

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

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2. Thomas Aquinas (1225–1274): new intellectual construction, making Christian doctrine and Aristotelian natural philosophy compatible

- ▶ “Medieval synthesis” of reason and faith, became official doctrine

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3. Scientific revolution: heliocentrism, atomism, infinitesimals, empiricism  
Completely upended Aquinian synthesis  $\Rightarrow$  **banned, severely repressed**  
by Roman Church (Jesuits, Inquisition)
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5. United States: origins of Earth, evolution of life, stem cell research ban, climate change... in perpetual flux / debate

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- ① Historical and contemporary examples
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- Remarks:
  - ▶ State variables: stocks of knowledge and religious capital
  - ▶ Scientific progress  $\rightarrow$  religious beliefs  $\rightarrow$  coalition gaining power (religious or secular led)  $\rightarrow$  pace of scientific progress

# I - Innovation and Religiosity Across Countries

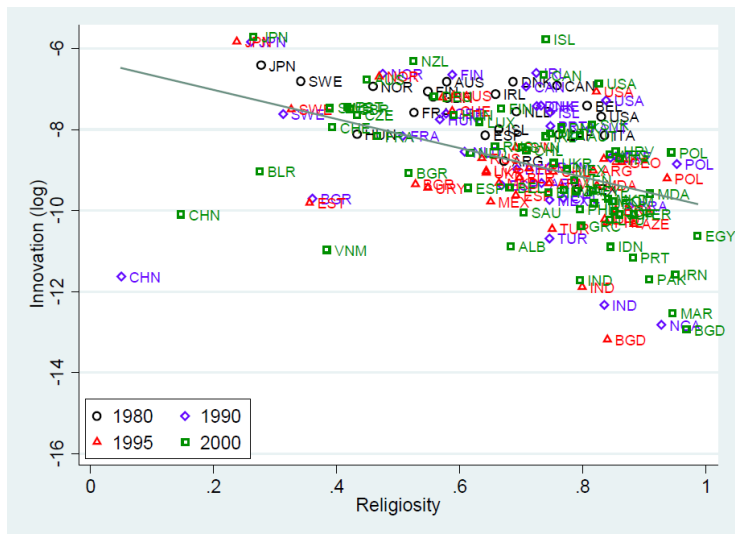


Figure 1

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

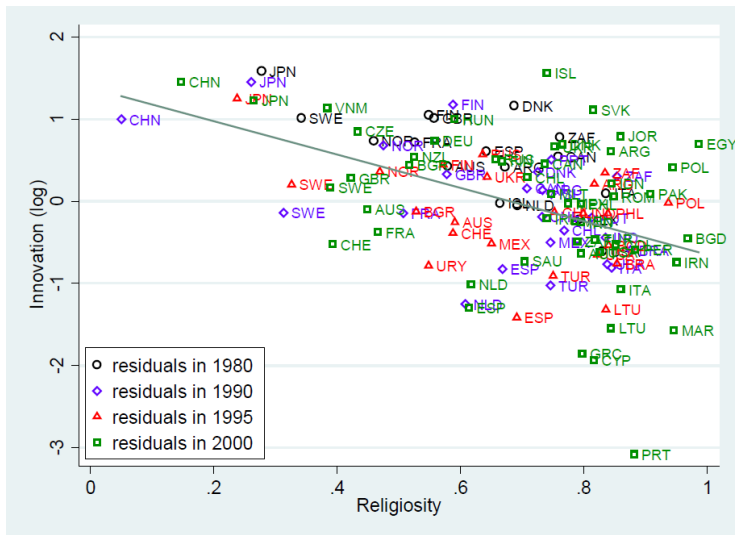


Figure 3



**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%.

## II - Innovation and Religiosity Across U.S. States

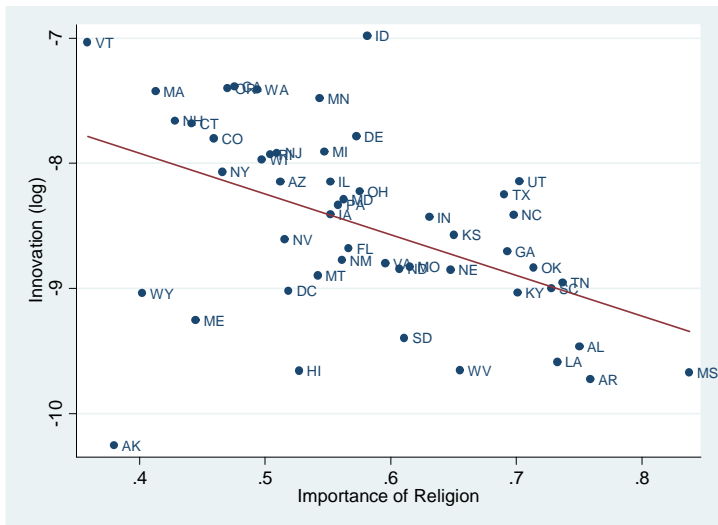


Figure 5

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

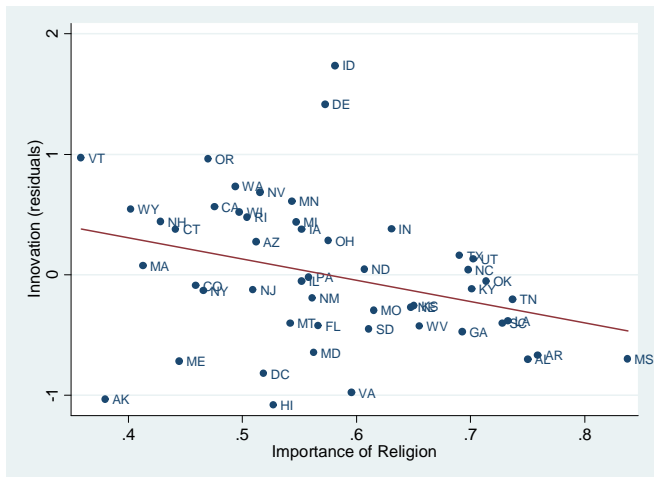


Figure 7

**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%.

### III - The Model: Agents

- Non-overlapping generations: youth ( $t$  even), old age ( $t + 1$  odd):

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

- ▶ All magnitudes measured relative to current TFP ( $a_t, a_{t+1}$ )
  - ▶  $vT_{t+1}$ : utility from standard (secular) public goods, transfers
  - ▶  $\beta^i b_{t+1} G_{t+1}$  : utility from (organized) religion
- Beliefs  $b_{t+1}$  complementary to “religious public goods”  $G_{t+1}$  : sanctuaries (churches, temples, mosques), priests, rituals

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- Majority  $r > 1/2$  of religious agents,  $\beta^i = 1$ , rest secular,  $\beta^i = 0$ 
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  - ▶ Types fixed, but **intensity** of religious beliefs ( $b_t, b_{t+1}$ ) endogenous
- Income  $\theta^i$  in both periods  $\Rightarrow c_s^i = (1 - \tau_s)\theta^i, \forall s$ 
  - ▶ **Part I**: no income differences,  $\theta^i \equiv 1, \forall i \Rightarrow$  religious majority rules
  - ▶ **Part II**: rich and poor,  $\theta_L < 1 < \theta_H \Rightarrow$  **coalitions** among four groups

## Public Policies in Second Subperiod ( $t+1$ )

- Linear income tax  $\tau \Rightarrow$  revenue  $R(\tau)$ , per unit of TFP
  - ▶  $R(\cdot) \curvearrowright$ , revenue-maximizing tax rate  $\hat{\tau}$



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- **Alternative G**: legislation on school prayer, abortion, women's role...
  - ▶ Key is that provides different (dis)utility to different groups

## Public Policies in First Subperiod (t)

- Policy decision is whether to invest resources in a **control and repression apparatus** designed to block diffusion of ideas deemed heretical, dangerous to the faith.
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- **Set-up cost**, normalized by TFP, is  $\varphi(a_t)$   $\nearrow$  with society's level of knowledge and technology  $\Rightarrow$  Gvt's budget constraint at  $t$ :

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- Censoring “dangerous ideas” emanating from scientific inquiry, methodology entail:
  - ▶ **Ex ante**: cost  $\varphi(a_t)$  of setting up repressive apparatus
  - ▶ **Ex-post**: foregone TFP gains that could be reaped from applications

## Discoveries: Productivity, Beliefs, and Blocking

- Scientific discoveries: Poisson arrival rate  $\lambda$ , during the youth of each generation. Exogenous (domestic or from abroad), could endogenize
- If allowed to diffuse  $\Rightarrow$  advances in practical knowledge & technology

$$\Rightarrow a_{t+1} = (1 + \gamma)a_t$$

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- May also contradict doctrine, sacred texts' statements about natural or social world  $\Rightarrow$  shake and weaken the faith:
  - ▶ Fraction  $p_R = 1 - p_N$  are belief-eroding (*BR*): if diffuse in population, erode religious capital  $\Rightarrow b_{t+1} = (1 - \delta)b_t$
  - ▶ Fraction  $p_N$  are belief-neutral (*BN*): no impact on  $b_t$
  - ▶ Later on, allow for (exogenous) belief-enhancing (*BE*) shocks



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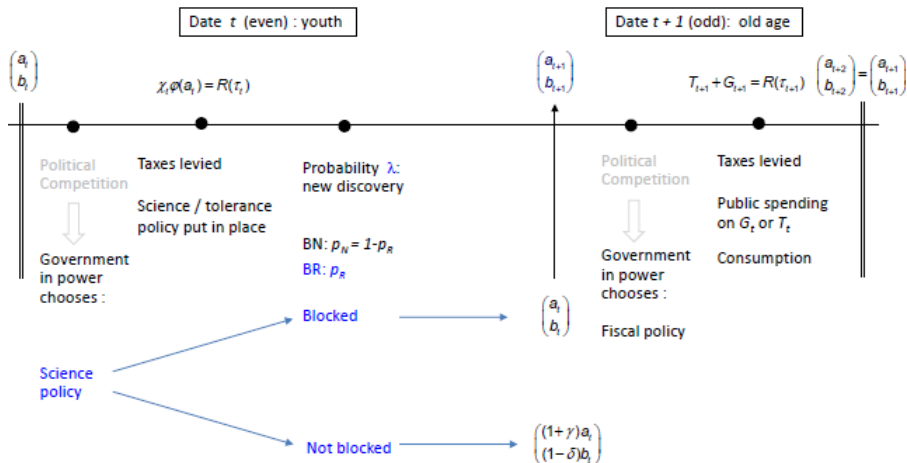
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  - ▶ Later on, allow for (exogenous) **belief-enhancing (BE)** shocks
- **Blocking:** religious majority or coalition may want to censor, deny, restrict access to, the new knowledge
  - ▶ Blocking can be targeted at *BR* innovations, is fully effective

$$\Rightarrow b_{t+1} = b_t, \text{ but also } a_{t+1} = a_t$$

# Timeline



## The Church / Religious Sector

- Small (zero-measure) set of agents, drawn among the religious
- Whenever a *BR* scientific discovery occurs and diffuses through society, can attempt to “repair” the damage done to the faith:
  - ▶ Doctrinal adaptation through internal reform, e.g. working out reinterpretation of sacred texts, more compatible with scientific facts.
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- Treat here organized religion as a single actor, with preferences

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

- Internalizes the religious utility  $b_{t+1} G_{t+1}$  of the faithful.
  - ▶ Partially benevolent, or just capturing **rents**

## Doctrinal Adaptation - Repairing Beliefs

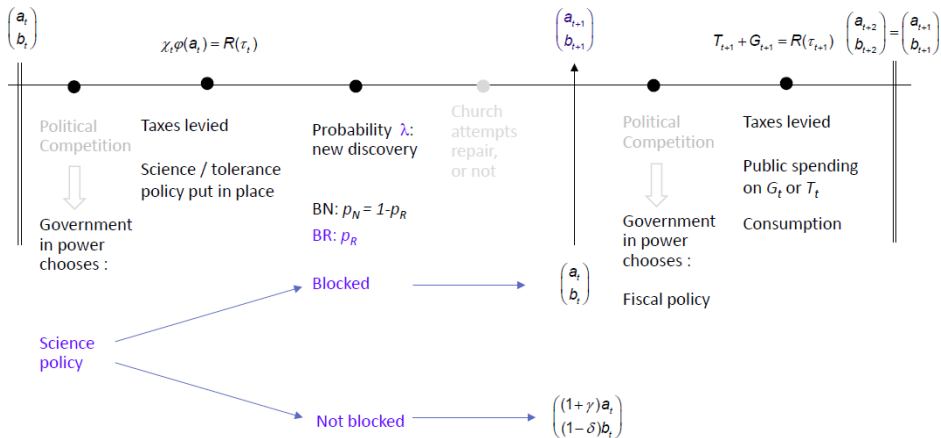
$$\Gamma_t^i = \mathbb{E}_t [b_{t+1} G_{t+1} - \rho_t \eta b_t], \quad \rho_t \in \{0, 1\},$$

- Incurs effort costs  $\eta b_t$  if, following the diffusion of a *BR* innovation, it undertakes the work required to prevent  $b_t$  from eroding
- Succeeds with probability  $q \Rightarrow b_{t+1} = b_t$   
Fails with probability  $1 - q \Rightarrow b_{t+1} = (1 - \delta)b_t$ 
  - ▶ In either case:  $a_{t+1} = (1 + \gamma)a_t$ , as idea has diffused
- Empirical counterparts of  $\eta$ : key determinant 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

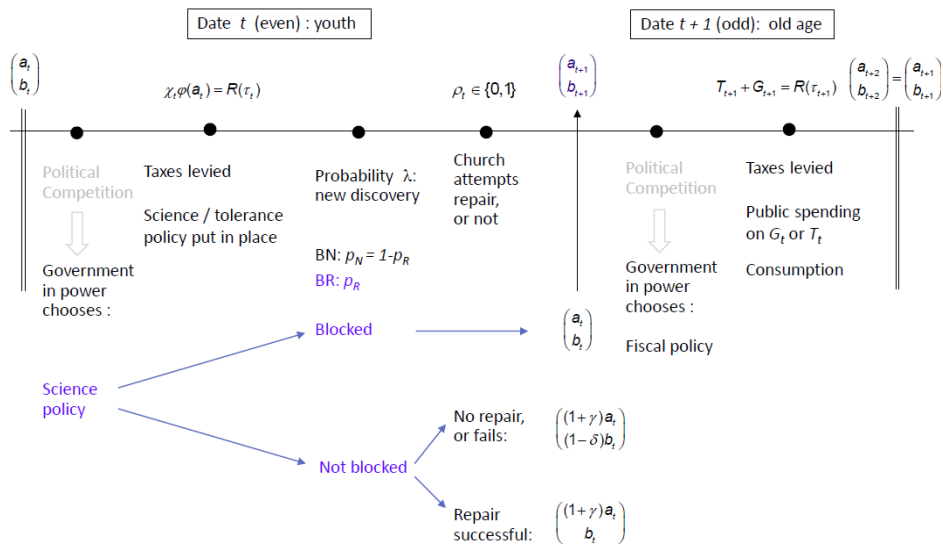
# Timeline

Date  $t$  (even) : youth

Date  $t + 1$  (odd): old age



# Timeline



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

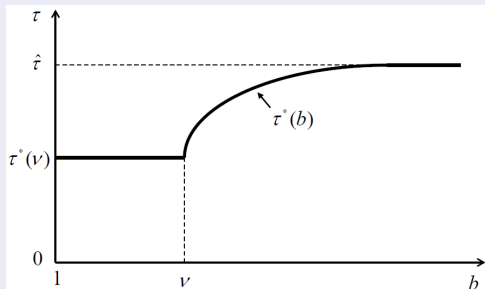
- No income differences  $\Rightarrow$  religious majority rules

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

$$\forall x, \text{ let } \tau^*(x) \text{ solve FOC : } xR'(\tau^*) = 1$$

### Proposition

(1) With religiosity  $b$ , tax rate in old age is:



(2) Spending on  $G$  is then  $G(b; v) = 0$  if  $b < v$ ,  $= R(\tau^*(b))$  if  $b \geq v$



## Church's Doctrinal Adaptation - Belief-Repairing

- Church cares about  $bG(b; \nu) \Rightarrow$  beliefs worth more when strongly affect choice of  $G \Rightarrow \pi \curvearrowright$  in  $b$
- Working to repair the damage done to  $b$  by a  $BR$  innovation costs  $\eta b$ , succeeds with probability  $q \Rightarrow$  Church attempts iff

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

### Proposition (repairing range)

(1) There exist unique  $\underline{b}$  and  $\bar{b}$ , such that the Church attempts repair after a belief-eroding innovation (not blocked by the state) iff  $b$  lies in  $[\underline{b}, \bar{b}]$ .

(2)  $\nu \leq \underline{b} < \nu/(1 - \delta) < \bar{b}$

## State Policy Toward Science (date $t$ )

- Decision at  $t$  : whether to invest in blocking potential  $BR$  discoveries.  
Tradeoff: **option value** of preserving religious capital vs. **foregone TFP gains** + **setup cost** of repressive apparatus

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- Two clear cases in which clearly no point in blocking:
  - ▶ When  $b < v$  : religious agents themselves prefer secular public goods to religious ones,  $\Rightarrow$  set  $G(b, v) = 0$ , derive no utility from organized religion. If  $b$  falls to  $(1 - \delta)b$ , no change
  - ▶ When  $b \in [\underline{b}, \bar{b}]$  : Church will attempt repair of unblocked  $BR$  innovations  $\Rightarrow$  if sufficient likelihood  $q \geq 1 / (1 + \gamma)$  that will succeed, government prefers to “take a pass”, let Church do the work

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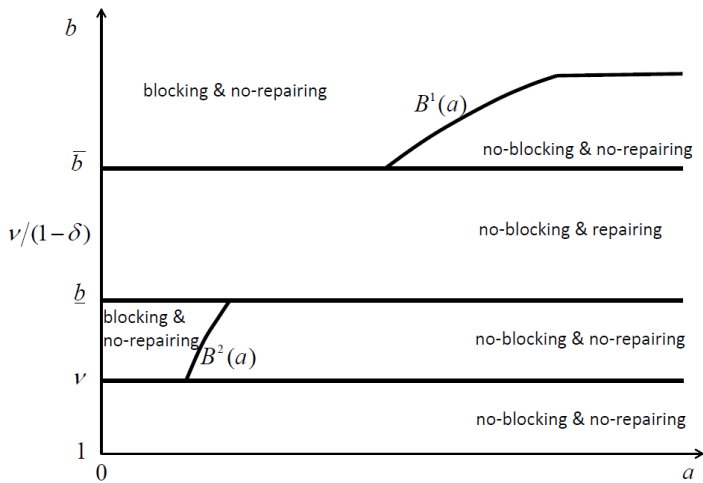
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- Two clear cases in which clearly no point in blocking:
  - ▶ When  $b < v$  : religious agents themselves prefer secular public goods to religious ones,  $\Rightarrow$  set  $G(b, v) = 0$ , derive no utility from organized religion. If  $b$  falls to  $(1 - \delta)b$ , no change
  - ▶ When  $b \in [b, \bar{b}]$  : Church will attempt repair of unblocked  $BR$  innovations  $\Rightarrow$  if sufficient likelihood  $q \geq 1 / (1 + \gamma)$  that will succeed, government prefers to “take a pass”, let Church do the work
- Outside these two regions:
  - ▶ Net expected value of blocking  $V^B - V^{NB} \nearrow$  in  $b$
  - ▶ Cost of blocking  $\varphi(a) \nearrow$  in  $a \Rightarrow$

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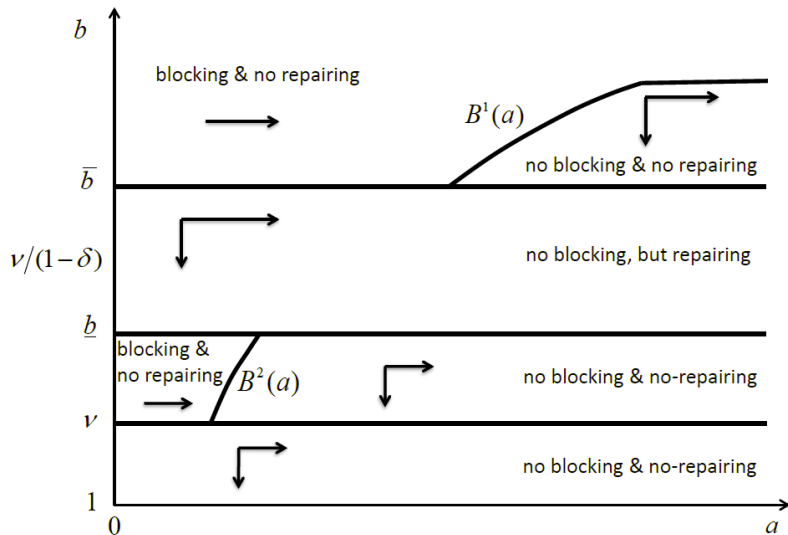
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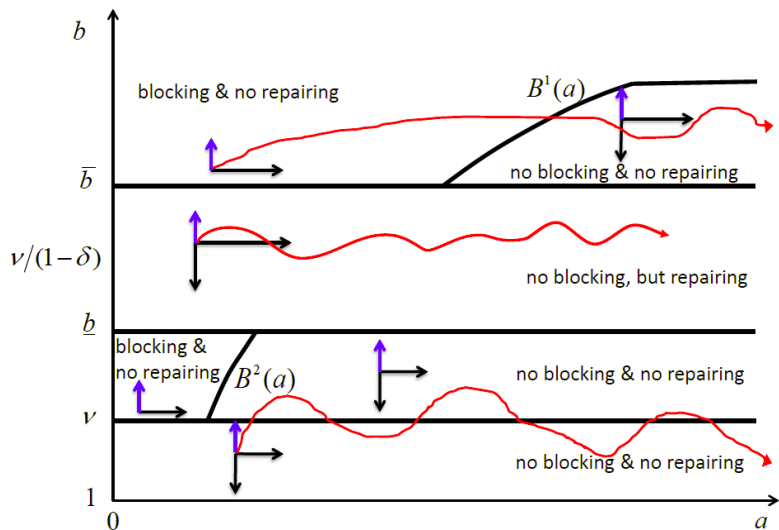
# Dynamics of Scientific Progress and Religiosity

- Within-generation: done. Between, simplest case is where young inherit final stocks of knowledge and religiosity of the old:  $(a_{t+2}, b_{t+2}) = (a_{t+1}, b_{t+1})$



# Dynamics of Scientific Progress and Religiosity

- Religiosity-enhancing shocks: plague, earthquake, flood, war; cultural change, immigration. No link to science:  $a_{t+2} = a_{t+1}$ ,  $b_{t+2} = (1 + \mu)b_{t+1}$  [prob.  $p_E$ ] or  $= b_{t+1}$





## Average Trajectories in Each Regime

- ① **Non-blocking, non-repair “secularization” region:** Western Europe, United States when  $b_t/a_t$  is 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  $b_t/a_t$  high:

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

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## Implications: Growth With and Without Secularization

- “Western Europe” and “United States” grow at the **same rate**  $1 + \lambda\gamma$  (neither blocks), but
  - ▶ In WE, there is a **downward trend** in religiosity (with periodic upward shocks preventing degenerate long-distribution)
  - ▶ In US, can be mostly offset by adaptive response of the religious sector  
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  - ▶ In US, can be mostly offset by 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 religious sector (also  $\eta$ )
- In the “theocratic” region  $b > \bar{b}$ , religiosity trends up while **knowledge and TFP stagnate**, particularly if  $\lambda_R \approx 1$ .

## IV - Inequality, Religion and the Politics of Science

- In each generation,  $n < 1/2$  of rich agents, majority of poor.  
Pretax incomes  $\theta_H$  or  $\theta_L$  in both youth and old age,

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

- ▶  $T$  never worth it for the rich  $\Rightarrow$  can also interpret as **pure transfers**
- Income and religiosity distributed independently  $\Rightarrow$  four groups:
  - ▶ Secular Poor,  $SP = (1 - n)(1 - r)$ , Secular Rich,  $SR = n(1 - r)$ ,  
Religious Poor,  $RP = (1 - n)r$ , Religious Rich,  $RR = nr$

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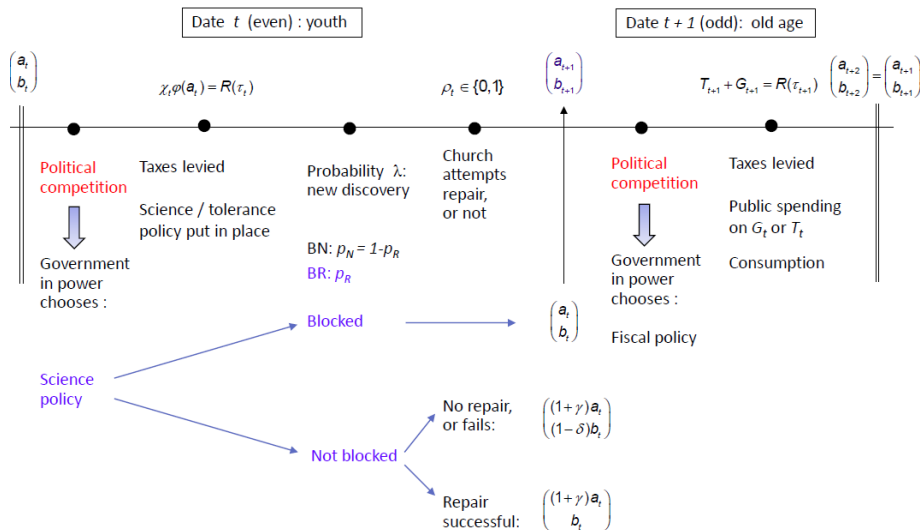
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Religious Poor,  $RP = (1 - n)r$ , Religious Rich,  $RR = nr$
- Assumption: Group's sizes (or power) ranked as:

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

- Thus no group constitutes a majority on its own, but **religious agents together**, as well as **poor agents together**, do

# Timeline



## The Political Process

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  - ▶ If not, **runoff** round or battle between the two with most support
- 4 Victorious leader implements his preferred policy.
  - ▶ No credible commitment to do otherwise.

## Whom Do the Religious Poor Side With ?

- When / if in power at  $t + 1$ , 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) at a level less than what the religious poor desire
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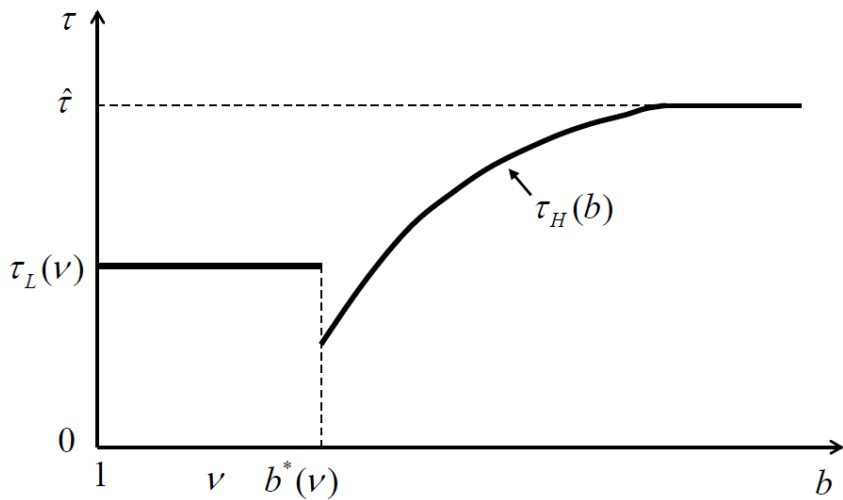
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### Proposition (CPNE at $t + 1$ )

*The unique equilibrium outcome is characterized by belief threshold  $b^*(v)$  :*

- 1 *If  $b < b^*(v)$ , the RP back the SP, who thus come to power and implement their ideal policy  $\tau^*(v/\theta_L)$ , with all revenue spent on  $T$ .*
- 2 *If  $b \geq b^*(v)$ , the RP back the RR, who thus come to power and implement their ideal policy  $\tau^*(b/\theta_H)$ , with all revenue spent on  $G$ .*
- 3  *$b^*(v)$  is increasing in  $v$ , as well in  $\theta_H - \theta_L$ ,*

## Whom Do the Religious Poor Side With?



Religiosity and equilibrium tax rate

# Key Implications

## ① Religion as a “wedge” issue

- ▶ In countries with low religiosity, secular governments come to power, implement welfare-state policies that (mostly) benefit the poor
- ▶ Such countries tax more and have a larger public sector than somewhat more religious ones, such as the US, which provide not only a different set of public goods but also at a lower level
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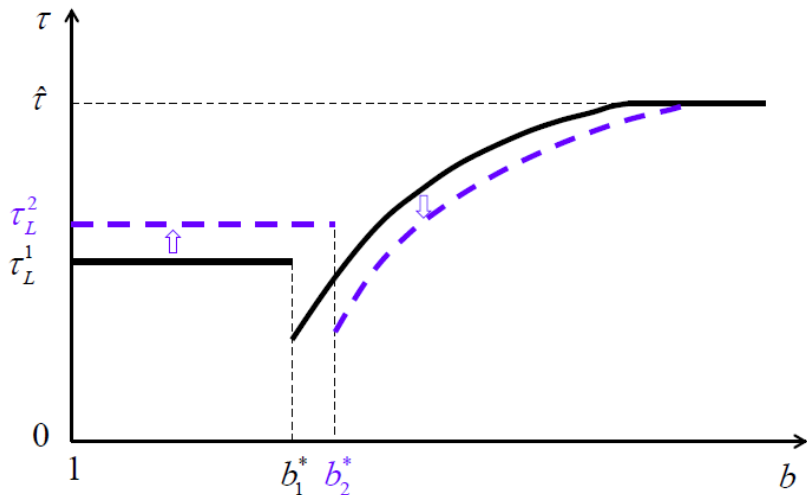
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## ② Fiscal effects of greater income inequality:

- ▶ Higher taxes and government spending in **low-religiosity** countries (WE)
- ▶ **Lower levels** of both (and different mix) in **more religious ones** (US)



## Effect of Increased Inequality Depends on Religiosity



Mean-preserving spread in incomes:  $nd\theta_H + (1-n)d\theta_L = 0$

## • Church: Doctrinal Adaptation

- ▶ Same basic intuition as before: expected return highest when  $b \searrow$  would have large effect on  $G \Rightarrow \pi(b)$  is single-peaked
- ▶ Even sharper now: at  $b^*(v)$ , power switches from  $RR$  to  $SP \Rightarrow G \Downarrow 0$

### Proposition (Church policy and income inequality)

- (1) *There exist a unique  $\underline{b}$  and  $\bar{b}$ , such that the Church attempts repair of a belief-eroding innovation (not blocked by the state) iff  $b \in [\underline{b}, \bar{b}]$ .*
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## ● State: Blocking Ideas

- ▶ Costs same as before (taxes at  $t$  to finance repressive apparatus, foregone TFP at  $t + 1$ ), but incidence is different for rich and poor
- ▶ Benefits now differ not only between secular and religious but also by income, as erosion of beliefs can trigger reallocation of power from (religious) rich to (secular) poor at  $t + 1$

## Equilibrium Blocking Policy (date $t$ )

- Study, compare the four groups' blocking prefs.  $\Rightarrow$  show that:
  - 1 The  $SP$  never want to block; nor do the  $SR$ , if  $\gamma$  is large enough
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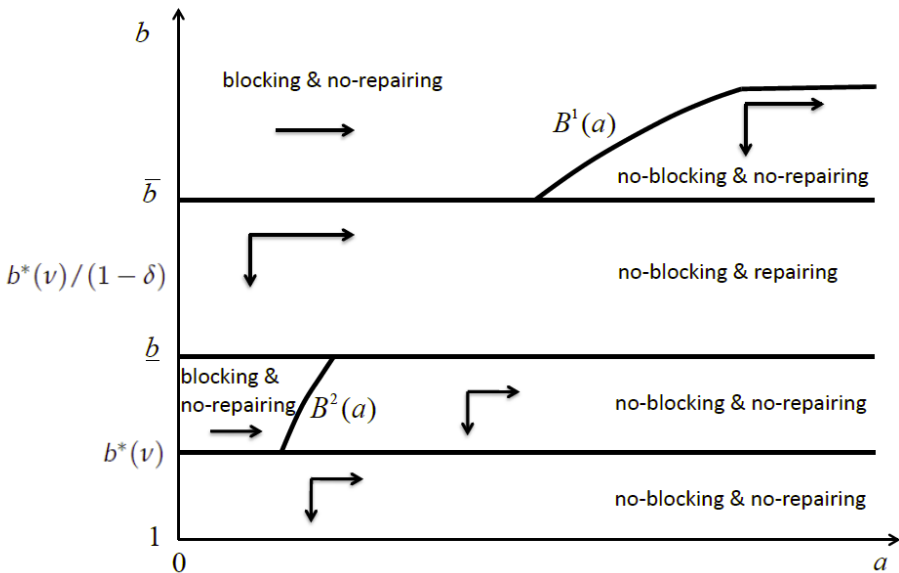
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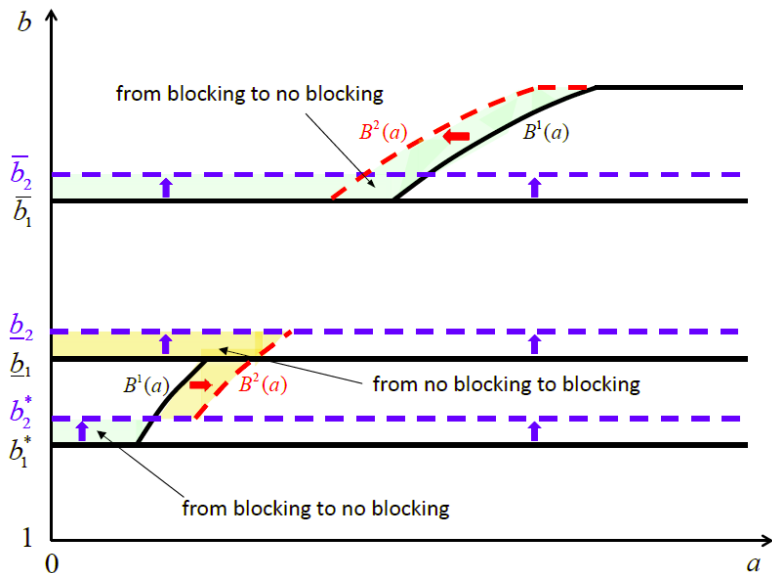
### Proposition (PCPNE)

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

## Phase Diagram with Inequality



# Income Inequality and Science Policy



Mean-preserving spread in incomes:  $nd\theta_H + (1 - n)d\theta_L = 0$



## Proposition (Inequality and the politics of science)

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- ③ This incentive is stronger, the more redistribution would occur at  $t + 1$  if the  $RP$  (lacking faith) allied themselves with the  $SP$  instead –hence, the greater is income **inequality**  $\theta_H - \theta_L$

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  - ▶ Former block science that would erode the beliefs of the latter
  - ▶ Latter then prefer low taxes + religion-tilted policies to high redistribution, favored by secular poor

## Remarks

- Leading examples of “forbidden fruits” discussed involved the **hard sciences** on the one hand, religion **stricto sensu** on the other
- Clear from the model that both concepts should be taken in a much more general sense:
  - ① **Lysenkoism** (official science in Soviet Union, 1935 to 1964)
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- It is largely the **scientific method** itself, with its emphasis on systematic **doubt**, contradictory debate and **empirical falsifiability**, that inevitably runs afoul of preestablished dogmas
- Could use model to study interactions between
  - ▶ Other types of radically new ideas: (social, political)
  - ▶ Threatened beliefs & interests (cultural, ideological, corporate)

## Directions for Further Research

- Besides being source of utility for some, religiosity may also
  - ▶ Promote certain forms of human capital accumulation
  - ▶ Induce greater **trust** and trustworthiness among individuals
  - ▶ **Legitimize** authority of ruler or state  $\Rightarrow$  reduce agency problems

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- **Empirics:** inverse relationship between religiosity and innovation, found across countries & US states, deserves further investigation.



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# 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

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Source: A. Alexander "Infinitesimal: How a Dangerous Mathematical Theory Shaped the Modern World" (2014)

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*Therefore no one shall defend any opinion that goes against the axioms received in philosophy or in theology, or against that which the majority of competent men would judge is the common sentiment of the theological schools.*