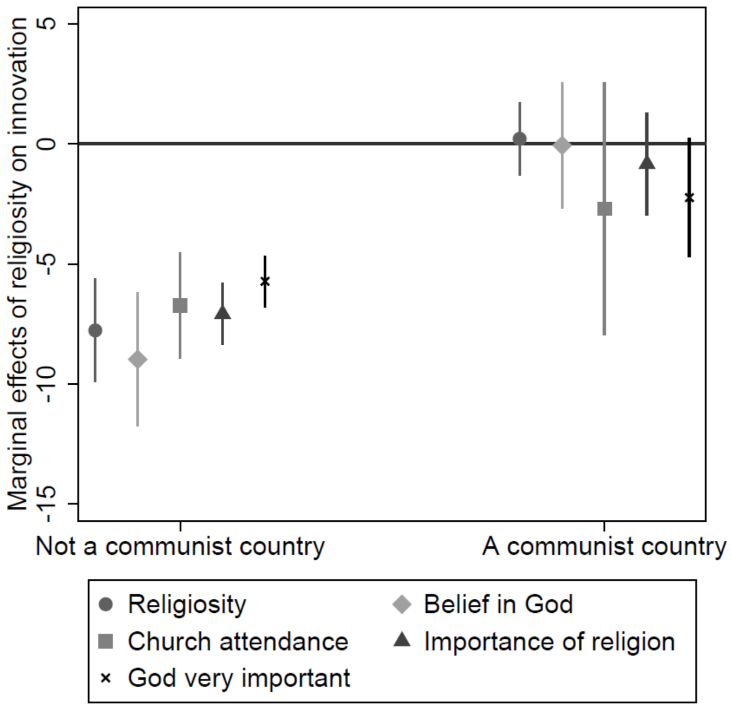


FIGURE F.5a: Unconditional estimates

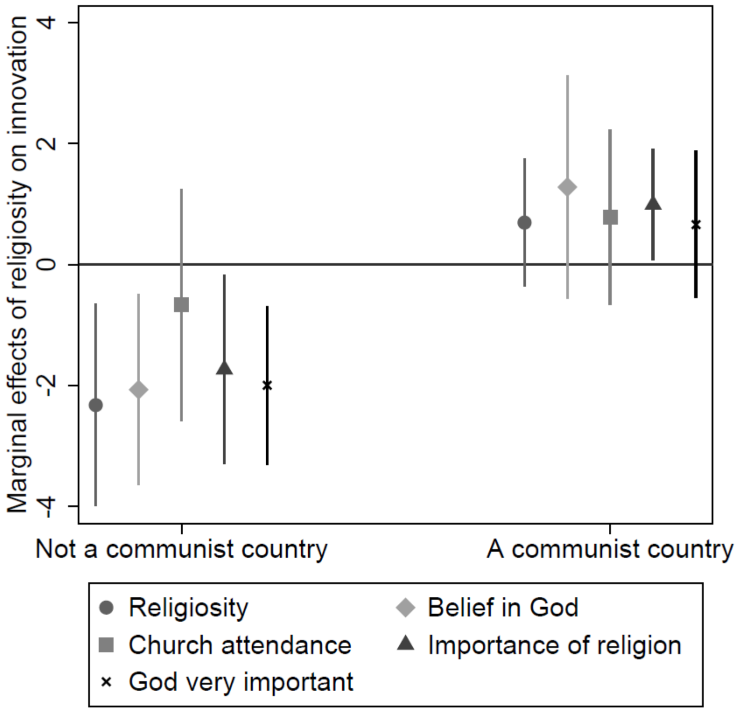


FIGURE F.5b: Conditional estimates

Table F.4 reports the estimates of the relationship between the level of innovation and all five measures of religiosity, when controlling for the population shares of major religions, rather than which one is dominant (as reported in Columns 10-12 of Table 2 and Columns 7-8 of Table F.1).

TABLE F.4: Religiosity and Innovation: Cross−Country Estimates. *Robustness with the shares of religions*

Dep. var.: *Residents' patents per capita (log)*	(1)	(2)	(3)	(4)	(5)
Religiosity	-1.712^{***} (0.626)				
Belief in God		-1.689^{**} (0.652)			
Church attendance			–0.864 (0.725)		
Importance of religion				-1.718^{***} (0.482)	
God very important					-2.094^{***} (0.534)
Religious freedom	–0.003 (0.012)	0.008 (0.011)	–0.002 (0.013)	0.001 (0.013)	0.007 (0.012)
GDP per capita (log)	0.906^{***} (0.194)	1.021^{***} (0.188)	0.937^{***} (0.187)	0.883^{***} (0.179)	0.889^{***} (0.180)
Population (log)	0.086 (0.084)	0.058 (0.069)	0.072 (0.082)	0.108 (0.084)	0.102 (0.082)
Protection intellectual property	0.548^{***} (0.178)	0.424^{***} (0.153)	0.578^{***} (0.162)	0.546^{***} (0.170)	0.405^{**} (0.171)
Tertiary education (years)	0.869^{*} (0.455)	0.583 (0.380)	0.856^{*} (0.477)	0.877^{*} (0.474)	0.831^{*} (0.438)
Foreign direct investment	–0.009 (0.010)	–0.011 (0.012)	–0.008 (0.011)	–0.007 (0.011)	–0.009 (0.011)
Protestant (share)	–0.392 (0.612)	–0.529 (0.659)	-1.061^{*} (0.583)	–0.547 (0.570)	–0.455 (0.602)
Catholic (share)	–0.757 (0.545)	-0.946^{*} (0.533)	-1.389^{***} (0.513)	-0.943^{*} (0.527)	–0.772 (0.529)
Muslim (share)	–0.650 (0.648)	–0.845 (0.665)	-1.223^{*} (0.648)	–0.429 (0.610)	0.124 (0.707)
Orthodox (share)	0.595 (0.708)	0.684 (0.755)	–0.182 (0.742)	0.392 (0.743)	0.415 (0.778)
Year fixed effects	YES	YES	YES	YES	YES
Constant	-19.315^{***} (2.670)	-20.050^{***} (2.648)	-19.845^{***} (2.542)	-20.301^{***} (2.666)	-20.306^{***} (2.652)
Observations	220	171	222	205	222
Adjusted R−squared	0.755	0.781	0.745	0.766	0.788

Notes: OLS estimates. Standard errors (in parentheses) are clustered by country. *Significant at 10%; **significant at 5%; ***significant at 1%.

F.2. The United States: Robustness checks

We first reproduce Table 3 and Figures 2a-2b, which are also reported in the main text. We next include the corresponding scatterplots when religiosity is measured by the variables *Belief in God* and *Church attendance*, respectively.

For each of the three religiosity variables used in the U.S. cross-state analysis, we list below the scatterplots for the unconditional and conditional (baseline) relationships, as well as the table and column containing the corresponding estimate:
(i) *Importance of religion*: Figures 2a, 2b (Table 3: Columns 1, 7).
(ii) *Belief in God*: Figures F.6a, F.6b (Table 3: Columns 2, 8).
(iii) *Church attendance*: Figures F.7a, F.7b (Table 3: Columns 3, 9).

TABLE 3: Religiosity and Innovation in the US: Cross-State Estimates

Dep. var.: *Patents per capita (log)*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Importance of religion	−3.226***			−3.015***			−3.913***		
	(1.057)			(0.787)			(0.625)		
Belief in God		−12.977***			−8.688**			−10.290***	
		(3.287)			(3.536)			(3.385)	
Church attendance			−2.737**			−2.373**			−3.181***
			(1.289)			(1.111)			(1.067)
GSP per capita (log)				−1.125*	−1.061	−1.222*	−0.477	−0.569	−0.709
				(0.588)	(0.663)	(0.617)	(0.489)	(0.673)	(0.618)
Population (log)				0.260***	0.199**	0.237***	0.218***	0.154	0.200**
				(0.078)	(0.090)	(0.085)	(0.079)	(0.094)	(0.089)
Tertiary education				0.074***	0.078**	0.086***	0.035*	0.050	0.054**
				(0.025)	(0.032)	(0.026)	(0.021)	(0.032)	(0.024)
Foreign direct investment							−3.017***	−2.232***	−2.545***
							(0.574)	(0.733)	(0.619)
Constant	−6.681***	3.718	−7.422***	−0.551	6.065	−0.227	−5.075	3.886	−3.803
	(0.647)	(3.128)	(0.550)	(5.907)	(7.258)	(6.420)	(5.267)	(7.887)	(6.559)
Observations	51	51	51	51	51	51	51	51	51
Adjusted *R*-squared	0.198	0.206	0.101	0.463	0.396	0.386	0.567	0.451	0.456

Notes: OLS estimates. Robust standard errors in parentheses. *Significant at 10%; **significant at 5%; ***significant at 1%.

(i) *Importance of religion*: Figures 2a, 2b (Table 3: Columns 1, 7).

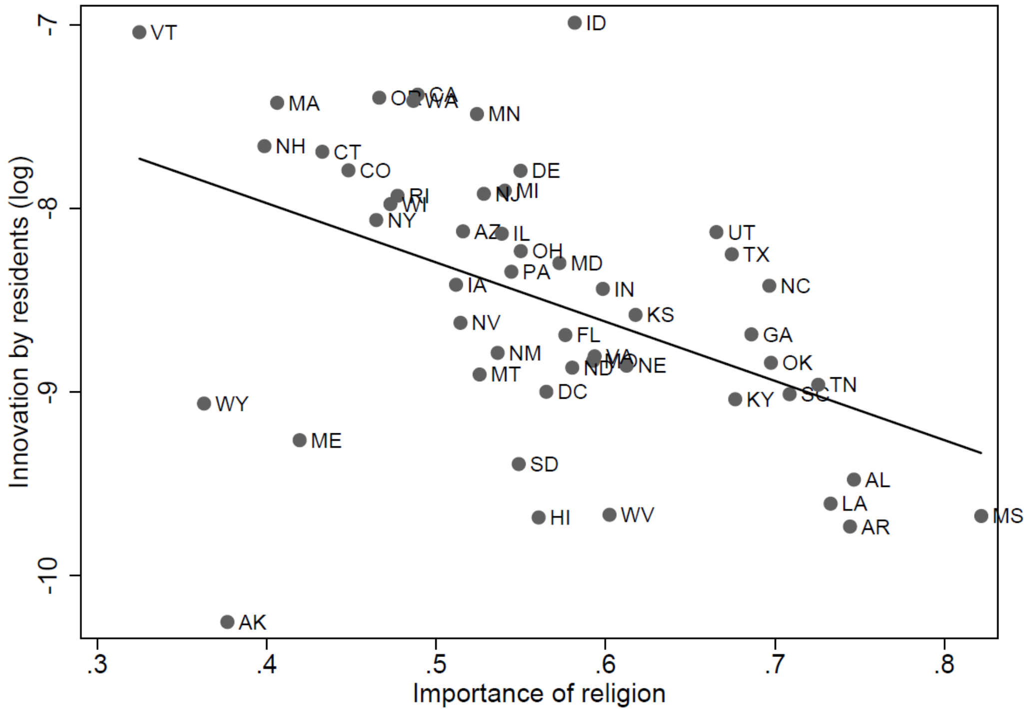


FIGURE 2a: Unconditional relationship

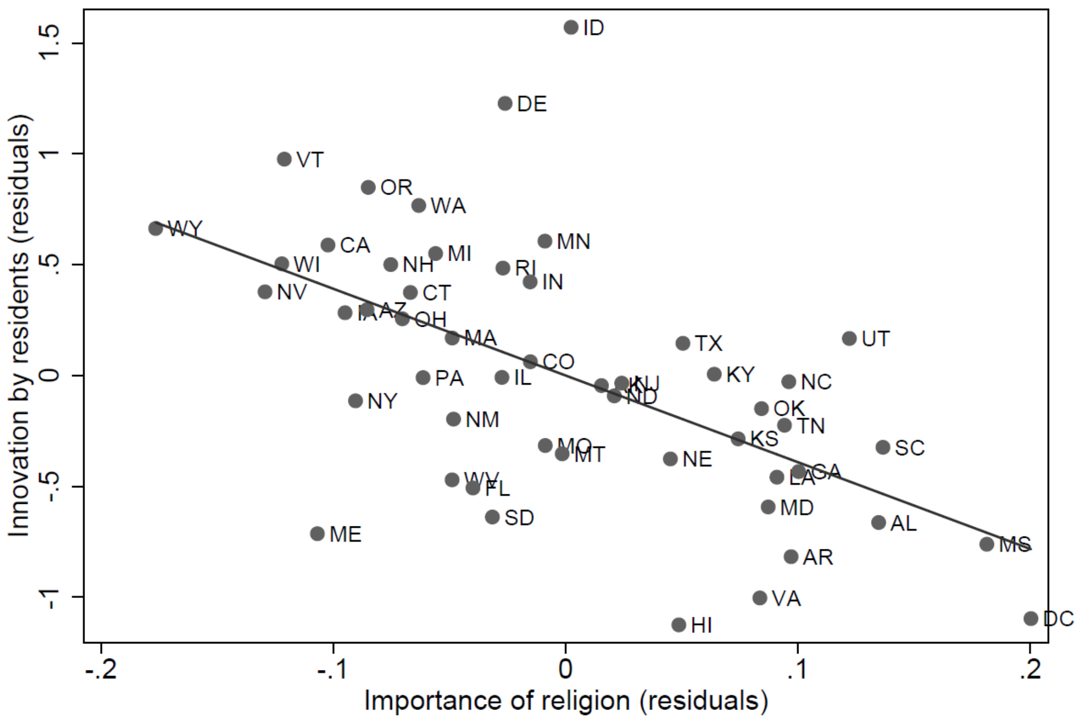


FIGURE 2b: Conditional relationship

(ii) *Belief in God*: Figures F.6a, F.6b (Table 3: Columns 2, 8).

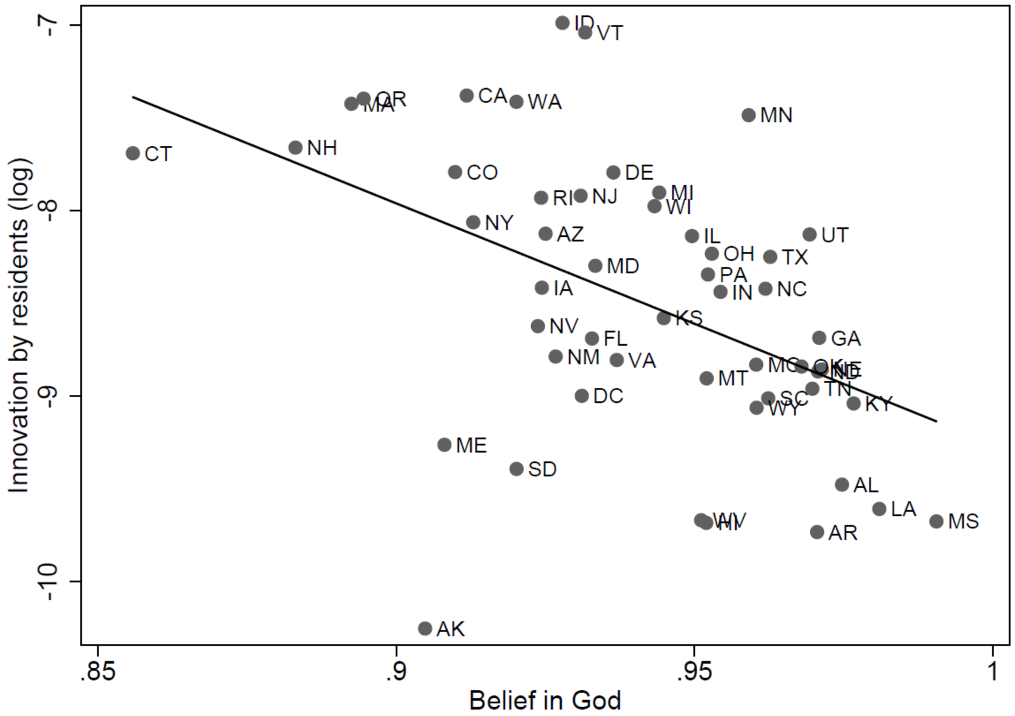


FIGURE F.6a: Unconditional relationship

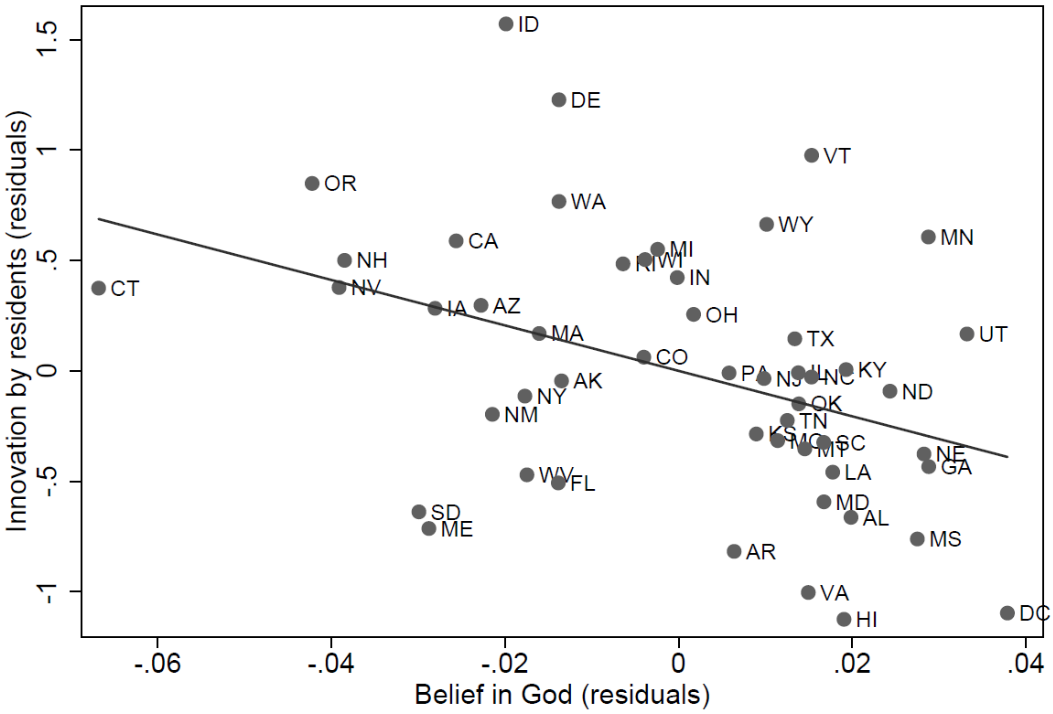


FIGURE F.6b: Conditional relationship

(iii) *Church attendance*: Figures F.7a, F.7b (Table 3: Columns 3, 9).

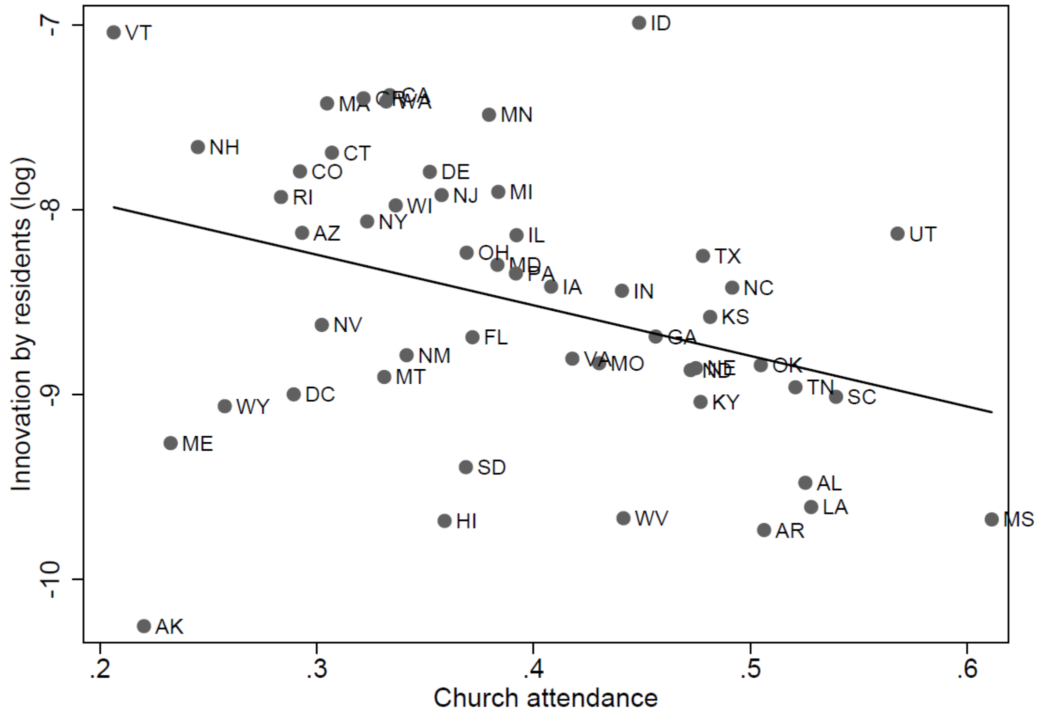


FIGURE F.7a: Unconditional relationship

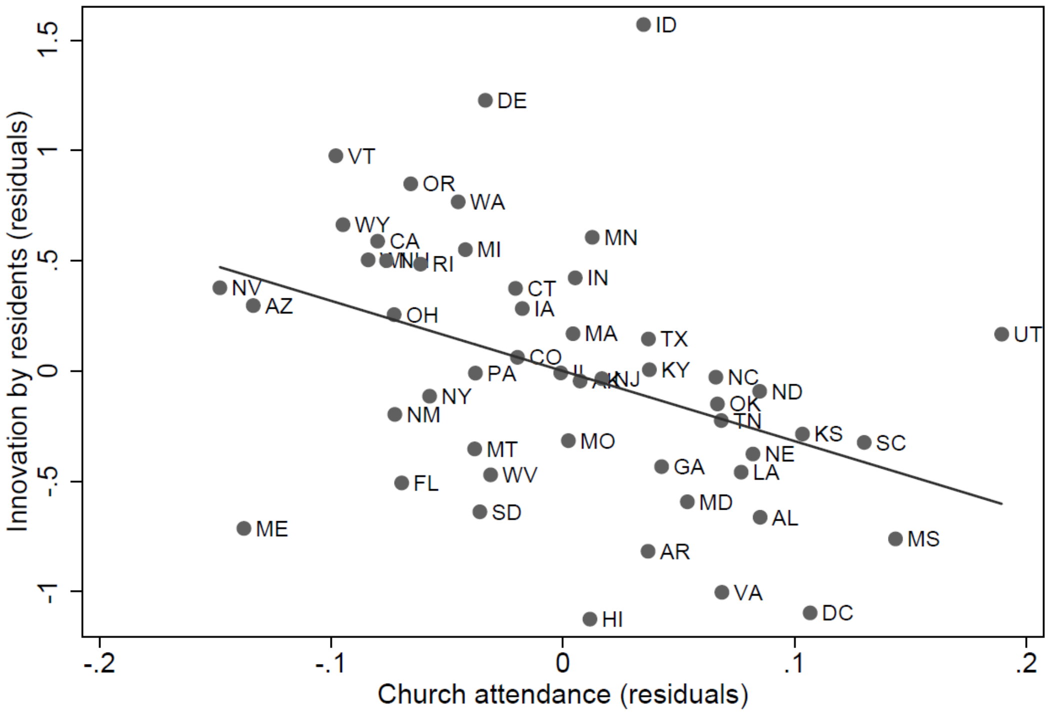


FIGURE F.7b: Conditional relationship

APPENDIX G: Data Appendix

This Data Appendix reports detailed information on each variable employed in the empirical analysis, i.e. the data source and how it is obtained, for the international cross-state analysis as well as for the one with the US data. A summary list with the datasets used is reported at the end of this appendix.

G.1. Data Appendix: *Religiosity and Innovation – International Cross-State Estimates*

The variables in this appendix are listed in the following order.
- Country code: WDI
- Country name: WVS and EVS
- Year
- Religiosity and Religion variables: WVS and EVS (1980 – 2010)
- Religious freedom: Norris (2009)
- Population, GDP per capita, Foreign Direct Investment: WDI
- Innovation variables, i.e. Patents per capita by residents and total: WIPO
- Protection of intellectual property index: Park (2008)
- Tertiary education: Barro and Lee (2013)
- Communist dummy: Wikipedia

Country Code
Variable name in our dataset: code2
The variable "code2" is a three-letter code that identifies the country and is taken from the World Development Indicators. The code is used for combining the various datasets as country names may contain minor differences and, therefore, are a less reliable variable for merging the datasets.
The dataset "codes.dta" in the source subfolder "Data/Source/ICC" contains a list with the name of each country and the variable "code2": the dataset comes from our elaboration.

Country name
Variable name in our dataset: country_wv
The name of the country is taken from the WVS/EVS (variable name: S003) and is reported also in the source dataset "codes.dta".

Year
Variable name in our dataset: year
The variable "year" identifies the reference year of the WVS/EVS wave as specified below and corresponds to the following six dates: 1980, 1990, 1995, 2000, 2005, 2010.

Preliminary notes on the religiosity and religion variables obtained from WVS and EVS

The (five) measures of religiosity and the (four) variables for predominant religions (as well as the shares of religions) all come from the World Values Survey (WVS) and the European Values Study (EVS), i.e., respectively:

Inglehart, R., C. Haerpfer, A. Moreno, C. Welzel, K. Kizilova, J. Diez-Medrano, M. Lagos, P. Norris, E. Ponarin & B. Puranen et al. (eds.). 2014. World Values Survey: All Rounds - Country-Pooled Datafile Version: http://www.worldvaluessurvey.org/WVSDocumentationWVL.jsp. Madrid: JD Systems Institute. (accessed January 27, 2020).
Datafile: "WVS_Longitudinal_1981_2016_stata_v20180912.dta" (not provided)
"WVS_Longitudinal_1981_2016_stata_v20180912_extract.dta" (the extracted datafile is provided)
Folder: "/Data/Source/ICC"

EVS (2020). European Values Study Longitudinal Data File 1981-2008 (EVS 1981-2008). GESIS Data Archive, Cologne. ZA4804 Data file Version 3.1.0, https://doi.org/10.4232/1.13486. (accessed July 16, 2021).
Datafile: "ZA4804_v3-1-0.dta" (not provided)
"ZA4804_v3-1-0_extract.dta" (the extracted datafile is provided)
Folder: "/Data/Source/ICC"

The six waves (1980–2010) of the World Values Survey are the following:
Wave 1: 1981-1984 – denoted as year 1980
Wave 2: 1990-1994 – denoted as year 1990
Wave 3: 1995-1998 – denoted as year 1995
Wave 4: 1999-2004 – denoted as year 2000
Wave 5: 2005-2009 – denoted as year 2005
Wave 6: 2010-2014 – denoted as year 2010

The four waves (1981-2008) of the European Values Study are the following:
Wave 1: 1981 – integrated with WVS Wave 1 – 1980
Wave 2: 1990 – integrated with WVS Wave 2 – 1990
Wave 3: 1999 – integrated with WVS Wave 4 – 2000
Wave 3: 2008 – integrated with WVS Wave 6 – 2010

Note 1: In computing the aggregate (five) variables of religiosity, the (four) variables for the shares of religions and the four dummies for the predominant religions (listed below) from the WVS/EVS datasets, individual data have been weighted with the variable Weight – S017 (Question text: Weight by gender and age). At the same time, in computing such aggregate variables, the denominator of each variable (i.e., the total number of respondents) does not include the individuals whose answer to the question considered is missing.
In the WVS/EVS the missing answers are denoted with negative values:
–5 Missing; Unknown; –4 Not asked in survey; –3 Not applicable; –2 No answer; –1 Don't know.

Note 2: There is generally no overlap between the data of the WVS and the EVS. However, we have used the rule of integrating the WVS with the EVS data. This implies that in case the data is contained in *both* datasets the WVS data prevails.

Religiosity
Variable name in our dataset: relig
Variable name in the WVS/EVS: F034 Religious person

Our variable *Religiosity* (also named *Religious person*) is the share of the individuals in each country that have replied they are "A religious person" to the following question:
F034 – Independently of whether you go to church or not, would you say you are?
1 A religious person
2 Not a religious person
3 A convinced atheist

The *total number of respondents* is the sum of those that responded 1, 2, or 3. Hence, the variable *Religiosity* is the ratio between the number of those that responded they are "A religious person" and the total number of respondents:
relig = #(1) / #(1, 2, 3)

Belief in God
Variable name in our dataset: god
Variable name in the WVS/EVS: F050 Believe in: God

Our variable *Belief in God* is the share of the individuals in each country that believe in God, i.e. that have replied "Yes" to the following question:
F050 – Which, if any, of the following do you believe in? God:
0 No
1 Yes

The *total number of respondents* is the sum of those that responded 0 or 1. Hence, the variable *Belief in God* is the ratio between the number of those that responded "Yes" and the total number of respondents:
god = #(1) / #(0, 1)

Church attendance
Variable name in our dataset: atleastweek
Variable name in the WVS/EVS: F028 How often do you attend religious services

Our variable *Church attendance* is the share of the individuals in each country that attend religious services at least once a week, i.e. that have replied they attend religious services "More than once a week" or "Once a week" to the following question:
F028 – Apart from weddings, funerals and christenings, about how often do you attend religious services these days?
1 More than once a week
2 Once a week
3 Once a month
4 Only on special holy days/Christmas/Easter days
5 Other specific holy days
6 Once a year
7 Less often
8 Never practically never

The *total number of respondents* is the sum of those that responded 1, 2, 3, 4, 5, 6, 7, or 8. Hence, the variable *Church attendance* is the ratio between the number of those that responded they attend religious services "More than once a week" or "Once a week" and the total number of respondents:
atleastweek = #(1, 2) / #(1, 2, 3, 4, 5, 6, 7, 8)

Importance of religion
Variable name in our dataset: imp_religion
Variable name in the WVS/EVS: A006 Important in life: Religion

Our variable *Importance of religion* is the share of the individuals in each country that have replied that religion is important in their life, i.e. that have replied "Very important" or "Rather important" to the following question:
A006 – For each of the following aspects, indicate how important it is in your life. Would you say it is: Religion
1 Very important
2 Rather important
3 Not very important
4 Not at all important

The *total number of respondents* is the sum of those that responded 1, 2, 3, or 4. Hence, the variable *Importance of religion* is the ratio between the number of those that responded that religion is "Very important" or "Rather important" and the total number of respondents:
imp_religion = #(1, 2) / #(1, 2, 3, 4)

God very important
Variable name in our dataset: imp_god10
Variable name in the WVS/EVS: F063 How important is God in your life

Our variable *God very important* is the share of the individuals in each country that have replied that God is very important in their life, i.e. that that have replied "10 Very important" to the following question:
F063 – How important is God in your life? Please use this scale to indicate—10 means very important and 1 means not at all important.
1 Not at all important
2 2
3 3
4 4
5 5
6 6
7 7
8 8
9 9
10 Very important

The *total number of respondents* is the sum of those that responded one of the categories between 1 and 10. Hence, the variable *God very important* is the ratio between the number of those that responded that God is "Very important" and the total number of respondents:
imp_god10 = #(10) / #(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)

Religion Shares of:
Protestant
Variable name in our dataset: prot
Catholic
Variable name in our dataset: cath
Muslim
Variable name in our dataset: musl
Orthodox
Variable name in our dataset: orth

These variables are obtained from the variable in the WVS/EVS named:
F025 Religious denomination – "Do you belong to a religious denomination? In case you do, answer which one."
Categories
0 No religious denomination
1 – 91, 12001, 360001, 528001, 528002, 710001, 710002 – "Various denominations"

Notes:
(a) The EVS contains only the main denominations denoted with the following numbers: 12, 28, 31, 42, 49, 52, 53, 62, 64.
(b) The share of each religion i is the ratio between the number of individuals belonging to the denominations that refer to that religion and the number of individuals that answered the question F025 on religious denomination, i.e. individuals included in categories "Other answer" are not considered (as explained above). Hence:
Share of religion i = #(i) / #(0 – 91, 12001, 360001, 528001, 528002, 710001, 710002)
The details for each of the four religions considered are reported below.

Religion Share of Protestant
Variable name in our dataset: prot
It is the share of the individuals in each country that have replied to question F025 by stating that they belong to one of the following categories:

5 Anglican
17 Christian[1]
18 Christian Fellowship
19 Christian Reform
20 Church of Christ / Church of Christ of Latter-day Saints[2]
25 Evangelical
28 Free church / Non denominational church
44 Lutheran
46 Methodists
61 Presbyterian
62 Protestant
78 The Church of Sweden

prot = #(5, 17, 18, 19, 20, 25, 28, 44, 46, 61, 62, 78) / #(0 – 91, 12001, 360001, 528001, 528002, 710001, 710002)

Religion Share of Catholic
Variable name in our dataset: cath
It is the share of the individuals in each country that have replied to question F025 by stating that they belong to one of the following categories:
15 Catholic: doesn't follow rules
29 Greek Catholic
64 Roman Catholic

cath = #(15, 29, 64) / #(0 – 91, 12001, 360001, 528001, 528002, 710001, 710002)

Religion Share of Muslim
Variable name in our dataset: musl
It is the share of the individuals in each country that have replied to question F025 by stating that they belong to one of the following categories:
2 Al-Hadis
22 Druse[3]
49 Muslim
63 Qadiani
70 Shia
75 Sunni

musl = #(2, 22, 49, 63, 70, 75) / #(0 – 91, 12001, 360001, 528001, 528002, 710001, 710002)

Religion Share of Orthodox
Variable name in our dataset: orth
It is the share of the individuals in each country that have replied to question F025 by stating that they belong to one of the following categories:

---

[1] We included the "Christian" reporting category in the Protestant denomination, because, in the WVS dataset: (i) about half of these respondents are in Nigeria, where Christians are mostly Protestant; (ii) Nigeria is also the only country containing a non-negligible share answering "Christian" to question F025. Excluding this category (0.76% of the sample) from the Protestant denomination would not change the "Predominant Religion" dummies for any country, so all results in Tables 2, F.1, F.2 and F.3 would remain unchanged. It would also only generate minuscule changes in the shares of religions, resulting in quantitatively irrelevant variations in the results of Table F.4. These same two points apply to the treatments, discussed later on, of the Church of Latter-Day Saints and of the Druse.
[2] The Church of Jesus Christ of Latter-Day Saints, also known as the LDS Church, Mormon Church, or simply "Mormons", is often considered part the Protestant religion, although it is not from a legal perspective. The WVS dataset reports very few adherents (0.01%) and their exclusion from the Protestant denomination does not affect any of the estimated coefficients, as discussed in Footnote 1.
[3] Druse do not self-identify as Muslims, but we include them in the Muslim category because this faith originally developed out of Ismailism, which is a branch of Shia Islam. The WVS dataset reports very few adherents (0.01%), and their exclusion from the Muslim denomination does not affects the estimated coefficients (see Footnote 1).

6 Armenian Apostolic Church
30 Gregorian
52 Orthodox

orth = #(6, 30, 52) / #(0 - 91, 12001, 360001, 528001, 528002, 710001, 710002)

Predominant religion:
Predominant religion in each country is a dummy variable denoting which religious group represents the absolute majority. Specifically, the dummy variable is equal to 1 if the fraction of members of religious group i is greater than 0.5 and it is 0 otherwise.
The details for each of the four religions considered are reported below.

Protestant (predominant)
Variable name in our dataset: pred_prot
pred_prot = 1 if prot > 0.5
pred_prot = 0 if prot <= 0.5
pred_prot = missing if prot is missing

Catholic (predominant)
Variable name in our dataset: pred_cath
pred_cath = 1 if cath > 0.5
pred_cath = 0 if cath <= 0.5
pred_cath = missing if cath is missing

Muslim (predominant)
Variable name in our dataset: pred_musl
pred_musl = 1 if musl > 0.5
pred_musl = 0 if musl <= 0.5
pred_musl = missing if musl is missing

Orthodox (predominant)
Variable name in our dataset: pred_orth
pred_orth = 1 if orth > 0.5
pred_orth = 0 if orth <= 0.5
pred_orth = missing if orth is missing

Religious freedom
Variable name in our dataset: Relfree

The Religion Freedom scale is a measure of religious freedom of the country developed by
Norris, Pippa and Ronald Inglehart (2011). *Sacred and Secular: Religion and Politics Worldwide*. Cambridge Studies in Social Theory, Religion and Politics. Cambridge, UK: Cambridge University Press.

The index is based on twenty criteria. Countries were coded from information contained in the U.S. State Department report on International Religious Freedom, 2002. Each criterion was coded 0/1 and the total scale was standardized to 100 points, ranging from low to high religious freedom. See for more details the technical note "Freedom of Religion State" at pp. 293-294 of Norris and Inglehart (2011).

The Religion Freedom index is the same for all of the six years of our sample and taken from the following dataset.

Norris, Pippa (2009). "Democracy Cross-national Data. Release 3.0 Spring 2009." (accessed March 8, 2013).
Datafile: "Democracy Crossnational Data Spring 2009 StataSE.dta"
Folder: "/Data/Source/ICC"

Data publicly available at the author's webpage:
http://www.pippanorris.com/

Population
Variable name in our dataset: pop
Total population of the country correspondent to the year considered.
Source: World Development Indicators. Washington, D.C., The World Bank. (accessed January 27, 2020).
The data are in the public domain and available at:
http://data.worldbank.org/data-catalog/world-development-indicators
Datafile: "WDIData.csv"
Folder: "/Data/Source/ICC"
Variable: Population, total. Series code: SP.POP.TOTL

Population (log)
Variable name in our dataset: lpop
lpop = ln(pop)

Gross Domestic Product per capita
Variable name in our dataset: gdp
GDP per capita in constant 2010 U.S. dollars of the country correspondent to the year considered.
Source: World Development Indicators. Washington, D.C., The World Bank. (accessed January 27, 2020).
The data are in the public domain and available at:
http://data.worldbank.org/data-catalog/world-development-indicators
Datafile: "WDIData.csv"
Folder: "/Data/Source/ICC"
Variable: GDP per capita (constant 2010 US$). Series code: NY.GDP.PCAP.KD

Gross Domestic Product per capita (log)
Variable name in our dataset: lgdp
lgdp = ln(gdp)

Foreign direct investment
Variable name in our dataset: fdi
Foreign direct investment, net inflows (% of GDP) of the country correspondent to the year considered.
Source: World Development Indicators. Washington, D.C., The World Bank. (accessed January 27, 2020).
The data are in the public domain and available at:
http://data.worldbank.org/data-catalog/world-development-indicators
Datafile: "WDIData.csv"
Folder: "/Data/Source/ICC"
Variable: Foreign direct investment, net inflows (% of GDP). Series code: BX.KLT.DINV.WD.GD.ZS

Patents by residents and nonresidents
Patents are taken from the World Intellectual Policy Organization (WIPO) statistics database. "Intellectual property right: Patent". Last updated: October 2019. (accessed January 27, 2020).
Datafile: "patent_1980_2018.csv"
Folder: "/Data/Source/ICC"
The data are in the public domain and available at:
https://www3.wipo.int/ipstats/index.htm?tab=patent
Indicator 1: Total patent applications (direct and PCT national phase entries)
The data include all people who apply for a patent in a country, resident and non-residents (see below), for the year considered.

Specifically, our dataset contains the following three variables.

Total number of patents submitted by residents' applicants.
Variable name in our dataset: pat_wipores

Total number of patents submitted by non-residents' applicants.
Variable name in our dataset: pat_wipononres

The total number of patents submitted by all, residents and non-residents, applicants.
Variable name in our dataset: pat_wipo_tot
pat_wipo_tot = pat_wipores + pat_wipononres

Patents per capita by residents
Variable name in our dataset: innov_res
Patents per capita by residents is the ratio between the total number of patents filed by residents' applicants and total population, i.e.
innov_res = pat_wipores / pop

Innovation by residents (log)
Variable name in our dataset: linnov_res
This is the variable used as a main proxy of innovation and it is the logarithm of the patents per capita by residents, i.e.:
linnov_res = log(innov_res)

Total patents per capita
Variable name in our dataset: innov_tot
Total patents per capita is the ratio between total number of patents filed by all, residents and nonresidents, applicants and total population, i.e.
innov_tot = pat_wipo_tot / pop

Total patents per capita (log)
Variable name in our dataset: linnov_tot
This variable is the logarithm of total patents per capita used for the robustness check presented in the Online Appendix F, i.e.:
linnov_tot = log(innov_tot)

Protection intellectual property
Variable name in our dataset: ipr
This variable is an index of patent protection between 0 and 5 that has been initially proposed by:
Ginarte, J.C., Park, W.G. (1997). "Determinants of patent rights: a crossnational study." Research Policy, 26, 283-301.
The index has been updated to 2005 and extended by:
Park, Walter G. (2008) "International patent protection: 1960-2005." Research Policy, 37(4), 761-766. https://doi.org/10.1016/j.respol.2008.01.006. (accessed January 28, 2020).
We have used the latest version of the index that has been recently revised by Park and extended up to the year 2015. The data can be freely downloaded from the Walter Park's webpage:
http://fs2.american.edu/wgp/www/?_ga=2.150063158.1045324815.1586191710-954683830.1586191710
Datafile: "Patent index1960 - 2015.xlsx"
Folder: "/Data/Source/ICC"

Tertiary education (years)

Variable name in our dataset: yr_sch_ter
Average years of tertiary schooling attained in the population age 25 and over.
The data come from:
Barro, Robert and Jong-Wha Lee (2013) "A New Data Set of Educational Attainment in the World, 1950-2010." Journal of Development Economics, 104, 184–198. (accessed December 28, 2015).
The data are in the public domain and available at:
http://www.barrolee.com/
Datafile: "BL2013_MF1599_v2.0.dta"
Folder: "/Data/Source/ICC"

Communist
Variable name in our dataset: communist
Dummy variable equal to 1 if the country is a communist state or was a communist state, and 0 otherwise.
Information gathered from Wikipedia – History of communist states:
Wikipedia (2020) "Communist state", April 1, 2020. https://en.wikipedia.org/wiki/Communist_state. (accessed April 7, 2020).
Datafile: "14_communism_labels.do"
Folder: "/Programs"
Data for the variable "communist" is imported in the final dataset using the do program file "14_communism_labels.do" contained in the folder "/Programs".

We report below the list of countries from Wikipedia. The countries that are not in our dataset are reported in brackets.
Current communist states: China, (Cuba), (Korea – DPRK), (Laos), Vietnam.
Current non-communist states with communist majority: (Nepal).
Previous communist states: (Afghanistan), (Albania), (Angola), (Benin), Bulgaria, (Congo), Czechoslovakia (see below), Ethiopia, (Germany, GDR), (Grenada), Hungary, (Kampuchea), (Mongolia), (Mozambique), Poland, Romania, (Somalia), Soviet Union (see below), (Tuva), Yemen – PDRY, Yugoslavia (see below).
Countries in our sample from:
Ex-Czechoslovakia: Czezh Republic, Slovakia.
Ex-Yugoslavia: Bosnia Herzegovina, Croatia, Macedonia, Montenegro, Serbia, Slovenia.
Ex-Soviet Union: (Abkhazia), Armenia, (Artsakh), Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Russia, (South Ossetia), (Tajikistan), (Transnistria), (Turkmenistan), Ukraine, Uzbekistan.

List of former and current communist countries in our dataset (other country names in parenthesis) in alphabetical order:

Country name:	Code2:
Armenia	ARM
Azerbaijan	AZE
Belarus	BLR
Bosnia Herzegovina	BIH
Bulgaria	BGR
China	CHN
Croatia	HRV
Czech Republic	CZE
Estonia	EST
Ethiopia	ETH
Georgia	GEO
Hungary	HUN
Kazakhstan	KAZ
Kyrgyzstan	KGZ
Latvia	LVA
Lithuania	LTU
Macedonia	MKD
Moldova	MDA
Montenegro	MNE
Poland	POL

Romania	ROU
Russia (Russian Federation)	RUS
Serbia	SRB
Slovakia (Slovak Republic)	SVK
Slovenia	SVN
Ukraine	UKR
Uzbekistan	UZB
Vietnam	VNM
Yemen	YEM

G.2. Data Appendix: *Religiosity and Innovation in the US – Cross-State Estimates*

The variables in this appendix are listed in the following order.
- State
- Code
- Religiosity variables (Importance of religion, Belief in God, Church attendance): Pew Forum on Religion & Public Life, 2007 U.S Religion Landscape Survey.
- Per capita real GDP: U.S. Bureau of Economic Analysis.
- Population: U.S. Census Bureau.
- Tertiary education: U.S. Census Bureau.
- Gross domestic product: U.S. Bureau of Economic Analysis.
- Foreign direct investment: U.S. Bureau of Economic Analysis.
- Patents per capita: U.S. Patent and Trademark Office.

State
Variable name in our dataset: state1
Name of the State.

Code
Variable name in our dataset: code
Two letters abbreviation denoting the code of the State.

Preliminary notes on the three religiosity variables obtained from Pew Forum on Religion and Public Life

The three measures of religiosity (*Importance of religion*, *Belief in God*, *Church attendance*) all refer to the year 2007 and come from:
Pew Forum on Religion and Public Life (2007). "U.S. Religion Landscape Survey". (accessed November 3, 2013).
Datafiles: "Religious Landscape Survey Data - Continental US.dta"
"Religious Landscape Survey Data - Alaska and Hawaii.dta"
Folder: "/Data/Source/USA"
Data can be freely downloaded from the Pew Research Center website at:
https://www.pewforum.org/dataset/u-s-religious-landscape-survey/

Note 1: The two original datasets are in SPSS format (.sav, with the same name reported above) and have been converted in Stata format (.dta) before use.

Note 2: In computing the aggregate variables *Importance of religion*, *Belief in God*, and *Church attendance* respondents have been weighted using the variable "Weight", that is the sample weight for all landline respondents, as this is "Recommended for use in all analyses" by PEW. Moreover, the denominator (i.e. the total number of respondents) does not include those individuals whose answer is:
9 Don't know/refused

Importance of religion
Variable name in our dataset: very_imp
Share of individuals (in a 0-1 scale) that have responded "Very important" to question Q.21 - How important is religion in your life - very important, somewhat important, not too important, or not at all important?
1 Very important
2 Somewhat important
3 Not too important
4 Not at all important
9 Don't know/refused

The *total number of respondents* is the sum of those individuals that responded 1, 2, 3, or 4. Hence, the variable *Importance of religion* is the ratio between the number of those that have responded that religion is "1 Very important" and the total number of respondents as follows:
very_imp = #(1) / #(1, 2, 3, 4)

Belief in God
Variable name in our dataset: belief_god
Share of individuals (in a 0-1 scale) that believe in God or a universal spirit, i.e. that have responded "Yes" to question Q.30 – Do you believe in God or a universal spirit?
1 Yes
2 No
3 Other
9 Don't know/refused

The *total number of respondents* is the sum of those individuals that responded 1, 2, or 3. Hence, the variable *Belief in God* is the ratio between the number of those that have responded that "1 Yes" and the total number of respondents as follows:
belief_god = #(1) / #(1, 2, 3)

Church attendance
Variable name in our dataset: atleastweek
Share of individuals (in a 0-1 scale) that declare to attend church at least once a week, i.e. the share of individuals that have responded "1 More than once a week" or "2 Once a week" to question Q.20 – Aside from weddings and funerals, how often do you attend religious services... more than once a week, once a week, once or twice a month, a few times a year, seldom, or never?
1 More than once a week
2 Once a week
3 Once or twice a month
4 A few times a year
5 Seldom
6 Never
9 Don't know/Refused

The *total number of respondents* is the sum of those individuals that responded 1, 2, 3, 4, 5, or 6. Hence, the variable *Church attendance* is the ratio between the number of those that responded to attend religious services "1 More than once a week" or "2 Once a week" and the total number of respondents as follows:
atleastweek = #(1, 2) / #(1, 2, 3, 4, 5, 6)

GSP per capita
Variable name in our dataset: gsp_c_2007
Per capita real GDP by State (Chained 2012 dollars) in 2007.
Source: U.S. Bureau of Economic Analysis, "Gross Domestic Product by State". Last updated: November 7, 2019. https://www.bea.gov/data/gdp/gdp-state. (accessed February 13, 2020).
The data are in the public domain and available at:
https://www.bea.gov/data/gdp/gdp-state
Datafile: "Per capita real GDP by state 2006 2007.xls"
Folder: "/Data/Source/USA"
Variable: (SAGDP10N) Per capita real GDP by State (Chained 2012 dollars) in 2007.

GSP per capita (log)
Variable name in our dataset: l_gsp_cap
Logarithm of the (SAGDP10N) Per capita real GDP by State (Chained 2012 dollars) in 2007.

l_gsp_cap = log(gsp_c_2007)

Population
Variable name in our dataset: pop2007
Population of the State in 2007.
Source: U.S. Census Bureau, "Table 1. Intercensal Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2000 to July 1, 2010 (ST-EST00INT-01)". Last Revised: November 30, 2016. https://www.census.gov/data/tables/time-series/demo/popest/intercensal-2000-2010-state.html. (accessed February 13, 2020).
The data are in the public domain and available at:
https://www.census.gov/data/tables/time-series/demo/popest/intercensal-2000-2010-state.html
Datafile: "st-est00int-01.xls"
Folder: "/Data/Source/USA"
Variable: Intercensal Estimate of the Resident Population of the State in 2007.

Population (log)
Log of the population of the State in 2007.
Variable name in our dataset: l_pop
l_pop = log(pop2007)

Tertiary education
Variable name in our dataset: at_least_ba
Share (in percentage term) of the State population with bachelor's degree or more.
Source: U.S. Census Bureau (2009), "Educational Attainment in the United States: 2007". Issued January 2009, P20-560. (accessed February 12, 2020).
Datafiles: "p20-560.pdf"
"ba_US.xls"
Folder: "/Data/Source/USA"
The publication is in the public domain and available at:
https://www.census.gov/library/publications/2009/demo/p20-560.html
The data of the share (in percentage term) of the State population with bachelor's degree or more used for the analysis are contained in "Table 2. Educational Attainment for the Population Aged 25 and Over by Region, State, and Nativity Status: 2007" at page 8 of the file "p20-560.pdf". These data have been reported by the authors in the Excel file "ba_US.xls" that is saved in the folder "/Data/Source/USA".

Gross domestic product (GDP) by State in 2006
Variable name in our dataset: gsp2006
Gross domestic product (GDP) by State in 2006.
Source: U.S. Bureau of Economic Analysis, "Gross Domestic Product by State". Last updated: November 7, 2019. https://www.bea.gov/data/gdp/gdp-state. (accessed February 13, 2020).
The data are in the public domain and available at:
https://www.bea.gov/data/gdp/gdp-state
Datafile: "Gross domestic product (GDP) 2006 2007.xls"
Folder: "/Data/Source/USA"
Variable: Gross domestic product (GDP) by State (SAGDP2N) in 2006 (All industry total). In millions of current dollars.
Note: the variable Gross domestic product by State in 2006 is used to compute the Foreign direct investment as a share of GSP (see next).

Foreign direct investment
Variable name in our dataset: fdi_st
Foreign Direct Investment as a share of GSP, i.e. it is the ratio between Foreign Direct Investment by State in the United States (FDIUS) in 2006 (variable name in

the dataset = FDI) and the Gross domestic product (GDP) by State (SAGDP2N) in 2006 (variable name in the dataset = gsp2006).
fdi_st = FDI / gsp2006

FDI = Foreign Direct Investment in the United States (FDIUS) in 2006. Table III.D11. Gross Property, Plant, and Equipment of Affiliates, State by Use. In millions of dollars.
Source: U.S. Bureau of Economic Analysis, "Foreign Direct Investment in the United States (FDIUS): 2006 Data Tables". https://www.bea.gov/international/foreign-direct-investment-united-states-fdius-2006-data-tables. (accessed February 13, 2020).
The data are in the public domain and available at:
https://www.bea.gov/international/foreign-direct-investment-united-states-fdius-2006-data-tables
Datafile: "Tab III.D11.xls"
Folder: "/Data/Source/USA"

Note: we have used the Foreign Direct Investment for the year 2006 because the corresponding data for 2007 is missing for some States.

Patents
Variable name in our dataset: patents
Total number of patents submitted by residents of the State in 2007.
Source: U.S. Patent and Trademark Office, Electronic Information Products Division, Patent Technology Monitoring Team (PTMT) (2007). "Calendar Year 2007 Patent Counts by Patent Type and by State and Country of Origin (01-Jan-2007 to 31-Dec-2007)". http://www.uspto.gov/web/offices/ac/ido/oeip/taf/st_co_07.htm. (accessed November 4, 2013).
Datafile: "patents_US.csv"
Folder: "/Data/Source/USA"
The data of the total number of patents submitted by residents of the State in 2007 are contained in the report available in the webpage with the URL reported above. The data have been reported by the authors in the csv format file "patents_US.csv" that is saved in the folder "/Data/Source/USA".

Patents per capita (log)
Variable name in our dataset: l_innov
Logarithm of the ratio between the total number of patents submitted by residents of the State and the population of the State in 2007.
l_innov = log(patents / pop2007)

Summary of the Datasets used in the international cross-state analysis

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