

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

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Introduction

- Throughout history, periodic clashes between science and organized religion. Political power then arbitrates
- Sacred texts, doctrines, tied to **fixed** “world view”. Scientific **discoveries** recurrently contradicts, falsifies important aspects

1. Heliocentric model of the universe and the Roman Inquisition:
 - ▶ Copernicus (1453), Bruno (1600), Galileo (1610), Newton (1687)
2. Works of Aristotle: first books on logic, language translated into Latin in early 6th century, widely read, taught by Church. In 12th century, rediscovered:
 - ▶ Missing volumes of Organon: immediately incorporated into curriculum
 - ▶ Treatises on “natural philosophy”: Physics, On the Soul, On Generation & Corruption, Metaphysics, Meteorology, On the Heavens. Contained many doctrines regarding physical world, universe, human life, soul, conflicting with Christian one ⇒ declared heretical, **banned under penalty of excommunication** from 1210 to 1325

3. Thomas Aquinas (1225–1274): new intellectual construction, making Christian doctrine and Aristotelian natural philosophy compatible
4. Following “golden age”, deep and prolonged decline of science and knowledge-seeking in Muslim world, from 11th century until present
5. Gutenberg’s printing press (1436):
 - ▶ No opposition from the Roman Catholic Church.
 - ▶ Ottoman Empire forbade it in 1483, under penalty of death, until 1727 (only non-religious, practical books allowed), de facto no printing until 19th century
6. Origins of earth, and evolution of life (creationism), politics of stem cell research, climate change in the United States
 - ▶ In US, issue in constant flux / debate. In other countries (Europe, Muslim countries), one side or the other seems to have prevailed.

Science and Islam Today

- Top 46 Muslim countries produced 1.17% of world scientific literature, vs. .48% for Spain
- Top 20 Arab countries produced 0.55%, vs. 0.89% for Israel
- Among 28 lowest producers of scientific articles in 2008, half were members of Organization of Islamic Cooperation
- Pakistan's one Nobel prize (physicist) is member of sect declared heretical in 1974. Banned from setting foot on any university campus
- Major University in Islamabad: 3 mosques + 1 planned, no bookstore
- Books translated per year into Arabic: 330
- Patents by Pakistan over 43 years: 8

Source: Pervez Hoodbhoy (2007)

Main Ideas

- ① Scientific discoveries, process, recurrently **damage religiosity** by contradicting / falsifying important doctrinal statements about “how the world works”
- ② Religiosity in the population affects the allocation of **political power** (e.g., Religious Right in US) and extent of redistribution
- ③ Political outcomes, fiscal policy (taxes, nature of public spending) reflect interplay between distributions of religiosity and income, as these shape what **coalitions** form
- ④ Social group in power may **repress** diffusion of growth-promoting discoveries or knowledge, because of their potential impact on religious beliefs and hence political power
- ⑤ Church, or religious entrepreneurs, may endeavor to adapt or reform doctrine, **repair** beliefs, following erosion from scientific discoveries

Innovation and Religiosity Across Countries

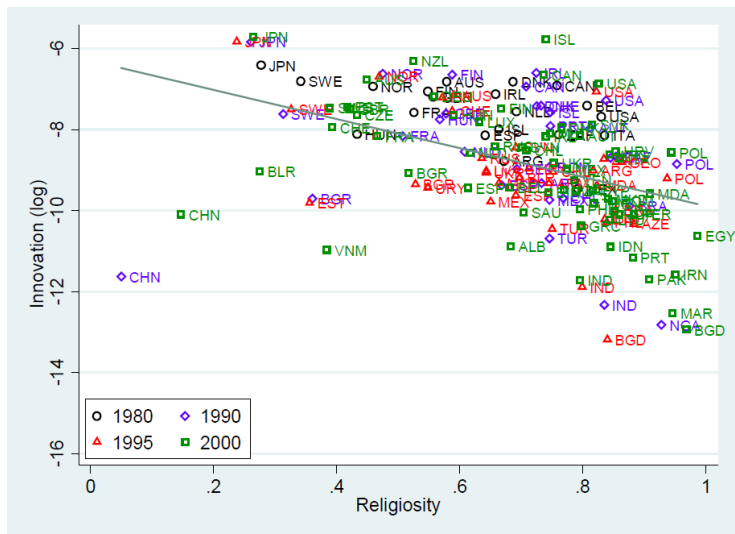


Figure 1

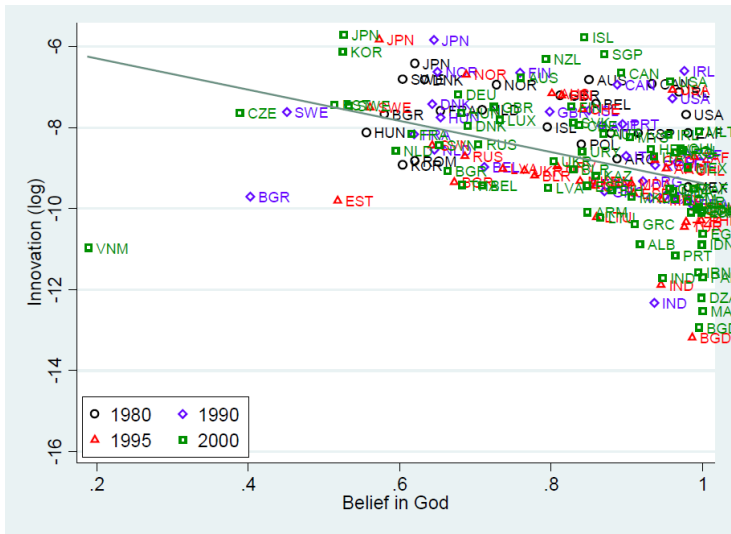


Figure 2

Controls: GDP per capita, Population, Religious Freedom, Intellectual Property Right Protection, Foreign Direct Investment, Years of Tertiary Schooling

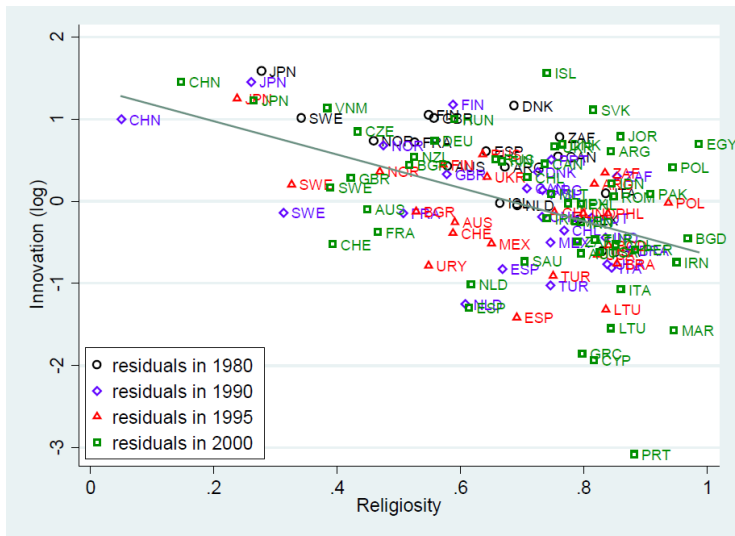


Figure 3

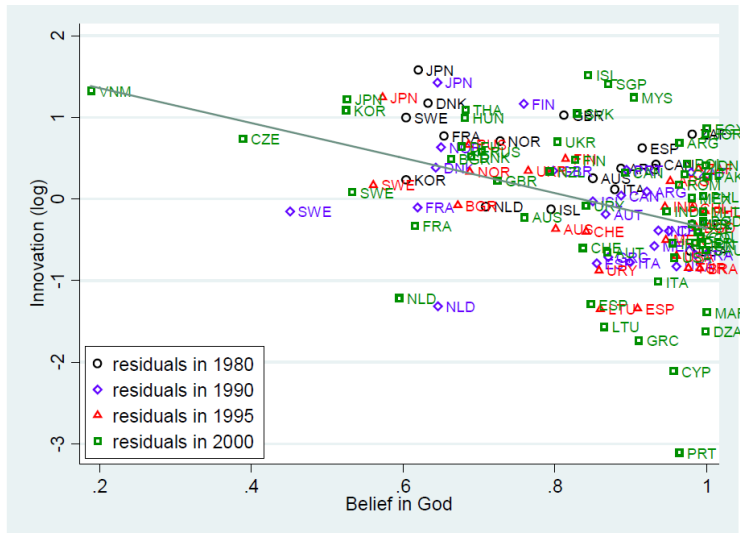


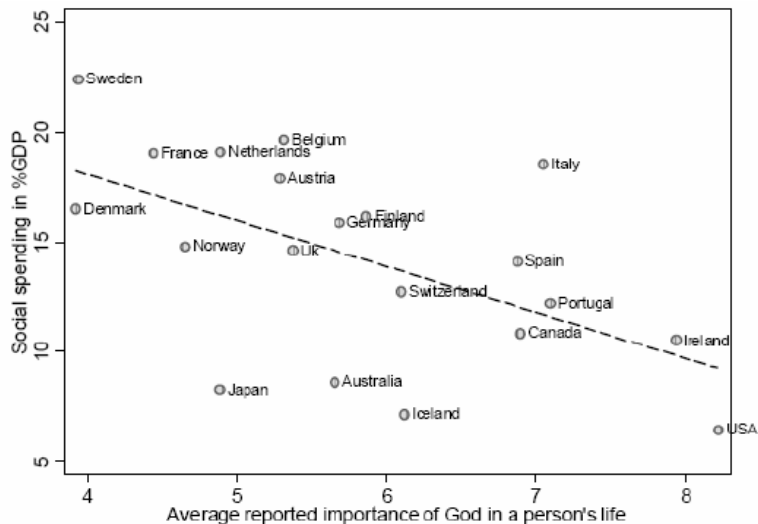
Figure 4

Table 1: Religiosity and Innovation: Cross-Country Estimates (OLS)

Dep. var.:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>Patents per capita (log)</i>								
<i>Religiosity</i>	-3.584 (1.314)***		-2.23 (0.424)***		-2.079 (0.449)***		-1.478 (0.589)**	
<i>Belief in God</i>		-3.853 (1.235)***		-2.444 (0.56)***		-2.302 (0.566)***		-1.581 (0.66)**
<i>Religious freedom</i>			0.024 (0.007)***	0.028 (0.006)***	0.021 (0.007)***	0.025 (0.006)***	0.015 (0.008)*	0.021 (0.008)***
<i>GDP per capita (log)</i>			1.074 (0.1)***	1.199 (0.107)***	0.928 (0.106)***	1.114 (0.116)***	0.909 (0.133)***	1.071 (0.138)***
<i>Population (log)</i>			-0.135 (0.062)**	-0.09 (0.071)	-0.141 (0.059)**	-0.097 (0.068)	-0.144 (0.059)**	-0.137 (0.061)**
<i>Protection intellectual property</i>			-0.013 (0.095)	-0.11 (0.109)	0.116 (0.104)	-0.048 (0.114)	0.102 (0.103)	-0.001 (0.108)
<i>Tertiary education (years)</i>			0.791 (0.25)***	0.873 (0.277)***	0.985 (0.253)***	1.006 (0.288)***	1.013 (0.28)***	1.043 (0.328)***
<i>Foreign direct investment</i>			-0.056 (0.016)***	-0.041 (0.02)**	-0.043 (0.022)**	-0.036 (0.023)	-0.039 (0.017)**	-0.034 (0.018)*
<i>Years fixed effects</i>					YES	YES	YES	YES
<i>Predominant religion</i>							YES	YES
Observations	146	151	115	116	115	116	115	116
R-squared	0.184	0.165	0.815	0.797	0.834	0.809	0.85	0.832

Notes: Standard errors are clustered by country. Predominant religion includes the following religions: Protestant, Catholic, Muslim, Orthodox. *Significant at 10%; **significant at 5%; ***significant at 1%.

Religion and Redistribution



The United States

- Rep. Paul Broun (R-Ga.) also an M.D., June 2012

“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. Broun sits on U.S. House Committee on Science, Space & Technology
 - ▶ Favorite for 2014 race to fill vacant U.S. Senate seat from Georgia

Innovation and Religiosity Across U.S. States

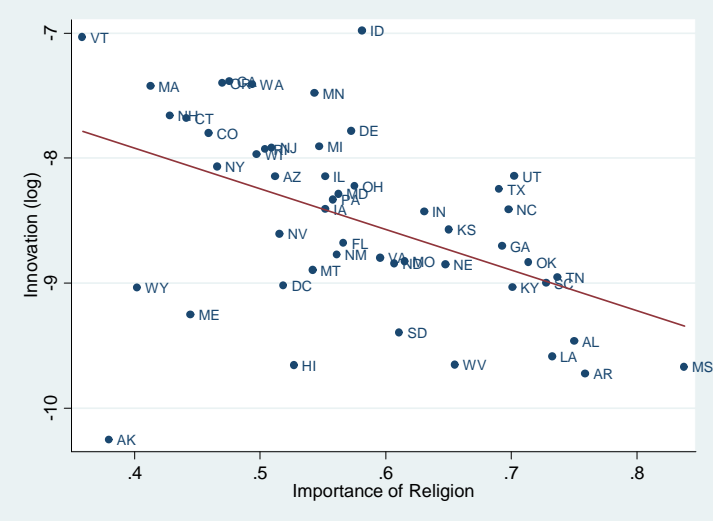


Figure 5

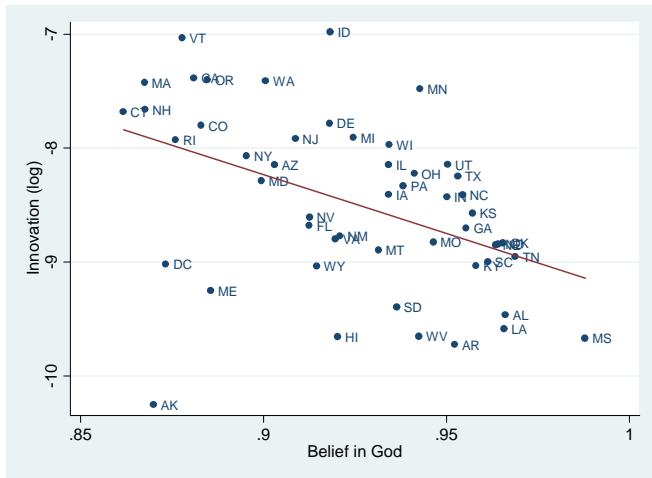


Figure 6

Controls: GSP per capita, Population, Fraction with at least Bachelor's Degree, Foreign Direct Investment,

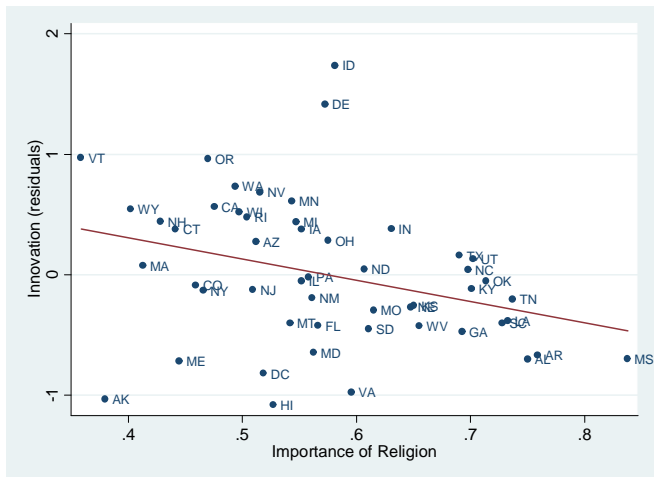


Figure 7

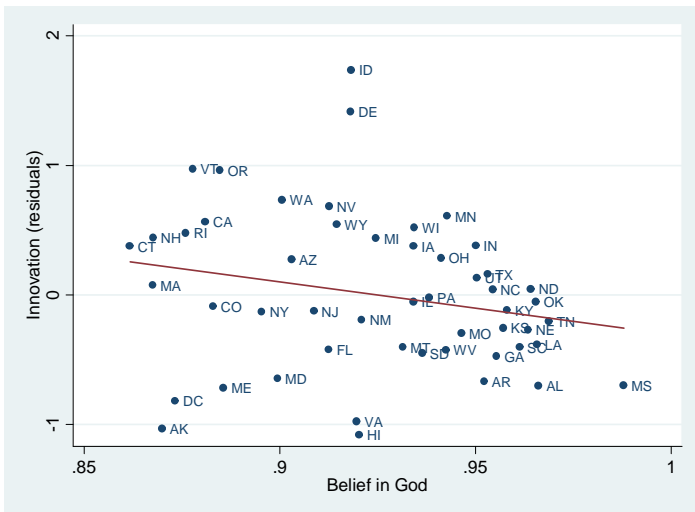


Figure 8

Table 2: Religiosity and Innovation in the US: Cross-State Estimates (OLS)

Dep. var.: <i>Patents per capita (log)</i>	(1)	(2)	(3)	(4)	(5)	(6)
<i>Importance of religion</i>	-3.245 (1.064)***		-2.803 (0.947)***		-3.922 (0.737)***	
<i>Belief in God</i>		-10.324 (3.289)***		-7.766 (3.861)**		-11.238 (3.275)***
<i>GSP per capita (log)</i>			-1.112 (0.607)*	-1.104 (0.64)*	-0.503 (0.513)	-0.561 (0.62)
<i>Population (log)</i>			0.23 (0.078)***	0.21 (0.079)**	0.185 (0.079)**	0.166 (0.083)*
<i>Tertiary education</i>			0.071 (0.027)**	0.072 (0.032)**	0.028 (0.021)	0.031 (0.03)
<i>Foreign direct investment</i>					-29.877 (5.73)***	-26.677 (6.716)***
Observations	51	51	51	51	51	51
R-squared	0.222	0.203	0.475	0.43	0.597	0.523

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

The Model: Agents I

- Non-overlapping generations of risk-neutral agents $i \in [0, 1]$, living for two periods: youth (t even) and old age ($t + 1$ odd):

$$U_t^i = \mathbb{E}_t[c_t^i + c_{t+1}^i + \beta^i b_{t+1} G_{t+1}]$$

- ▶ (c_t^i, c_{t+1}^i) : post-tax-and-transfer consumptions of goods & services
- ▶ $\beta^i b_{t+1} G_{t+1}$: utility derived (in old age) from organized religion
- Fraction $1 - r$ of agents are “secular”: $\beta^i = 0$
Majority: $r > 1/2$ are “religious”: $\beta^i = 1$
- Distribution of types fixed, but **intensity** of religious agents’ beliefs during their lifetimes, (b_t, b_{t+1}) , will be endogenous.
- Beliefs b_{t+1} complementary to “religious public good” G_{t+1} : sanctuaries (churches, temples, mosques), priests rituals

The Model: Agents II

- Model faith not as probability distribution over some state of the (after)world updated in Bayesian manner (B-T 2006, 2011), but as durable stock of “religious capital” b_t that may be eroded by certain shocks –especially, scientific news– and augmented by others
- First half of paper: agents differ only in their attitudes or propensities toward religion, $\beta^i = 0, 1$. All have the same income, normalized to the economy’s TFP, denoted (a_t, a_{t+1}) in each period of their life.
- Second half: interplay of religious and income differences
- All real magnitudes $c_t^i, c_{t+1}^i, G_{t+1}$, etc., will be measured in units of contemporary TFP.

Taxes and Public Expenditures I

- Linear income tax $\tau \Rightarrow$ government revenues $R(\tau)$, per unit of TFP
 - ▶ Strictly quasiconcave, $R(0) = 0$, $R'(0) = 1$, $R'(\hat{\tau}) = 0$, where
 - ▶ $\hat{\tau}$ is the **revenue-maximizing** tax rate. Furthermore, $R'''(\tau) \leq 0$
- Religious agents are majority \Rightarrow control the state, by force or by vote \Rightarrow choose tax rates (τ_t, τ_{t+1}) and how to allocate spending
- In old age, two types of public expenditures:
- **Religious public good** G_{t+1} : provided directly (state religion) or, equivalently, through tax exemptions, subsidies and other advantages conceded to religious sector. Will treat as direct spending.
 - ▶ Key is that only part of the population benefits
- **Standard public goods and services** T_{t+1} : infrastructure, safety, education. Valued equally by those with $\beta^i = 1$ and $\beta^i = 0$.
 - ▶ T_{t+1} can also correspond to pure transfers (e.g., pensions).

Taxes and Public Expenditures II

▶ A unit of T_{t+1} is worth $\nu > 1$ units of numeraire-good consumption

- Net consumption levels of generation t are

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

- During youth (period t), no public-goods consumption

State's decision, $\chi_t \in \{0, 1\}$, is whether or not to invest resources in a **control and repression apparatus** designed to block the diffusion of ideas deemed sacrilegious, dangerous to the faith.

- Let φ_t be resource cost required to set up repressive apparatus
⇒ Government's budget constraints (TFP-normalized) are

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

Discoveries, Productivity Growth, and Beliefs I

- **Scientific discoveries:** Poisson arrival rate λ , during the youth of each generation. Exogenous (domestic or from abroad), could endogenize.
- If allowed to diffuse widely \Rightarrow generates, at start of $t + 1$, advances in practical knowledge & technology that raise TFP: $a_{t+1} = (1 + \gamma)a_t$.
- May also affect religious beliefs: new scientific findings that contradict professed doctrine and sacred texts' statements about natural world (origins of universe or mankind, determinants of moral behavior, abilities of women) shake and weaken the faith of religious agents
- Not all discoveries have such effects \Rightarrow two main types:
 - ▶ A fraction p_N of are **belief-neutral (BN)**: no impact on b .
 - ▶ A fraction $p_R = 1 - p_N$ are **belief-eroding (BR)**: if diffuse widely in population, erode religious capital: $b_{t+1} = (1 - \delta)b_t$.

Discoveries, Productivity Growth, and Beliefs II

- Later on, also allow for belief-enhancing (BE) shocks:
 - ▶ While (popular) religiosity occasionally benefits from certain technological innovations (e.g., televised evangelism, videotapes), discoveries in basic science very rarely / do not / have such an effect
 - ▶ Increases in religiosity arise from: immigration, cultural change, or increased demand for reassurance, divine forgiveness and salvation following major disasters (Great Plague, famine, war, defeat, etc.)
- Will therefore model BE shocks as exogenous events that raise b , occurring between rather than within generations, independently of scientific discoveries and political developments.

Blocking I

- Religious majority / government may want to censor, deny, restrict access to, the new knowledge.
- Assume that blocking can be targeted at BR innovations and is fully effective \Rightarrow beliefs of religious citizens (and govt.) remain unchanged, as does TFP: $a_{t+1} = a_t$ and $b_{t+1} = b_t$
- Censoring “dangerous ideas” emanating from scientific inquiry and methodology involves two types of costs:
 - ① Foregone TFP gains that could be reaped from applications
 - ② Direct cost required to set up, **in advance**, a repressive apparatus that will stand ready to quash / impede such ideas
 - Functionaries who monitor and repress “heretical” or “blasphemous” notions and their proponents (Inquisition, religious police)

Blocking II

- Enforcing censorship of school lessons and textbooks, if not banning printing outright.
 - Subsidizing official or parallel doctrine-friendly “science” (creationism, climate change denial, etc.)
- (Normalized) resource cost φ_t required increases with society’s level of knowledge and TFP:

$$\varphi_t = \varphi(a_t), \nearrow$$

- ▶ New knowledge more difficult to contain, repress or counteract in a society that is intellectually and technologically more sophisticated (printing press, travel, radio, TV, fax, internet, etc.)
- φ_t is independent of religious capital, b
 - ▶ Costs of impeding flow of free information largely independent of its content and of the strength of the beliefs it might affect

The Church I

- Small (zero-measure) set of agents, drawn from among the religious
Produce no income, but may engage in another type of work
- Whenever a *BR* scientific discovery occurs and diffuses through society, this Church or religious sector can attempt to “repair” the damage done to the faith:
 - ▶ Doctrinal adaptation through internal reform, e.g. working out and proclaiming a reinterpretation of the sacred texts more compatible with scientific facts.
 - ▶ Can also take the form of conflictual Reformation, schism or creation of new sects by competing faith entrepreneurs
- Will treat organized religion as a single actor, with preferences

$$\mathbb{E}_t [b_{t+1} G_{t+1} - \rho_t \eta b_t], \quad \rho_t \in \{0, 1\},$$

The Church II

- Church cares about strength of beliefs b_{t+1} in the religious population and provision of complementary goods and services, G_{t+1} , which generate benefits $b_{t+1} G_{t+1}$ for the faithful.
 - ▶ Benevolent, or just capturing **rents**: either
- Incurs effort costs ηb_t if, following the diffusion of a *BR* innovation, it undertakes the work required to prevent religious capital from eroding.
 - ▶ Larger stock of religious capital (more devout beliefs) more expensive to adapt and reform.
- Empirical counterpart: key determinant of η is **religious freedom**:
 - ▶ Ease with which heterodox interpretations, new sects or cults are allowed to develop, and people to switch affiliation
 - ▶ State religion vs. competitive sector
- Also: doctrine-specific features making adaptation easy/hard $\sim \eta$

Doctrinal Adaptation - Repairing Beliefs

- Repairing can only be attempted after the new discovery diffuses, as revision in the doctrine must be appropriately tailored to it
- Succeeds with probability $q \in [0, 1] \Rightarrow$ damage done to beliefs of the faithful is completely undone $\Rightarrow b_{t+1} = b_t$
- If fails, religious capital eroded just as much as if there had been no attempt to preserve it: $b_{t+1} = (1 - \delta)b_t$.
- In either case: $a_{t+1} = (1 + \gamma)a_t$

Timeline

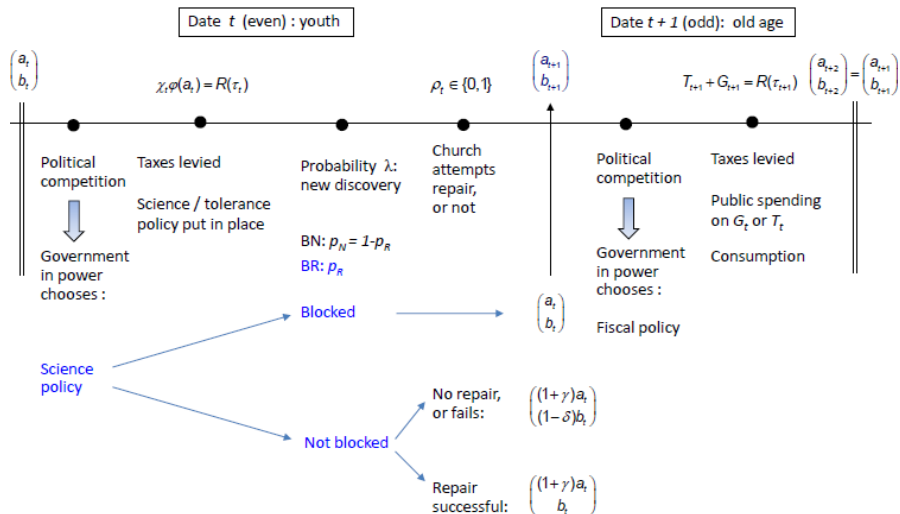


Figure: timing of events in each generation

Political Equilibrium at $t+1$: Fiscal Policy

- Religious majority sets taxes and spending:

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

- Define, $\forall x$, solution in τ to FOC $xR'(\tau) = 1$ as

$$\tau^*(x) \equiv (R')^{-1}(1/x), \quad \text{strictly } \nearrow \text{ in } x$$

Proposition (fiscal outcome)

The fiscal policy implemented in the second period is:

- If $b < \nu$, then $(\tau, T, G) = (\tau^*(\nu), R(\tau^*(\nu)), 0)$, with $\tau^*(\nu)$ and $R(\tau^*(\nu))$ increasing in ν .*
- 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 $\hat{\tau}$ and constant afterwards*

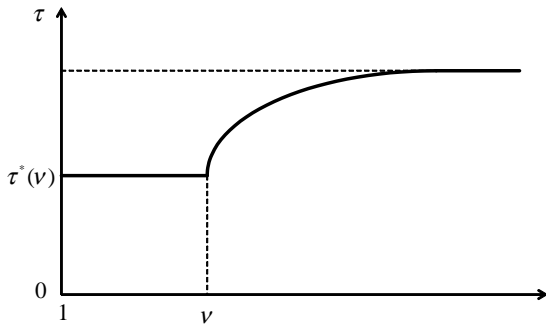


Figure: equilibrium tax rate as a function of religiosity

- Denote second-period equilibrium spending on G as

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

Church's Belief-Repairing Strategy

- Working to repair the damage done to b by a BR innovation succeeds with probability $q \Rightarrow$ Church attempts it if and only if

$$qbG(b, v) + (1 - q)(1 - \delta)bG((1 - \delta)b, v) - \eta b \\ \geq (1 - \delta)bG((1 - \delta)b, v) \iff$$

$$\pi(b, v) \equiv G(b, v) - (1 - \delta)G((1 - \delta)b, v) \geq \eta/q.$$

Lemma (value of doctrinal repair)

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

Value of Successful Repair

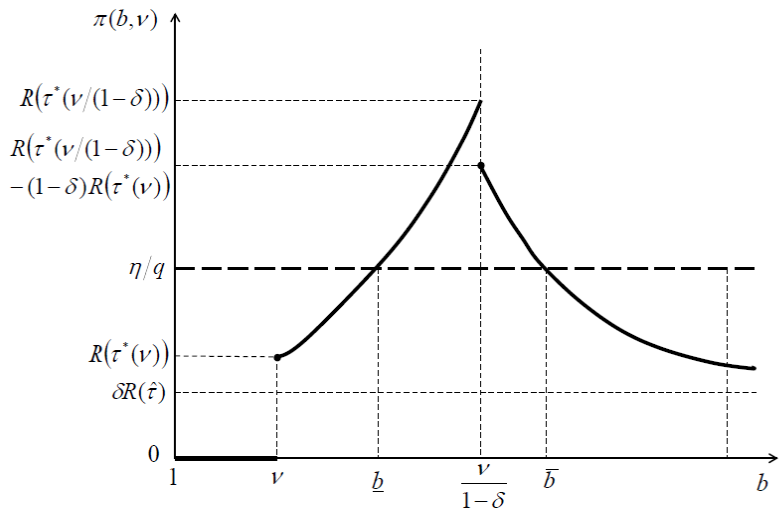


Figure: Church's expected value of repairing beliefs

Proposition (repairing range)

There exist a unique \underline{b} and \bar{b} , with

$$v \leq \underline{b} < \frac{v}{1 - \delta} < \bar{b},$$

such that the Church attempts to repair after belief-eroding innovations (not blocked by the state) if and only if b lies in $[\underline{b}, \bar{b}]$.

- Intuitively, when religious capital is below \underline{b} it is not worth repairing, given cost η
- When it is above \bar{b} , there is enough of it (hence also enough demand for G) that Church can afford to let it depreciate somewhat

State Policy Toward Science (date t)

- Decision at t : whether to invest in blocking potential BR discoveries, trading off option value of preserving religious capital vs. foregone TFP gains + cost of setting up a repressive apparatus
- Two clear cases in which government (religious majority) clearly does **not** find it optimal to invest in blocking.
 - ▶ When $b < \nu$, religious agents themselves prefer secular public goods (or transfers) to religious ones, \Rightarrow set $G(b, \nu) = 0$, derive no utility from organized religion. Remains a fortiori true if b falls to $(1 - \delta)b$
 - ▶ If state expects the Church to attempt repair after unblocked BR innovations, and has *sufficient confidence* that it will succeed, it prefers to “take a pass”, let Church do the work
- **Assumption** : $q \geq 1 / (1 + \gamma)$.

- Will show: blocking occurs when $b \geq B(a)$, i.e. society is sufficiently religious, **relative** to its state of scientific and technical development

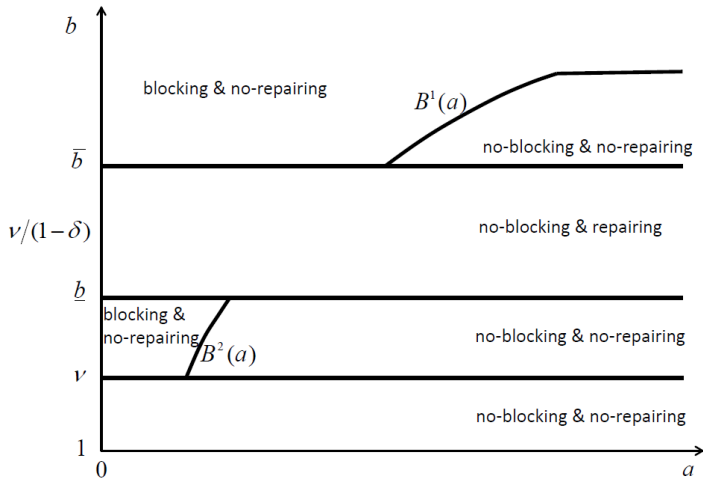


Figure: blocking and repairing regions

Blocking Decision I

- Religious agents' old-age utility when gvt. finances a public good which they value at u per unit, relative the numeraire:

$$V(u) \equiv 1 - \tau^*(u) + uR(\tau^*(u)),$$

setting tax rate at optimal $\tau^*(u)$. In equilibrium, $u = \max\{b, v\}$

- Value of blocking.** Blocking BR discoveries requires ex-ante investment of $\varphi(a)$. Beliefs are then fully protected \Rightarrow expected intertemporal utility of religious majority is

$$\begin{aligned} V^B(a, b) &= 1 - R^{-1}(\varphi(a)) \\ &\quad + [1 - \lambda + \lambda p_R + \lambda(1 - p_R)(1 + \gamma)] V(b) \end{aligned}$$

Blocking Decision II

- Value of not blocking. BR innovations also diffuse and raise standards of living, but now erode religiosity to $b' \equiv (1 - \delta) b$, and in this range Church does not repair. Two cases:
- Region 1: $b > \bar{b}$. No repairing, continued provision of G .

Since $b > \bar{b} > v/(1 - \delta)$, religious capital remains high enough that $G(b') > 0$ is chosen over secular spending \Rightarrow

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

- Government blocks when $V^B \geq V^{NB}$, or

$$\begin{aligned} R^{-1}(\varphi(a)) &\leq \Delta^1(b) \equiv \lambda p_R [V(b) - (1 + \gamma) V(b')] \\ &= \lambda p_R \{1 - \tau^*(b) + bR(\tau^*(b)) \\ &\quad - (1 + \gamma) [1 - \tau^*(b') + b'R(\tau^*(b'))]\} \end{aligned}$$

Blocking Decision III

Proposition

For $b > \bar{b}$, the state implements the blocking of BR discoveries if and only if (a, b) lies above the upward-sloping locus $b = B^1(a)$.

- Region 2: $v \leq b < \underline{b}$. No repairing, no provision of G

Now $b' = (1 - \delta) b < v \Rightarrow$ unblocked, unrepaired BR discovery damages beliefs sufficiently that religious agents now prefer secular public spending: $G = 0$ and $T = R(\tau^*(v))$

- Value of not blocking is now

$$\begin{aligned} V^{NB}(a, b) &= 1 + [1 - \lambda + \lambda(1 - p_R)(1 + \gamma)] V(b) \\ &\quad + \lambda p_R(1 + \gamma) V(v) \end{aligned}$$

Blocking Decision IV

- Govt. blocks when

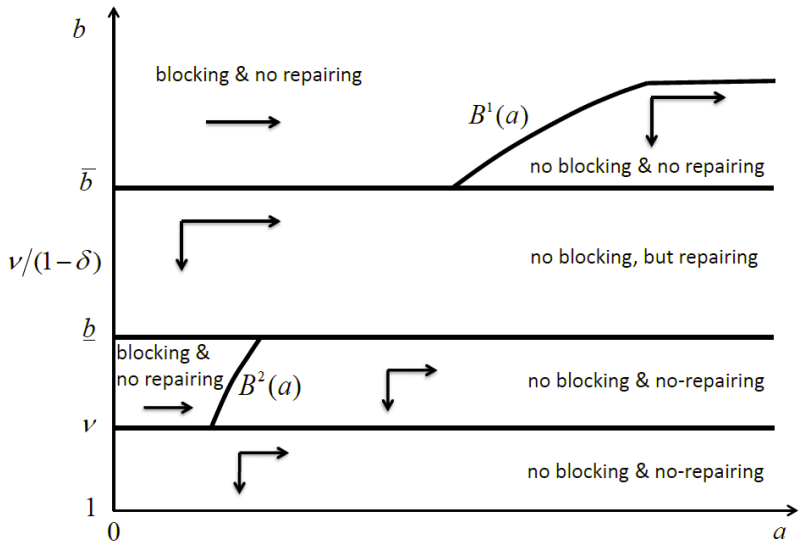
$$\begin{aligned}R^{-1}(\varphi(a)) &\leq \Delta^2(b) \equiv \lambda p_R [V(b) - (1 + \gamma) V(v)] \\ &= \lambda p_R \{1 - \tau^*(b) + bR(\tau^*(b)) \\ &\quad - (1 + \gamma) [1 - \tau^*(v) + vR(\tau^*(v))]\}\end{aligned}$$

Proposition

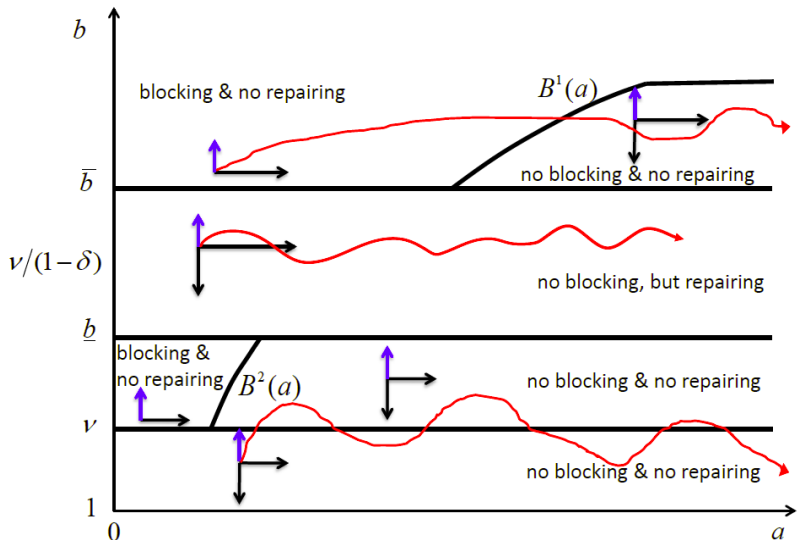
For $v \leq b < \underline{b}$, the state implements the blocking of BR discoveries if and only if (a, b) lies above the upward-sloping locus $b = B^2(a)$.

Dynamics of Scientific Progress and Religiosity

- Have derived the law of motion of (a_t, b_t) **within** a generation
- **Between** generations, simplest case is where the young inherit, without change, the final stocks of knowledge and religiosity of the old: $(a_{t+2}, b_{t+2}) = (a_{t+1}, b_{t+1})$
- In this simple benchmark, however, religiosity can only decrease, or remain constant.
- In practice: periodical events, societal changes that **enhance** religiosity
 - ▶ Typically not linked to scientific discoveries \Rightarrow treat them as exogenous: at the start of each new generation $a_{t+2} = a_{t+1}$, but
 - $b_{t+2} = b_{t+1}$ with probability $1 - p_E$,
 - $b_{t+2} = (1 + \mu)b_{t+1}$ with probability p_E , where $\mu > 0$



Dynamics without BE shocks



Dynamics with BE shocks

Average Trajectories in Each Regime

- ① **Non-blocking, non-repair “secularization” region:** Western Europe, or the United States when b_t/a_t is relatively low:

$$\mathbb{E}_t(a_{t+1})/a_t = 1 + \lambda\gamma,$$

$$\mathbb{E}_t(b_{t+1})/b_t = (1 - \lambda p_R \delta)(1 + p_E \mu).$$

- ② **Non-blocking with repair region:** United States for b_t/a_t moderately high; Singapore

$$\mathbb{E}_t(a_{t+1})/a_t = 1 + \lambda\gamma,$$

$$\mathbb{E}_t(b_{t+1})/b_t = [1 - \lambda p_R (1 - q) \delta](1 + p_E \mu).$$

- ③ **Blocking region:** theocratic regimes (Medieval Europe, Ottoman Empire, Ancient China, Pakistan), United States for b_t/a_t very high:

$$\mathbb{E}_t(a_{t+1})/a_t = 1 + \lambda(1 - p_R)\gamma,$$

$$\mathbb{E}_t(b_{t+1})/b_t = 1 + p_E \mu.$$

Growth With and Without Secularization

Let

$$g_r^{EU} \equiv (1 - \lambda p_R \delta)(1 + p_E \mu) < 1,$$

$$g_r^{US} \equiv [1 - \lambda p_R (1 - q) \delta](1 + p_E \mu) \approx 1.$$

- “Western Europe” and the “United States” grow at the same rate $1 + \lambda \gamma$ (neither blocks)
 - ▶ In EU, there is a downward trend in religiosity (with periodic upward shocks preventing degenerate long-distribution)
 - ▶ In US, it is mostly offset by the adaptive response of the religious sector \Rightarrow trendless fluctuations or slow-moving shifts in religiosity
- Provided a society is not excessively religious ($b < \bar{b}$), economic growth can thus occur both with and without secularization, as a result of endogenously different responses of the religious sector
- In the “theocratic” region $b > \bar{b}$, religiosity trends up while knowledge and TFP stagnate, particularly if $\lambda_R \approx 1$.

Inequality, Religion and the Politics of Science

- Interplay between religious and class differences: in each generation, fraction $n < 1/2$ of agents are rich, majority $1 - n > 1/2$ are poor
- Pretax incomes are θ_H and θ_L in both youth and old age, with

$$\theta_L < v < \theta_H \quad \text{and} \quad \theta_H + (1 - n)\theta_L \equiv 1$$

- Income and religiosity are distributed independently \Rightarrow four social groups with respective sizes:
 - ▶ Secular Poor, $SP = (1 - n)(1 - r)$, Secular Rich, $SR = n(1 - r)$,
Religious Poor, $RP = (1 - n)r$, Religious Rich, $RR = nr$.
- **Assumption** : Let $\frac{1}{3} < n < \frac{1}{2} < r$ and $2r(1 - n) < 1 < r(1 + n)$.
- Thus no group is a majority on its own, but religious agents together, as well as poor agents together, do. Groups sizes / power ranked as:

$$SR < SP < SR + SP < RR < RP < 1/2 < 1 - n < r.$$

The Political Process I

- At both t and $t + 1$, **four groups** vying for power. Also, policy space at $t + 1$ is **two-dimensional**: level and nature of public spending \Rightarrow
- Majority voting not applicable. Instead, in each period political competition (voting, open conflict) unfolds as follows
- ① In each social group, a randomly chosen member is selected as **leader**. The four leaders then simultaneously decide whether to make a bid for power, at no personal cost, or to stay out.
 - ▶ Entry choices **fully strategic**, both within and across periods
- ② Citizens independently choose which active contender for power to support (vote or fight for). Since no individual can affect aggregate outcome, each just **chooses sincerely** his preferred candidate

The Political Process II

- ③ If a leader gains support from 50%, he wins. If not, **runoff** round or battle takes place between the two who received the most support.
 - ▶ The one who then attracts a majority wins.
- ④ Victorious leader implements policy that maximizes his own utility, as in **citizen-candidate** models on which we build (Osborne-Slivinsky 1996, Besley-Coate 1997). No way for politicians to credibly commit to following a given course of action once in power
 - ▶ Leader's choices coincide here exactly with what core constituency (socioreligious group of origin) wants him to do: their interests summarized by b and θ , are aligned at both t and $t + 1$
 - ▶ Thus, no issue of agency / lack of commitment within group. Only **between** them: can't offer to compromise

The Political Process III

- As before, in any even period t the government in power only chooses blocking policy $\chi_t \in \{0, 1\}$ and implied taxes $\tau_t = R^{-1}(\chi_t \varphi(a_t))$
- In any odd period $t + 1$ the (possibly different) government holding office chooses nature and level of public spending, together with required taxes: $T_{t+1}, G_{t+1}, \tau_{t+1} = R^{-1}(T_{t+1} + G_{t+1})$.

Equilibrium Concept

- Four groups, none of which constitutes a majority \Rightarrow coalitions will need to form in order to gain power
- Citizen-candidate-type models typically feature multiple NE in which different coalitions arise to support different entry profiles \Rightarrow impose
- Stronger requirement: Perfectly Coalition-Proof Nash equilibrium (PCPNE, Bernheim et al. 1987) of the two-period (t and $t + 1$) stage game played by each generation. Focus on pure-strategies.
 - ▶ Unlike standard NE, CPNE for normal-form games takes into account joint deviations by coalitions; however, only self-enforcing deviations are considered to be credible threats
 - ▶ In extensive-form games, the additional subgame-perfection requirement further restricts admissible coalitional agreements and deviations to be dynamically consistent
- Will show unique PCPNE, solve as function of state variables (a, b) .

Timeline

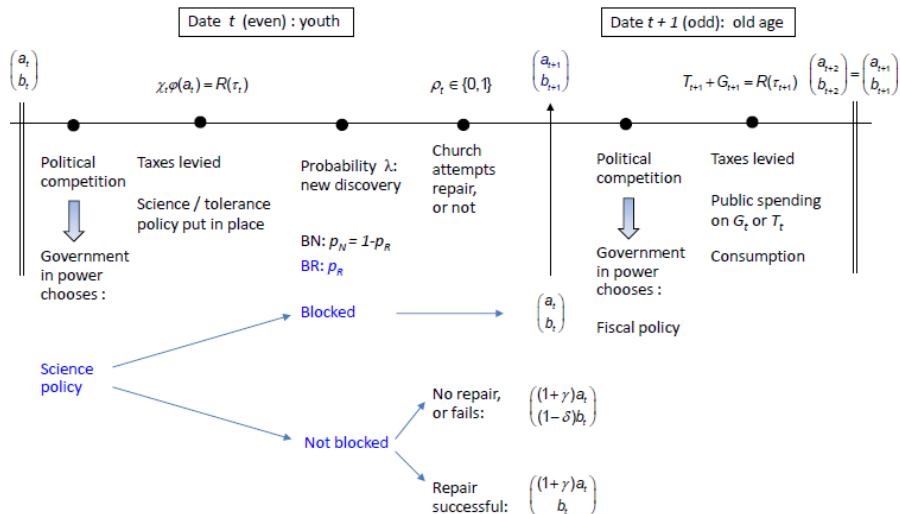


Figure: timing of events in each generation

Equilibrium Fiscal Policy (date $t+1$) I

- Characterize in turn:
 - ① Preferred fiscal policies of each of the four groups
 - ② Outcome that emerges from their competition
- Secular Poor maximize $(1 - \tau)\theta_L + \nu R(\tau) \Rightarrow \tau = \tau^*(\nu/\theta_L)$
- Religious poor maximize $(1 - \tau)\theta_L + \nu [R(\tau) - G] + bG$ over $\tau \in [0, \hat{\tau}]$ and $G \leq R(\tau) \Rightarrow$ depends on $b \gtrless \nu$

Lemma (fiscal preferences of the poor)

(1) The ideal policy of secular poor is $(\tau, T, G) = (\tau_L(\nu), R(\tau_L(\nu)), 0)$, with $\tau_L(\nu) \equiv \tau^*(\nu/\theta_L) \nearrow$ in ν/θ_L .

(2) The ideal policy of religious poor is the same if $b < \nu$. If $b \geq \nu$ it is $(\tau, T, G) = (\tau_L(b), 0, R(\tau_L(b)))$, with $\tau_L(b) \equiv \tau^*(b/\theta_L) \nearrow$ in b/θ_L .

Equilibrium Fiscal Policy (date $t+1$) II

- Secular rich: always want $\tau = 0$.
- Religious rich: maximize $(1 - \tau)\theta_H + v [R(\tau) - G] + bG$ over $\tau \in [0, \hat{\tau}]$ and $G \leq R(\tau)$

Lemma (fiscal preferences of the rich)

- (1) *The ideal policy of the secular rich is $(\tau, T, G) = (0, 0, 0)$*
- (2) *The ideal policy of the religious rich is the same if $b < \theta_H$. If $b \geq \theta_H$, on the other hand, it is $(\tau, T, G) = (\tau_H(b), 0, R(\tau_H(b)))$, with $\tau_H(b) \equiv \tau^*(b/\theta_H) < \tau_L(b) \nearrow$ in b/θ_H .*

Whom do the religious poor side with ?

- When in power, the *SP* provide a lot of T and no G , the *RR* no T and a positive G , but (due to their distaste for taxes) at a level less than what the religious poor desire \Rightarrow
 - ▶ First policy is preferred when beliefs b , which are complements to G , are relatively low compared to value v attached to T by poor agents

Lemma (religiosity and fiscal coalitions)

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

- Using these properties of the different groups' fiscal preferences, we prove existence and uniqueness of CPNE in political subgame at $t + 1$

Proposition (CPNE)

The equilibrium fiscal policy in the second period is unique:

(1) If $b < b^(v)$, either the **secular poor** come to power and implement their preferred policy $(\tau, T, G) = (\tau_L(v), R(\tau_L(v)), 0)$, or the **religious poor** do and implement that same policy.*

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

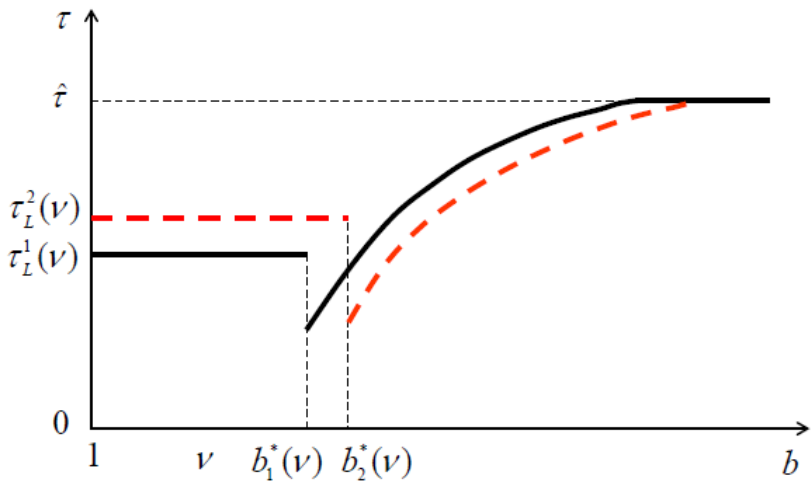


Figure: religiosity and equilibrium tax rate (black curve)

Implications

① Religion as a “wedge” issue

- ▶ In countries with low religiosity, secular governments come to power, 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 US, religion splits the standard pro-redistribution coalition of the poor. Decisive class is then not only more religious, but also richer (related to Roemer 1998, but political mechanism quite different)

② Effects of rising income inequality

- ▶ Results also imply that greater income inequality leads to the usual effect of *higher* taxes and government spending in low-religiosity countries such as those of Western Europe, but to *lower* levels of both (and different mix) in more religious ones, such as the United States.

Equilibrium Policy of the Church

- Same as with no income differences, except that allowing religious capital to fall below $b^*(v)$ will now lead to a drastic **reallocation of power** toward secular (poor) agents.

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

- Decision to repair doctrine still given by $\pi(b, v) \geq \eta/q$, but in $\pi(b, v)$ the provision of religious public goods is now defined as above: $b^*(v)$ replaces v and $\tau_H(b)$ replaces $\tau^*(b)$

Lemma (effects of inequality on church policy)

- (1) As θ_L rises, the graph of $\pi(b, v; \theta_L, \theta_H)$ shifts (weakly) to the left.
- (2) As θ_H rises, the graph of $\pi(b, v; \theta_L, \theta_H)$ shifts (weakly) to the right.

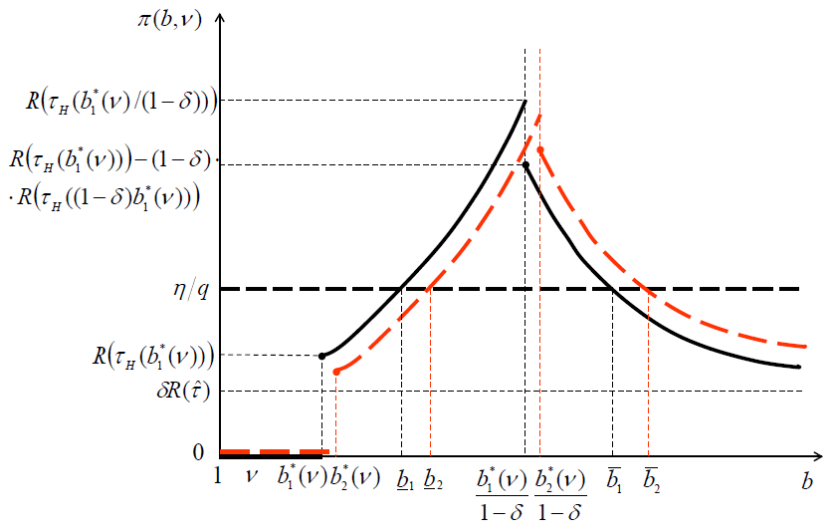


Figure: Church's doctrinal-repair behavior

Proposition (Church policy and income inequality)

(1) There exist a unique \underline{b} and \bar{b} , with $b^*(v) \leq \underline{b} < \frac{b^*(v)}{1-\delta} < \bar{b}$, such that the Church attempts repair of a belief-eroding innovation (not blocked by the government) 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 $\theta_L \Rightarrow$ strictly increasing with income inequality (mean-preserving change in θ).

● Intuition:

- ▶ At \bar{b} , power reallocation not an issue: RR will be in control at $t + 1$ no matter what, but if their faith erodes, will provide a lower level of G_{t+1}
- ▶ As they become relatively richer and thus face a higher tax price for G this effect is amplified \Rightarrow the Church, which cares about $b_{t+1} G_{t+1}$, has a **greater incentive** to preserve b_{t+1}
- ▶ At \underline{b} , repairing or not determines whether RR or 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 \Rightarrow Church has **lower incentive** to preserve b_{t+1} in order to ensure RR 's victory.

State's Policy Toward Science (date t) I

- Aggregate **costs** of blocking are the same as before (lower consumption at t to finance the repressive apparatus and foregone TFP gains at $t + 1$), but their **incidence** is different for rich and poor.
- **Benefits** now differ not only between secular and religious but also **by income**, since erosion of beliefs can trigger reallocation of political power from (religious) rich to (secular) poor agents at $t + 1$.
- **Preferences of Secular Poor**: they are always against blocking. Not only do *BR* innovations raise productivity, but the erosion of beliefs they generate are always beneficial for *RP* :
 - ▶ Reduces taxation and spending on the religious public good G_{t+1} if the *RR* are in power at $t + 1$, namely if b_{t+1} remains above $b^*(\nu)$
 - ▶ Increases the chance that *SP* themselves will gain power at $t + 1$, which occurs if b_{t+1} falls below $b^*(\nu)$.

State's Policy Toward Science (date t) II

- Preferences of Secular Rich: simplifying assumption, ensuring that they also never want to block:

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

- ▶ Productivity gains from implementing new (BR) discoveries large enough that, even if erosion of beliefs brings SP to power, **aftertax** incomes at $t + 1$ are higher than if blocking had occurred and the (lower-taxing) RR held power as a result.
- Other simple cases. As without income differences, there are two regions in which even a religious government never blocks:
 - ▶ For $b < b^*(\nu)$, the SP will always be in power at $t + 1$ and set $G_{t+1} = 0 \Rightarrow$ no point for anyone to invest in blocking
 - ▶ For $b \in [\underline{b}, \bar{b}]$, Church will attempt to repair unblocked BR discoveries \Rightarrow if likelihood of success q high enough, any religious government will let repair be attempted rather than make own investment in blocking

State's Policy Toward Science (date t) III

- Leaves two regions to analyze: $b > \bar{b}$ and $b^*(v) \leq b < \underline{b}$
- ① Characterize here the **ideal blocking policy** of the *RR*
- ② Those of the *RP* and *SR* classes obtained by simple substitutions:
 - ▶ $\theta_H \rightsquigarrow \theta_L$ and $bR(\tau_H(b)), bR(\tau_H(b)) \rightsquigarrow 0$
- ③ Show, in paper, that the *RR* always end up being **pivotal** at date t

Blocking Decisions I

- Region 1: $b > \bar{b} > b^*(v)/(1 - \delta)$

The religious rich will be in power at $t + 1$ even if beliefs are eroded by a new discovery \Rightarrow

$$V_{RR}^B(a, b) = [1 - R^{-1}(\varphi(a))] \theta_H + [1 - \lambda + \lambda p_R + \lambda(1 - p_R)(1 + \gamma)] V_{RR}(RR|b),$$

where, for all b ,

$$V_{RR}(RR|b) \equiv [1 - \tau_H(b)] \theta_H + bR(\tau_H(b))$$

represents their utility in old age. Similarly, with $b'(1 - \delta)b$,

$$V_{RR}^{NB}(a, b) = \theta_H + [1 - \lambda + \lambda(1 - p_R)(1 + \gamma)] V_{RR}(RR|b) + \lambda p_R(1 + \gamma) V_{RR}(RR|b')$$

Blocking Decisions II

- The RR 's blocking condition, $V_{RR}^{NB} \leq V_{RR}^B$, is

$$\begin{aligned} R^{-1}(\varphi(a))\theta_H &\leq \lambda p_R [V_{RR}(RR|b) - (1 + \gamma) V_{RR}(RR|b')] \\ &\equiv \Delta_{RR}^1(b) \\ &= \lambda p_R \{ [1 - \tau_H(b)]\theta_H + bR(\tau_H(b)) \\ &\quad - (1 + \gamma) [(1 - \tau_H(b'))\theta_H + b'R(\tau_H(b'))] \}. \end{aligned}$$

Blocking Decisions III

- Region 2: $b^*(v) \leq b < \underline{b} < b^*(v)/(1 - \delta)$

The *RR* hold power at $t + 1$ if beliefs remain intact, while the *SP* take over if it erodes

$$V_{RR}(SP) \equiv [1 - \tau_L(v)]\theta_H + vR(\tau_L(v)).$$

The blocking condition becomes

$$\begin{aligned} R^{-1}(\varphi(a))\theta_H &\leq \Delta_{RR}^2(b) \equiv \lambda_{pR} \{V_{RR}(RR|b) - (1 + \gamma)V_{RR}(SP)\} \\ &= \lambda_{pR} \{[1 - \tau_H(b)]\theta_H + bR(\tau_H(b)) \\ &\quad - (1 + \gamma)[(1 - \tau_L(v))\theta_H + vR(\tau_L(v))]\} \end{aligned}$$

- The blocking preferences of the religious poor are obtained, in each region, by simply replacing θ_H with θ_L . Those of secular agents by replacing $bR(\tau_H(b))$ and $bR(\tau_H(b))$ with zero

Equilibrium Blocking Policy I

- By studying and comparing the four groups' blocking loci, show that their relative rankings remain invariant throughout state space:
 - ▶ Whenever the *RR* block, then so do the *RP*
 - ▶ The *SR* never want to block, as is the case for the *SP*.
- These properties imply that **the *RR* are always pivotal** in the date- t political competition that determines science policy.
 - ▶ When they are against blocking the *SP* and the *SR* agree with them, resulting in an absolute majority
 - ▶ When the *RR* do want to block, the *RP* agree with them, again adding up to an absolute majority.

Equilibrium Blocking Policy II

Proposition (PCPNE)

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

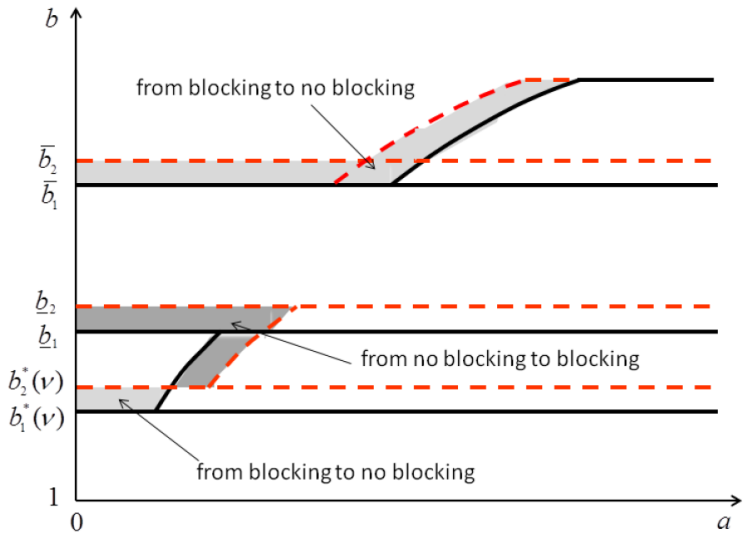


Figure: Science-blocking policy with inequality (black curve)

Income Inequality and Science Policy

- Keeping the sizes $(n, 1 - n)$ of the rich and poor classes constant, consider mean-preserving spread in incomes: $(d\theta_H, d\theta_L)$, 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** $\theta_H - 1 \geq v \frac{(1-n)^2}{n} [-R''(\hat{\tau})] \left(1 + \frac{R^{-1}(\bar{\varphi})}{\lambda p_R(1+\gamma)} \right)$.

Proposition

A marginal increase in income inequality (mean-preserving spread) causes the equilibrium blocking and repairing loci to shift as follows:

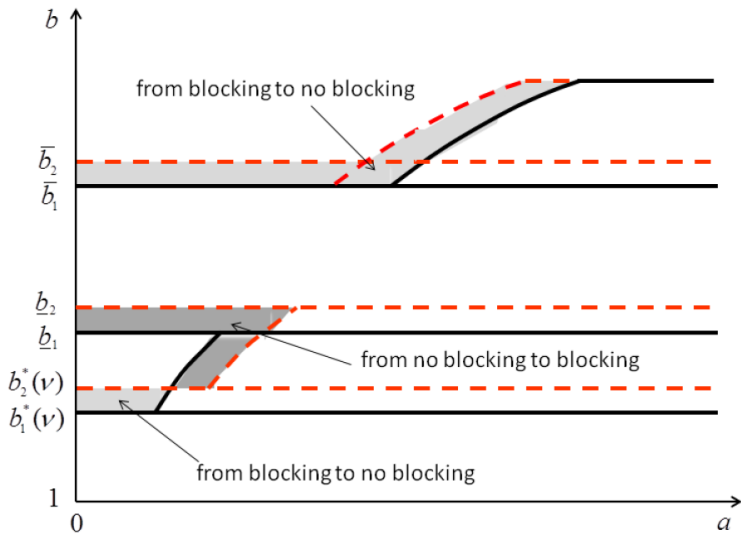


Figure: effects of higher inequality on science-blocking policy

Proposition (inequality and attitudes toward science)

(1) In the “American” regime, corresponding to intermediate values of b/a , greater income *inequality* leads to more blocking of “threatening” scientific findings, and to (weakly) *greater doctrinal rigidity* (less adaptation) of the religious sector.

(2) At high enough levels of religiosity, corresponding to “theocratic” regimes, it has the opposite (“Arab Spring”) effects.

- Underlying details are somewhat involved (each potential coalition at t must envision all possible coalitions at $t + 1$ that its actions can empower or defeat), but
- Main intuition for how increased inequality leads to the emergence of a **Religious-Right alliance** in the “American” regime is simple:

- ① Choices over fiscal policy and public spending at $t + 1$:
 - ▶ If RP 's faith has eroded, will ally themselves with SP and implement high level of redistribution – worst possible outcome for RR
 - ▶ If RP remain sufficiently pious, however, will support instead the RR 's “compromise” policy of moderate taxes but religion-favoring spending
- ② Looking forward at date t , the RR realize that in order to hold power at date $t + 1$ they must preserve the religiosity of the RP , which may require blocking certain economically valuable innovations
- ③ When stakes of who will control fiscal policy at $t + 1$ become high enough (inequality \uparrow), this concern dominates over the fact that rich agents benefit most from productivity gains
 \Rightarrow The RR strategically give priority to religion over science at date t , and in so doing they have the support of the RP , who are always those with the greatest incentive to block
- ④ The dynamic outcome is that the RR gain power at date t , and thanks to blocking they keep it at date $t + 1$.

Further Thoughts I

- Leading examples of “forbidden fruits” discussed involved the **hard sciences** on the one hand, religion **stricto sensu** (belief in deities and spirits, creation, afterlife, etc.) on the other
- Clear from the model that both concepts should be taken in a much more general sense. Two concrete cases:
 - ① **Lysenkoism** in the Soviet Union between 1935 and 1964.
 - ★ During three decades, Inquisition-like methods (forced denunciations, imprisonments, executions) were used to repress “bourgeois” scientific knowledge and methodology in evolutionary biology and agronomy, with adverse spillovers onto many other areas.
 - ★ Stalinist regime also promoted and enforced a pseudoscience which it saw as more compatible with its dogma of Man's and society's malleability to rapid social change.

Further Thoughts II

- ② **Modern contraception:** a very applied innovation though directly derived from fundamental advances in human biology. Here again, find the four key characteristics of *BR* innovations in our model:
 - ★ Large positive impact on long-term productivity, by allowing greater participation of women in the labor force and increasing their return to human capital investment
 - ★ Conflict with several of the world's major religious doctrines and their teachings about the divinely ordered role of women, purpose of sexuality and sacrality of the body
 - ★ As a result, its condemnation by religious authorities and initial proscription by the state
 - ★ Over time (and not in all places), as society becomes more secular or/and religious doctrine is “modernized”, the innovation is allowed to diffuse, affecting both productivity and mentalities

Further Thoughts III

- Many other examples could be drawn: medicine, social sciences...
- As much as individual discoveries and ideas, it is to a large extent the **scientific method** itself, with its emphasis on systematic **doubt**, contradictory debate and empirical **falsifiability**, that inevitably runs afoul of preestablished dogmas.

Directions for Further Research I

- Besides being source of utility for some, religiosity could also
 - ▶ promote certain forms of human capital accumulation
 - ▶ induce greater **trust** and trustworthiness among individuals (up to point where becomes a source of civil strife)
 - ▶ **legitimize** authority of ruler or state \Rightarrow reduce agency problems

Key tradeoff with allowing belief-eroding ideas to diffuse would remain \Rightarrow likely hill-shaped relationship between religiosity and growth

- **Interstate conflict:** intensely religious population and strong state-church links are
 - ▶ valuable assets in short to medium run: increase people's willingness to fight and die for the cause
 - ▶ in the long run, a drag on scientific knowledge and technological innovation, leads to military backwardness (Ottoman Empire)

Directions for Further Research II

- Model could also be used to study the interactions between
 - ▶ many other types of new ideas: scientific, social, political
 - ▶ vested beliefs religious, cultural, ideological, corporate,
- ⇒ Emergence of stable regimes where either form of “reasoning and knowing” gains primacy, or the two manage to coadapt.
- On the empirical side, the robust inverse relationship between religiosity and innovation uncovered by our simple analysis, across both countries and US states deserves further investigation.

“I did not major in math, I majored in miracles.

And I still believe in them.”

Sen. Mike Huckabee, 2008 presidential campaign
Preparing to run again in 2016...