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## Secularization, Evolution, and Politics

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### ABSTRACT

This article proposes three evolutionary games to study secularization. The games assume that there is a severe competition for a resource defined as the material wealth a society produces. Successful strategies emerge out of the process, become the authority, capture and allocate the resource. Individuals who prefer a heavier or lighter weight of religion within the organization of the polity respectively named as religious and secular types can become wealthier and be emulated in the population depending on their initial proportions in the population. The society can evolve into a stable division of secular and religious types or can evolve opposite directions toward secularization. Impostors who misrepresent their religious preferences can invade a population that is equally halved into religious and secular types. No evolutionary stability is reached if impostors make no mistake in misrepresenting their beliefs; otherwise secular or religious strategies become evolutionarily stable.

### Introduction

How does the strength of religion vary across political systems? Are some societies immune to the penetration of religion in their political life? These questions are in general related to the concept of secularization which has multiple definitions.<sup>1</sup> In this paper, secularization is taken as a process implying a gradual reduction of the weight religion occupies in politics and therefore measuring balances of authority between a state's political and religious institutions. The balances expose the extent to which religion penetrates polity and religious institutions become politicized.

Secularization evolves through time indicating a societal and political dialogue.<sup>2</sup> Accordingly, we propose three evolutionary games to capture the evolving flow of

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<sup>1</sup>C. Calhoun, M. Juergensmeyer, and J. VanAntwerpen, *Rethinking Secularism* (Oxford: Oxford University Press, 2011); J. Casanova, *Public Religions in the Modern World* (Chicago, IL: University of Chicago Press, 1994); 'Rethinking Secularization: A Global Comparative Perspective', *The Hedgehog Review* (Spring-Summer 1996), pp. 7–22; M. Chaves, 'Secularization as Declining Religious Authority', *Social Forces*, 2:3 (1994), pp. 749–774; J. Fox, *A World Survey of Religion and State. Cambridge Studies in Social Theory, Religion, and Politics* (New York: Cambridge University Press, 2008); K. Dobbelaere, 'Secularization: A Multidimensional Concept', *Current Sociology*, 29 (1981), pp. 1–21; D. Philpott, 'Explaining Political Ambivalence of Religion', *American Political Science Review*, 101 (2007), pp. 505–525; T. Shah and D. Philpott, 'The Fall and Rise of Religion' in J. Snyder (ed.) *Religion and International Relations Theory* (New York: Columbia University Press, 2011), pp. 24–59; A. Tamimi, 'The Origins of Arab Secularism' in J. Esposito and A. Tamimi (eds) *Islam and Secularism in the Middle East* (New York: NYU Press, 2000), pp. 13–28.

<sup>2</sup>R. Bellah, 'Religious Evolution', *American Sociological Review*, 29 (1964), pp. 358–374.

conflicting ideas and political demands with respect to religion's place in the polity. With religions breeding cultural systems,<sup>3</sup> models explore cultural evolution occurring over shorter time scales instead of biological reproduction taking over long generations. The evolution hints at how political demands upon religion change by exposing the interplay of secularizing and counter-secularizing preferences and ideas in a society.<sup>4</sup>

The games posit that individuals who form a large population and who have similar needs to subsist but opposing preferences toward secularization compete to capture the resource, that is, the wealth the society produces. Individuals who prefer either a low or a high distance between religion and state but get wealthier are imitated by others in the population. Success breeds success. The equilibria of the games imply results which help us to discover varying secularization trajectories for the case of Turkey. It is found that the Turkish population will never evolve toward an equal separation of individuals into those who favor more and those who favor less weight of religion in politics. No such polarization will occur; either preference will progressively gain superiority over the other. The introduction of impostors who misrepresent their preference toward the weight of religion within politics brings no impact upon the direction of evolutionary trajectories. Impostors who err in imitating others and who represent an opportunistic behavior of bandwagon-ing to reap high shares of the resource never survive. Their preferences become genuine over time as they prefer a low or a high distance between religion and state.

The results inform us that the disillusionment with economic reforms and modernization efforts does not necessarily lead to desecularization.<sup>5</sup> The place of religion within politics can evolve in terms of alternative politically legitimate attitudes. Desecularization is not a one-way track. In fact, democracies where alternative preferences toward the impact of religion upon politics can legally compete to capture the resource constitute suitable environments for different paths toward the level of secularization to emerge.

In addition, evolutionary games do not require the assumption of rationality unlike n-person cooperative or non-cooperative games. Rational-choice theory of religion posits players as agents making no mistakes in terms of strategy choices, information conditions, and consequences of interactions.<sup>6</sup> Rational players are super-agents but they are difficult to observe in the real life. The assumption that individuals can commit mistakes can be evaluated as less restrictive with respect to human behavior. Therefore, evolutionary game models have substantial empirical backing.

The rest of the paper is organized as follows. Section 1 presents the general theoretical framework. Section 2 includes basic assumptions of the evolutionary games proposed. Section 3 presents games. Section 4 discusses and interprets findings through simulations

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<sup>3</sup>C. Geertz, *The Interpretation of Cultures: Selected Essays by Clifford Geertz* (New York: Basic Books, 1973); A. Swidler, 'Culture in Action: Symbols and Strategies', *American Sociological Review*, 51 (1986), pp. 273–286; A. Wildavsky, 'Choosing Preferences by Constructing Institutions: A Cultural Theory of Preference Formation', *American Political Science Review*, 81 (1987), pp. 3–21.

<sup>4</sup>P. Berger, 'The Desecularization of the World: A Global Overview' in P.L. Berger (ed.) *The Desecularization of the World: Resurgent Religion and World Politics* (Washington, DC: Ethics and Public Policy Center, 1999), p. 7.

<sup>5</sup>S. Thomas, 'Taking Religious and Cultural Pluralism Seriously: The Global Resurgence of Religion and the Transformation of International Society', *Millennium*, 29 (2000), pp. 815–841.

<sup>6</sup>L. Iannaccone, 'Voodoo Economics? Reviewing the Rational Choice Approach to Religion', *Journal for the Scientific Study of Religion*, 34 (1995), pp. 76–88; 'Why Strict Churches are Strong', *American Journal of Sociology*, 99 (1994), pp. 1180–1211; L. Young (ed.), *Rational Choice Theory and Religion: Summary and Assessment* (New York: Routledge, 1997).

of the games and their implications for Turkish secularization. The conclusion summarizes results and indicates areas of future research directions.

## General Framework

The gradual reduction or the increase of the weight religion occupies in politics is a process enduring through generations in a society. We assume that there are two pillars of the process: economic successes and failures of governments producing feelings of economic injustice<sup>7</sup> and prospects of dialogue and dissent between religious and secular forces about how to allocate wealth produced by society. Secular and religious forces can negotiate on the allocation of wealth the society produces. They can agree or fail to reach an agreement among themselves and with each other resulting in the emergence of politico-religious opposition to incumbent regimes or in secular pressures over religious groups.

Economic success plays a central role in the evolution of secularization. Economic crises lived under the rule of governments formed by secular-elites trigger socioeconomic grievances and an active politico-religious opposition preparing the ground for the revitalization of religious ideologies. The trend is commonly observed in Islamic societies.<sup>8</sup> Societies where secular elites fail in their efforts of modernization and increasing the wealth of their society constitute a fertile environment for the emergence of religious opposition to existing regimes. Latent religious forces become active and start to participate in domestic politics subsequent to economic failures. One of the consequences of economic setbacks becomes the formation of political parties using religion as an ideology and opposing incumbent secular governments.<sup>9</sup> Religion serves to generate alternatives against established political systems being a preferred opposition force in contrast to ideologies like Marxism-Leninism that denies God. The denial of the divine is an undesired feature in social environments where people have strong faith and belief.

If, after an election, a challenger party with religious inclinations comes to power and becomes economically successful, the more embedded religion becomes within the polity. As a result, religious political parties coming to power after democratic elections and reactions to secular elite regimes pave the way to a tendency toward a society in which religion matters more and secular institutions lose ground. Economic successes of the new government progressively attract more adherents and supporters in the population in contrast to established secular governments which become less attractive as they fail in increasing and allocating wealth through social layers. Therefore, the dualism between economically failing secular regimes and economically successful governments formed by religious-political parties triggers a tendency of desecularization. Religion gradually penetrates polity. Is indeed desecularization the only path under these conditions? The game models we develop generate alternative answers to the question. They eliminate such one-way streets in the evolution of secularization.

<sup>7</sup>P. Norris and R. Inglehart, *Sacred and Secular: Religion and Politics Worldwide* (Cambridge: Cambridge University Press, 2011).

<sup>8</sup>E. Sahliyyeh (ed.), *Religious Resurgence and Politics in the Contemporary World* (New York: State University of New York Press, 1990), p. 7.

<sup>9</sup>E. Karakoç and B. Başkan, 'Religion in Politics: How Does Inequality Affect Public Secularization?' *Comparative Political Studies*, 45 (2012), pp. 150–1541.

## Evolutionary Game Assumptions

Some individuals in society can prefer more secular regimes unlike others amounting to alternative strategies toward secularization.<sup>10</sup> Accordingly, two strategies drive the competition in the first model we propose: the one that prefers a large distance between religion and state and the other that prefers that the distance be shrunk. The second model adds a third strategy that denotes the misrepresentation of preferences toward secularization. All strategies compete with each other for the capture of the resource. Those mixtures of strategies that prove to be more or less successful in capturing the resource drive the evolution of secularization. Individuals emulate successful strategies.<sup>11</sup>

Human rationality has bounds. Assessments about the differential success of strategies are beyond human capacity as individuals cannot precisely calculate gains and costs their strategy choices lead to. It is difficult for individuals to assess which political and social forces will be successful in achieving political power and in producing wealth in a large population. There may be believers who do not participate in religious rituals and there may be those who participate without having faith.<sup>12</sup> Similarly, there may be religious individuals who might prefer a lower weight of religion within the polity, and, by the same token, there may be secular individuals who might prefer the opposite. Both types can become wealthier. Individuals cannot precisely calculate the probability of a specific strategy's success in such a complex competition environment. Thus, the individuals have limited views of interconnections between attitudes toward secularization and the distribution of wealth.

Instead of precise and rational calculations of maximizing gain, individuals adopt strategies through a process of trial and error. Individuals are not assumed as if each maximizes benefit by increasing gains and minimizing costs. They simply imitate the successful strategy that leads to an accumulation of wealth through time. Successful religious cultures cannot depend upon individual rationality as the rational-choice theory of religion assumes but only upon evolutionary pressures and natural selection.<sup>13</sup> The level of secularization then becomes the result of an evolving social dialogue proving to be critical especially under the condition of economically failed secular regimes.

The dispersal of strategies adopted in the population drives the evolution. The wealth of an individual cannot be evaluated in isolation. Individual resource shares derive from strategies are adopted toward religion in the whole population. The success of a strategy depends on how it interacts with the others in the competitive environment of polity-religion relations. Therefore, whether an individual gets a high or a low share of the resource is a consequence of the distribution of the religious modes of behavior of all other individuals. An individual preferring a higher weight of religion in the polity and choosing the strategy along his/her preferences can obtain higher resource shares in terms of rewards, benefits, and advantages, depending upon the frequency of individuals who share the same preference or oppose it in the population. If those individuals who prefer that the distance between religion and state is shrunk (or gets larger) become

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<sup>10</sup>H. Gintis, *Game Theory Evolving: A Problem Centered Introduction to Modeling Strategic Interaction* (Princeton, NJ: Princeton University Press, 2009), p. 229.

<sup>11</sup>This process is called replicator dynamics in evolutionary game theory.

<sup>12</sup>G. Davie, *Religion in Britain Since 1945: Believing Without Belonging* (Oxford: Basil Blackwell, 1994).

<sup>13</sup>Iannaccone, 'Voodoo Economics?' and 'Why Strict Churches are Strong,' Young, op. cit.

progressively wealthier, then they will have a tendency to stick to their preference and will be imitated by others. If all individuals prefer a lesser weight of religion in the polity, an individual might survive in a population only if he or she also prefers a lesser weight of religion in the polity; otherwise his/her wealth will diminish. Similarly, to react against forced attempts of desecularization or against elite secular cultures, rules, and practices can bolster the shares of those who oppose the regime.<sup>14</sup> The question then becomes: which strategy toward secularization will grow or die out? Evolutionary game models answer the question by examining those strategies having the tendency to persist in the population and those that have the tendency to be driven out by others.

Successful strategies propagate depending on how much they contribute to individual welfare, that is, individual resource shares.<sup>15</sup> The shares do not correspond to variations in spiritual satisfaction but to the partition of resource which affects the living conditions. If secular or religious strategies receive a larger share of the resource and benefit more from it, they will be adopted by more people in the population. The higher the resource share, the higher the individual fitness (welfare) and the higher the strategy's replication propensity.

An evolutionarily stable strategy (ESS) is a state of strategy distribution that cannot be invaded by alternative actions.<sup>16</sup> It is the end product of competing visions and preferences being molded through time, involving interactions among individuals that generate rewards and penalties for strategies adopted in the population. The strategy all individuals ultimately adopt and no different strategy can replace it becomes evolutionarily stable. A small minority of individuals employing any deviant behavior (mutants) will eventually disappear or will finally conform to the ESS under selection pressures; that is, mutant actions will be converted into successful ones.

## Games

### *Religious-secular game*

Individuals with similar preferences towards secularization can coordinate or fail in capturing and sharing the resource. Failure is costly. It is indicated by lower amount of the resource captured and economic crises. However agreement is rewarding as indicated by higher living standards. It is possible that individuals having opposite preferences to reach an agreement or fail to do so about how to capture and partition the resource. Competing actors can interact by forming strategic alliances and mobilizing actions through coordination or cooperation.<sup>17</sup> Social dialogue serves such a purpose. It means political negotiations between secular and religious forces.

The strategy preferring a large or a small distance between religion and state are called *S* and *R*, respectively. Secular individuals who adopt *S* are called *S*-types. They prefer a large distance between religion and state. The religious types who follow the opposite behavior are called *R*-types. They can switch from one preference to another and compete to get a share of the resource (the wealth the society produces) denoted by *V*. *R*-types might not

<sup>14</sup>V. Karpov, 'Desecularization: A Conceptual Framework', *Journal of Church and State*, 52 (2010), pp. 232–270, p. 235.

<sup>15</sup>M. Osborne, *An Introduction of Game Theory* (Oxford: Oxford University Press, 2004), p. 393.

<sup>16</sup>J. Maynard Smith, *Evolution and the Theory of Games*. (Cambridge: Cambridge University Press, 1982), p. 14.

<sup>17</sup>K. Wald, A. Silverman and K. Fridy, 'Making Sense of Religion in Political Life', *Annual Review of Political Science*, 8 (2005), pp. 121–143.

necessarily have a religious belief or participate in or attend religious services. They would, however, prefer that religion become more visible and powerful within society through institutions and social arrangements. *S* types might have religious beliefs and participate in religious services, yet they prefer that religion not interfere with state affairs. The assumption of two strategies helps simplify interactions by molding infinite variations of individual attitudes into two general categories of strategy toward religion's place within the state. It will be relaxed in the next game.

The evolutionary selection process favors those who obtain higher resource shares which represent fitness. While difficult, identifying those individuals who share the same preference is assumed to be critical in payoff asymmetries. Coordination is a strategic problem but generates cognitive clarity and easier achievement of higher resource shares producing desired amounts of religion's weight in polity-religion relations. Religions facilitate cooperation and help realize common gains among people. Individuals learn over time that the formation of a community with similar politico-religious aims produces better cooperation, higher cognitive clarity, and more social and economic benefits.

Let's assume that the competition for resources involves two strategies adopted by individuals interacting with each other at any point in time. The fitness in encounters between similar types mean values of successful coordination paying out larger shares of  $V$  as long as they can reach an agreement on how to allocate it.<sup>18</sup> Economic reforms and restructuring are such compromises on the distribution of the  $V$  across society. *R* and *S* types can reach an agreement over the division of  $V$  with each other as well. We assume that disagreements yield costs unlike agreements, however. Agreements do not represent high set-backs compared to the tremendous cost of failure to divide  $V$ .

*R* types matched with fellow *R* types and *S* types matched with fellow *S* types can succeed to win the resource  $V$  by agreeing on how to divide it with probability  $p$ ,  $0 \leq p \leq 1$ . They can also fail to cooperate. Such failures occur with probability  $1 - p$  and produce a cost denoted by  $a$ ,  $a > 0$ . Encounters among *R* types and *S* types yield therefore  $pV - a(1 - p)$ . We assume that *R*-types and *S*-types are on equal footing with respect to agreement and disagreement likelihoods and costs to prevent deductions of an assumed asymmetry between them. We let games to reveal their differences in securing higher fitness. Similarly, there exists a likelihood of successful agreement between *R* and *S* types, denoted by  $q$ , and a cost of disagreement among them denoted by  $b$ ,  $b > 0$ . We then obtain  $qV - b(1 - q)$  as the payoff to encounters between *R* types and *S* types. In general, costs indicate set-up costs, that is, investment costs in physical, organizational, and ideological sources realized when there is disagreement about the distribution of  $V$ . Hence, similar or different, it is assumed that all types can agree or disagree on how to divide the resource. The game reflects both coordination and cooperation.

The game matrix in Table 1 displays payoffs, where  $A$  and  $B$  denote  $pV - a(1 - p)$  and  $qV - b(1 - q)$ , respectively. The relative magnitudes, not specific values of  $A$  and  $B$ , matter for the analysis. Each cell shows the gain or loss to the row strategy when paired with the column strategy.

Strategy *R* is an ESS against strategy *S* if either:

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<sup>18</sup>Additional theories of bargaining greatly complicate the evolutionary game analysis and therefore they are omitted. The magnitudes of probabilities pertaining to bargaining success and failure can be interpreted as the indicators of the fate of such allocation processes. They are treated as dummy variables to search for evolutionary stability in simulations conducted and reported in the paper.



**Table 1.** Religious–secular game: cooperative version.

	R	S
R	A	B
S	B	A

Condition 1)  $E(R, R) > E(S, R)$

or

Condition 2)  $E(R, R) = E(S, R)$  and  $E(R, S) > E(S, S)$ ,

where  $E(R, R)$  denotes the payoff to an R type matched with a fellow R type,  $E(S, R)$  denotes the payoff to an S type matched with an R type,  $E(R, S)$  denotes the payoff to an R type matched with an S type, and  $E(S, S)$  denotes the payoff to an S type matched with a fellow S type.<sup>19</sup>

Similarly, strategy S against strategy R is an ESS if either:

Condition 1)  $E(S, S) > E(R, S)$

or

Condition 2)  $E(S, S) = E(R, S)$  and  $E(S, R) > E(R, R)$ .

**Result 1** If  $A = B$ , there will be no ESS. If all individuals are of R or S types, mutants using alternative strategies can invade the population but cannot dominate it.

**Result 2** The conditions of  $E(R, R) > E(R, S)$  and  $E(S, S) > E(S, R)$  imply the same condition of  $A > B$ , where  $E(R, R) = E(S, S) = A$  and  $E(R, S) = E(S, R) = B$ . Consequently, if  $A > B$ , then R and S are both ESS depending on S and R proportions. There is no need to verify the second condition. Hence, societies containing only R types or S types are stable; R types cannot invade a population of S types and vice versa. Initially, if more than half of the population consists of R types, the society will evolve into a pure population of R types; otherwise the society will evolve into a pure population of S types.

**Result 3** If  $E(R, S) = E(S, R) > E(R, R) = E(S, S)$ , that is,  $A < B$ , individuals find out that the best reply to R is S and vice versa. In this case, the unique symmetric Nash equilibrium is a in mixed strategy where each individual is an R or an S type with equal probabilities, that is,  $a = (\frac{1}{2}, \frac{1}{2})$ .

There are two conditions for the mixed strategy  $a$  to be stable: First we must have  $E(R, a) = E(S, a) = E(a, a)$ , and, if the first condition is satisfied, we must have  $E(a, R) > E(R, R)$  and  $E(a, S) > E(S, S)$ , which amounts to the second condition.<sup>20</sup> We indeed have  $E(R, a) = E(S, a) = E(a, a) = \frac{1}{2}(A + B)$ . The second condition is satisfied:  $E(a, R) = \frac{1}{2}(A + B) > A = E(R, R)$  and  $E(a, S) = \frac{1}{2}(A + B) > B = E(S, S)$  because  $pV - a(1 - p) = A < B = qV - b(1 - q)$ .

As a result, those R and S mutants can never invade an equally halved population. Even if the population consists of full R or S types, mutants become fitter and the population evolves toward an equal split under evolutionary pressures:  $a$  is an ESS. The varying costs of agreement failures, the probabilities of agreement and disagreement, and the

<sup>19</sup>J. Maynard Smith and G. Price, 'The Logic of Animal Conflict', *Nature*, 246 (1973), pp. 15–18; Maynard Smith, op. cit., 14.

<sup>20</sup>Maynard Smith, op. cit., pp. 182–183.



captured portion of  $V$  complicate results pointing to complexities of strategic coordination and cooperation.

### **Religious–secular–perfect impostor game**

People are sensitive to material and political costs and benefits of religiosity, and, as a consequence, can adopt a more versatile and hypocritical strategy toward secularization. Accordingly, we now add a third strategy, the impostor, denoted by  $I$ .<sup>21</sup> Impostors simply imitate others regardless of the costs attached to the trait.<sup>22</sup> They represent an opportunistic behavior of misrepresentation of religious beliefs and behavior to benefit from  $V$  and complicate the simple picture of religious duality or  $R$  versus  $S$  in a society.

We assume that impostors have a perfect imitation capacity. Impostors are an  $R$  type matched with an  $R$  type and an  $S$  type matched with an  $S$  type. Thus,  $I$  and  $R$  encounters, as well as  $I$  and  $S$  encounters, are respectively equivalent to  $R$  and  $R$  and to  $S$  and  $S$  encounters. As to  $I$  and  $I$  encounters, as the impostors have perfect capacity in emulating types, they either obtain  $A$  when they are matched with  $R$  types or again  $A$  when they are matched with  $S$  types. Thus, they obtain  $A$  on average. Table 2 gives the new game matrix.

**Result 4** The game has no pure-strategy ESS.<sup>23</sup>

**Result 5** The game has no mixed ESS. Mutants do not die out or come to dominate the population.

### **Religious–secular–imperfect impostor game**

The impostors might not be perfect imitators, however. They can correctly imitate types they encounter with the probability  $s$  and err with the probability  $(1 - s)$ . For example, an  $I$  type matched with an  $R$  type can be an  $R$  type with the likelihood  $s$  and an  $S$  type with the likelihood of  $1 - s$ . Thus, the payoff to an  $I$  type against an  $R$  type or the payoff to an  $R$  type against an  $I$  type is  $s(pV - a(1 - p)) + (1 - s)(qV - b(1 - q)) = sA + (1 - s)B$ , as  $R$  or  $I$  types obtain an  $E(R, R)$  payoff with the probability  $s$  and an  $E(R, S)$  payoff with probability  $(1 - s)$ . By the same token, the payoff to an  $S$  type against an  $I$  type and the payoff to an  $I$  type against an  $S$  type is  $sA + (1 - s)B$ .

The payoff to encounters among impostors is a little tricky. Impostors are two-faced types. Unlike impostors facing an  $R$  type or an  $S$  type, an impostor can meet an impostor who can imitate an  $R$  type or an  $S$  type with probability  $r$  and  $1 - r$ , respectively. Consequently, the probability  $rs$  denotes the likelihood of an  $I$  type matched with a fellow  $I$  type imitating an  $R$  type and the impostor's correct imitation of the  $R$  type;  $r(1 - s)$  the likelihood of an  $I$  type matched with a fellow  $I$  type imitating an  $R$  type and the impostor's imitation error of the  $R$  type;  $s(1 - r)$  the likelihood of an  $I$  type matched with a fellow  $I$  type imitating an  $S$  type and the impostor's correct imitation of the  $S$  type; and  $(1 - r)(1 - s)$  is the likelihood of an  $I$  type matched with a fellow  $I$  type imitating an  $S$  type

<sup>21</sup>I am grateful to David M. Lewis for his suggestion to consider a third strategy in the game.

<sup>22</sup>R. Boyd and P. J. Richerson, *Culture and Evolutionary Process* (Chicago, IL: University of Chicago Press, 1985).

<sup>23</sup>The proofs of results 4, 5, 6 and 7 are given in the Appendix.

**Table 2.** Religious–secular–perfect impostor game.

	R	S	I
R	A	B	A
S	B	A	A
I	A	A	A

**Table 3.** Religious–secular–imperfect impostor game.

	R	S	I
R	A	B	C
S	B	A	C
I	C	C	D

and the impostor's incorrect imitation of the S type. The payoff to an impostor against an impostor then becomes  $rs(pV - a(1 - p)) + s(1 - r)(pV - a(1 - p)) + r(1 - s)(qV - b(1 - q)) + (1 - r)(1 - s)(qV - b(1 - q)) = s(pV - a(1 - p)) + r(1 - r)(1 - s)^2(qV - b(1 - q)) = sA + r(1 - r)(1 - s)^2B$ .

We obtain the game matrix (Table 3) where payoff A denotes  $pV - a(1 - p)$ ; B denotes  $qV - b(1 - q)$ , as before; C denotes  $sA + (1 - s)B$ ; and D denotes  $sA + r(1 - r)(1 - s)^2B$ .

**Result 6** Either R or S are the ESS.

**Result 7** There exists no mixed ESS in the game.

## Discussion

Game results are theoretical. We need their empirical interpretations and investigate whether they can shed light, however dim, with respect to actual politico-religious interactions. Turkey is the prime example we can study. The level of secularization in Turkey declines and a wealthy Islamic lifestyle is on the rise since the electoral success of the Justice and Development Party (the JDP) in 2002. Islamic capital has progressively expanded and is now well entrenched within the Turkish economy.<sup>24</sup> Turkey now has five-star Islamic hotels where the sexes have separate accesses to pools and beaches, gated communities separating pious Muslims from the rest of the population, Islamic banks and firms, veiled Muslim women driving luxury cars, and Islamic TV channels, newspapers and organizations. These changes indicate a growing dualism among Turkish citizens in terms of wealth and a separation between Muslim and secular women.<sup>25</sup> Laws limiting the consumption of alcohol; the high construction rate of mosques, large-scale population dynamics favoring political Islam and the associated changes indicate an erosion of the secular nature of Turkish democracy. In other words, the distance between state and religion in Turkey is shrinking.

<sup>24</sup>Islam and capitalism are perfectly compatible: M. Rodinson, *Islam and Capitalism* (Austin: The University of Texas Press, 1978). The Prophet Muhammad was involved in commerce. Islam is a business-friendly religion; it does not prohibit but encourages trade (but forbids the capture of interest gain on money and loans). Islam's position toward trade constitutes a direct connection with the process of Turkish secularization.

<sup>25</sup>N. Göle, 'Secularism and Islamism in Turkey: The Making of Elites and Counter Elites', *Middle East Journal*, 51:1 (1996), pp. 46–59.

The JDP is rooted in a political reaction movement targeting the state-sponsored secularist system established by the inception of the Republic in 1923 and supported by the military and an elite republican ruling class. The meteoric rise of Islamic ‘green’ capital, including Islamic firms and banks, coincided with JDP rule.<sup>26</sup> The poor who benefit from the rise of Islamic capital form the principal electoral base of the party. Although the party lost its majority to form a government without needing any partners in June 2015 elections, it made a spectacular return with November 2015 elections by securing enough seats to govern the country alone.

Islamists and secularists that correspond respectively to *R* and *S*-types already existed at the inception of the Turkish republic. Secularists are opposed by Islamists who defend the view that Islam should not be banned from the public sphere, so that religion should not be excised from the polity and that nothing should prevent a more ‘visible’ Islam in the society.<sup>27</sup> The groups are still involved in a competition which did not exclude costly conflict for both sides.<sup>28</sup> As to the *I*-types, they conceal their religious beliefs when secularists control the government and appear as pious Muslims and profit from religious bonding in Islamic economic circles when Islamists are in power. Impostors can snatch large shares from governmental bids and auctions, become partners with fellow religious businessman and accumulate wealth. The growing number of Turkish veiled woman can to some extent be linked to this opportunistic behavior instead of Muslim identity and gender attitudes.<sup>29</sup> Veiling is not a costly signal for the desire to benefit from material wealth Islamic capital generates.<sup>30</sup> Veiled Muslim women can as well ease their spouses’ task to accumulate wealth and can directly obtain material help offered by Islamic foundations and charities.

The stylized games present *R*-types, *S*-types, and *I*-types as competitors in trying to capture the scarce resource *V*, the wealth produced by the Turkish society. The competitors can jointly agree or fail to capture and divide *V*. Islamists and secularists are not compact, however: there are divisions among themselves. Hence it is likely that there are disagreements among themselves. They do not have unanimity about how to allocate *V* across social layers. The likelihood *p* denotes Islamists’ and secularists’ propensity to agree among themselves on how to divide *V*, the likelihood *q* represents Islamists’ and secularists’ joint agreement probability on the division of *V*. If, for example,  $p = 1$ , it is certain that Islamists and secularists agree on the division of *V* across the population. The cost of disagreement among secularists or Islamists and the cost of disagreement of secularists and Islamists to jointly agree on the division of *V* are respectively denoted by *a* and *b*.<sup>31</sup>

<sup>26</sup>F. Başkan, ‘Religious versus Secular Groups in the Age of Globalisation in Turkey’, *Totalitarian Movements and Political Religions*, 11 (2010), pp. 167–183; S. Larrabee and R. Angel, *The Rise of Political Islam in Turkey* (Pittsburg: RAND Corporation, 2008); Ş. Pamuk, ‘Globalization, Industrialization, and Changing Politics in Turkey’, *New Perspectives on Turkey*, 38 (2008), pp. 267–273; H. Yavuz, *Islamic Political Identity in Turkey* (Oxford: Oxford University Press, 2003).

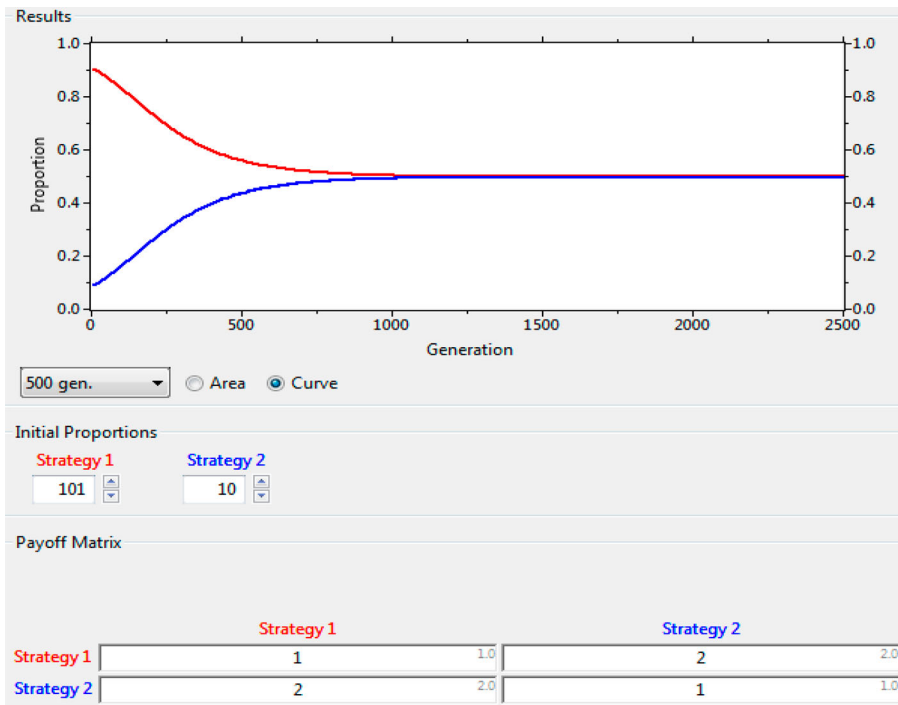
<sup>27</sup>A. Kuru, ‘Passive and Assertive Secularism: Historical Conditions, Ideological Struggles, and State Policies Toward Religion’, *World Politics*, 59 (2007), pp. 568–594.

<sup>28</sup>The National Order Party, the National Salvation Party, the Welfare Party, the Virtue Party, all Islamist parties, are banned respectively in 1971, 1980, 1998, and 2001. Under the rule of the JDP, bans on headscarves of women who attend college, who are lawyers, parliamentarians, doctors, or nurses are lifted.

<sup>29</sup>B. Brünig and F. Fleischmann, ‘Understanding the Veiling of Muslim Women in the Netherlands’, *Journal for the Scientific Study of Religion*, 54 (2015), pp. 20–37; D. Cindoğlu and G. Zencirci, ‘The Headscarf in Turkey in the Public and State Spheres’, *Middle Eastern Studies*, 44 (2008), pp. 791–806.

<sup>30</sup>R. Sosis and C. Alcorta, ‘Signaling, Solidarity, and the Sacred: The Evolution of Religious Behavior’, *Evolutionary Anthropology*, 12 (2003), pp. 264–274.

<sup>31</sup>We do not discuss the case of  $p = q = \frac{1}{2}$  under varying payoff conditions and we do not investigate the implications of  $A > B$ ,  $A = B$ ,  $A < B$  by letting *p*, *q*, *a*, *b*, and *V* vary to save space.



**Figure 1.** Simulation of the cooperative religious – secular game with payoffs  $A = 1$  and  $B = 2$ . The ESS becomes the stable and equal division of the population into  $R$  and  $S$  types (strategy 1 and 2, respectively).

### The equal mixture

The  $2 \times 2$  model implies that if  $B > A$ , then the population will ultimately be equally halved into Islamists and seculars as displayed by Figure 1.<sup>32</sup>

The result obtains if it is certain that secularists and Islamists disagree either jointly or among themselves upon the division of  $V$  by certainty ( $p = q = 0$ ) and that the cost of internal disagreement for Islamists and secularists is higher than the costs Islamists and secularists suffer when they disagree. The Turkish population will evolve through generations into an equal division of Islamists and secularists provided that no fruitful dialogue exists in the society. A Turkish population of full Islamists or full secularists then becomes destabilized with the occurrence of mutants, such as secularists among Islamists or Islamists among secularists. An individual can shift his/her preference toward secularization from  $S$  to  $R$  in a population fully consisting of  $S$ -types by a belief that  $R$  is a more successful strategy in accumulating wealth. It then follows that the evolutionary motion leads to an equal split of the population.

A perfect discord between Islamists and secularists and among Islamists and secularists is out of the question, however. The economic failures of incumbent secular parties rule out such prospects. Active politico-religious forces can propose and agree upon alternative economic programs to divide  $V$  in opposition to those established secular regimes try in

<sup>32</sup>The figure is obtained using GameBug. R. Wyttenbach (2012) *GameBug* (Version 2012) [Computer program]. Available at <http://ess.nbb.cornell.edu/ess.html> (accessed 23 October 2014).

vain to implement. Hence, the result does not really correspond to real interactions. In such an evolutionary context and economic success of *R*-types, one would expect that individuals gradually welcome revitalization of religious ideologies as they lead to higher level of prosperity. Consequently, the Turkish population will never be equally split into two opposing preferences toward secularization.

### **Evolutionary instability**

The  $2 \times 2$  model implies evolutionary instability if encounters among and across Islamists and secularists produce equal fitness and if it is certain that Islamists and secularists jointly and among themselves agree on the distribution of the resource ( $p = q = 1$ ). Both types are then successful. Disagreement costs do not matter when agreements are certain. The evolutionary instability occurs also when different types disagree by certainty ( $p = q = 0$ ) and costs of the discord are equal. Obtaining an equal fitness under these conditions, neither Islamists nor secularists will dominate Turkish population.

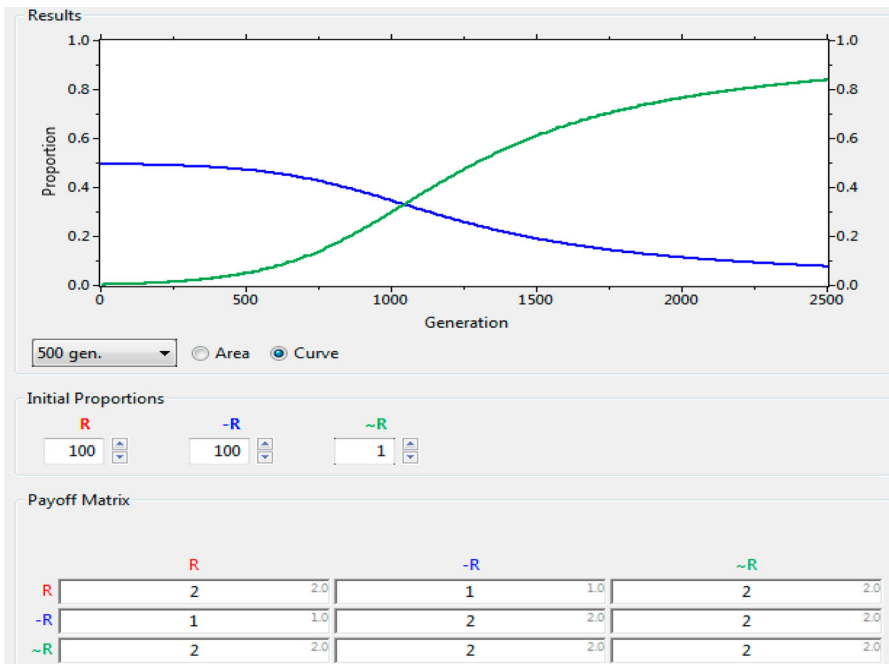
The instability generates infinitely many trajectories with all depending on the strategies' initial proportions. The game generates secularization paths that could correspond to all observations and therefore loses its explanatory power explaining all possible developments in the (de)secularization process. The equality of fitness for all encounters is however impossible. A slight difference in disagreement costs or possibilities of some compromise on the division of  $V$  discard the prospect of continuous vacillations between alternative preferences toward secularization. Hence it is difficult to explain evolutionary instability by the help of the  $2 \times 2$  model.

The  $3 \times 3$  model explains evolutionary instability in different terms. The model does not need fitness equality in all encounters to explain the inexistence of clear secular directions. If impostors perfectly hide their true preferences being perfect imitators, complete secularization or desecularization becomes impossible given that three preferences compete for  $V$ . Suppose that, for example, the population is equally divided between *R* and *S* types, then *I* types finally dominate the population, as [Figure 2](#) shows.

The invasion by perfect impostors of a population equally partitioned into Islamists and secularists occurs because payoffs from interactions among similar types exceeds that of payoffs from cross-interactions among them, and therefore the perfect impostor payoff strictly exceeds the one with the equally mixed population:  $A > B$  and  $A > \frac{1}{2} A + \frac{1}{2} B$ . Perfect impostors invade such populations. A Turkish population consisting only of perfect impostors is open to invasion in turn by Islamists and secularists. The intrusion of a mutant will produce a new evolutionary direction in the secularization process. Continuous changes in the proportion of strategies with alternative mutants will hint each time at different predictions for the country's secular future. In fact, a Turkish population fully consisting of perfect impostors is not a realistic depiction. In the presence of individuals having straight and robust preferences with respect to the penetration of religion in Turkish politics alternative ESSs can emerge as discussed.

### **Bifurcated evolution**

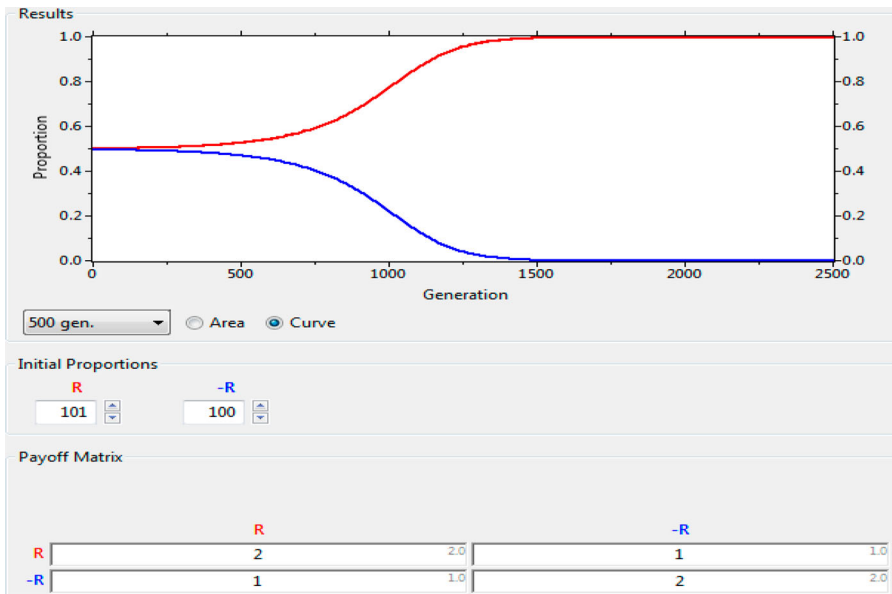
Another major implication of the  $2 \times 2$  model is that reconfigurations and interpenetrations of state and religion favor Islamists *or* secularists depending on initial strategy



**Figure 2.** Simulation of the religious–secular–perfect impostor game with payoffs  $A = 2$  and  $B = 1$ .  $I$  ( $\sim R$  types dominate the population if the initial proportion of  $R$  and  $S$  ( $-R$ ) types is equal and mutant  $I$  types start an evolution toward a full population of  $I$  types. The same curve going downward shows the evolution of  $R$  and  $S$  types.

proportions provided that  $A > B$ . If secularists constitute initially more than half of the population, political Islam will become extinct; otherwise, Islamic and wealthy lifestyle spread in the population and desecularization will be complete. Figure 3 displays how the evolution bifurcates almost right after the start of interactions when Islamists are more numerous than secularists. The decrease in the number of secularists and the increase of Islamists are complete in a few generations. The proportion of Islamists increases geometrically at the expense of secularists when the former is initially more numerous than secularists. The result reverses if secularists are initially more populous than Islamists.

In particular, if it is impossible that Islamists and secularists cooperate among themselves or with each other to divide  $V$  ( $p = q = 0$ ), or they do so with an equal frequency of half success and half failure ( $p = q = \frac{1}{2}$ ), the costs of failed cooperation drive the evolution, not the magnitude of  $V$ . The polarization of the Turkish society in terms of secularization preferences becomes complete given that costs of agreement failure across types exceed those among Islamists and secularists. Hence, the inexistence of dialogue or a prospect of a successful cooperation between Islamists and secularists leads to a deep schism in the population as long as  $A > B$ . The same result obtains provided that it is certain that Islamists and secularists agree upon the division of  $V$  ( $p = 1, q = 0$ ) but Islamists and secularists cannot jointly reach a deal. If individuals prefer that economic success will come with an opposition to secular forces, then Islamists will gain ground. Naturally, the opposite evolutionary direction is possible if some in the Turkish population



**Figure 3.** Simulation of the cooperative religious–secular game with payoffs  $A = 2$  and  $B = 1$  and the initial proportion of Islamists constituting more than half of the total population.  $R$  becomes the ESS as the result.

believe that they cannot blame secular elite regimes for economic failures and their number exceed the proportion of  $R$ -types. The direction of the evolution will then tend toward a stable reduction of the weight religion occupies in Turkish politics.

We have to note that Islamists do not constitute a firm and a unitary preference bloc toward the level of Turkish secularization. The Islamist Gülen movement, a branch of Turkish political Islam, and the JDP cadre are now acerbic enemies after a long period of cooperation. This means first of all that the likelihood of an Islamist agreement upon the division of  $V$  is not so high as a possibility of a modus vivendi between  $R$  and  $S$ -types as the condition as for example  $p = 1 > q = 0$  requires. The model does not imply the evolutionary stability of  $R$  in this case. Nevertheless, the evolutionary stability of  $R$  also follows the possibility of agreement failure costs across types exceeding the one among Islamists and secularists. Here, then, the question becomes whether the schism between  $R$  types is not as serious as the schism between  $R$  and  $S$ -types. If the conflict among  $R$ -types is less acute than the one among  $S$ -types, then we can still explain an evolutionary move toward a lesser distance between Turkish state and Islam.

In general, we cannot interpret the ESS of  $R$  as the end of privatization of religion, as desecularization may not prohibit or prevent religion from remaining within the private sphere. The evolutionary stability of strategy  $R$  implies the highest possible political significance of religion in the population,<sup>33</sup> but not necessarily the formation of a religious political regime. Unlike Stark<sup>34</sup> who equates secularization with the decrease of faith and

<sup>33</sup>B. Wilson, 'Secularization: The Inherited Model' in P. Hammond (ed.) *The Sacred in a Secular Age* (Berkeley: University of California Press, 1985), pp. 9–20.

<sup>34</sup>R. Stark, 'Secularization, R.I.P.,' *Sociology of Religion*, 60 (1999), pp. 249–273, p. 253.



religiosity, we do not equate desecularization with an increase in faith, or secularization with a decrease in the level of faith; differentiation may be the outcome when most of the population is of the *R* type. At the very least, secularism does not imply the inexistence of faith. There is faith in the secular.<sup>35</sup> Secularization does not impose conditions for belief (or not) in a future or afterlife, nor worldly conduct without reference to a deity.<sup>36</sup>

The 3×3 model implies a bifurcated evolution under the condition of imperfect impostors. One feature remains constant according to the two versions of the 3×3 model: the impostor strategy never becomes an ESS. Either Islamists or secularists ultimately compose the whole population with impostors dying out. Impostors have no say in the strength of mechanisms favoring religion or not in political institutions. Figure 4 shows the evolutionary stability of strategy *S*, provided that secularists constitute more than half of the total population.

In empirical terms, population proportions change every moment; the day's population proportion does not constitute an ESS unless all individuals ultimately adhere to the same strategy and no mutant strategy can survive. Hence, each point on the phase lines corresponds to a specific proportion of strategies in the population. Each point indicates differential successes of strategies for a given moment in time and the change in attitudes toward religion within the state.

When Islamists benefit and get wealthier as religion's impact on the institutional organization of politics increases, they are imitated and attract more adherents. This shift does not necessarily mean an increase in population; the population can be constant while adherents to alternative strategies can change. The ESS then represents a secularization level that cannot be disturbed by alternative strategies. Thus, the proliferation of Islamists is not due to demographic changes, as, for example, Kaufman argues,<sup>37</sup> but to the evolutionary success of the strategy. Not the population but the ideas change. If one maintains that religious communities offer benefits of improved health, survivorship, economic opportunities, sense of community, psychological well-being, assistance during crises, mating opportunities, and fertility, the proportion of Islamists may be initially higher than secularists or impostors, leading finally to the evolutionary stability of this strategy.

The attractiveness of *R* in Turkey is in fact derives from economic successes of the JDP governments since 2002. The luxurious life-style of Islamist elites in Turkey sets a new wealth criterion of Turkish citizens.<sup>38</sup> With impostors, either perfect or not, never surviving in the Turkish population, we can assert that a straight preference toward secularization in Turkey always wins ground as opposed to an opportunistic behavior of misrepresentation of religious beliefs and behavior to benefit from *V*. Individuals in the Turkish population prefer to be honest over the long run with respect to the distance between state and religion.

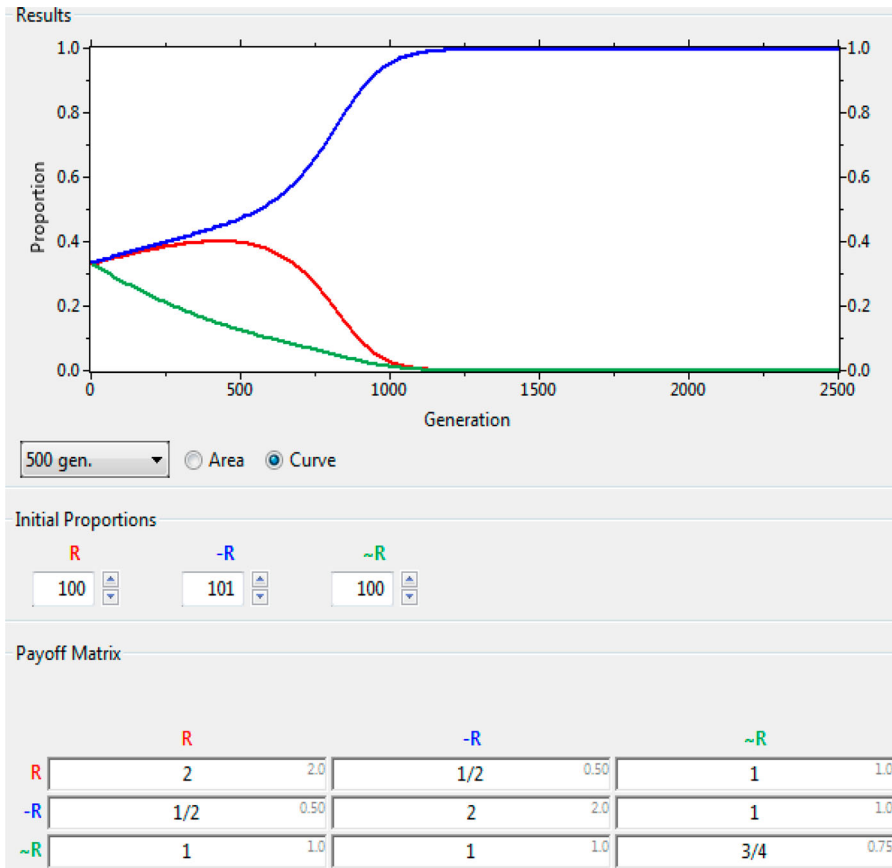
In general, the ESSs of the games inform us about why political mechanisms favor religion in some countries but not in others. Under economic failures and the disillusionment

<sup>35</sup>E. Hurd, 'The Political Authority of Secularism in International Relations', *European Journal of International Relations*, 10 (2004), pp. 235–262.

<sup>36</sup>Tamimi, op. cit.

<sup>37</sup>E. Kaufmann, *Shall the Religious Inherit the Earth? Demography and Politics in the Twenty-First Century* (London: Profile Books, 2010).

<sup>38</sup>B. Kılıçbay and M. Binark, 'Consumer Culture, Islam, and the Politics of Lifestyle: Fashion for Veiling in Turkey', *European Journal of Communication*, 17 (2002), pp. 495–511; Ö. Sandıkcı and G. Ger, 'Constructing and Representing the Islamic Consumer in Turkey', *Fashion Theory*, 2/3 (2007), pp. 189–210.



**Figure 4.** Simulation of the religious–secular–imperfect impostor game with payoffs  $A = 2, B = 0.5, C = 1, D = 0.75$ .  $S$  ( $-R$ ) becomes the ESS if the initial proportion of  $S$  types is more than half of proportion of  $R$  and  $I$  ( $\sim R$ ) types in the population.

with modernization efforts, some societies can have an effective and a fruitful dialogue between different preferences towards the place of religion within politics. The prospect of balanced preferences is more likely in such socio-political environments where the disdain toward an economically failed secular elite is limited. Religious institutions’ power can then be more balanced. However, when such dialogue and peaceful negotiation prospects are impossible and entail different costs, balances of authority between state and religion can take different directions.

Social and political dialogue is more likely in democracies. Thus, Islam and democracy are quite compatible. ‘The Turkish experience reflects the fact that many Muslims, whether living in formally secular or formally Islamic states, see democracy as their main hope and vehicle of effective political participation.’<sup>39</sup> Indeed, the ESSs inform us that secular failures in increasing wealth, democratic environments, and fair elections

<sup>39</sup>J. Esposito and J. Voll, ‘Islam and Democracy’, *Humanities*, 22:6 (2002), <http://www.neh.gov/humanities/2001/novemberdecember/feature/islam-and-democracy>.

are the best environments for politico-religious parties to emerge, stay in power, and attract adherents over time.

## Conclusion

The models can enlighten paths of evolving secularization in societies where there are socioeconomic grievances with respect to failed efforts of increasing wealth at societal level, a democratic competition, and therefore a dialogue between preferences toward secularization exists. Thus, they are more useful to investigate secularization in democratic but developing states where religious ideas can produce alternatives to increase wealth.

The games depict alternative artificial situations by greatly simplifying population dynamics. The assumption of a minimum two and maximum three strategies toward the weight of religion within the polity is highly abstract. It bears some resemblance to what we can derive from politico-religious dynamics, and there are surely more than three strategies in empirical terms. Indeed, the actual, observed world is full of examples of states granting a single religion constitutional status, as well as of states that do not specify one religion as the religion of state and still allow some religious institutions' involvement in its state and its worldly affairs. Changes in secularization may either not match changes in strategy proportions or vice versa, and religion may be attributed constitutional status with no observed changes in the sizes of *R* or *S* types taking place. It is simply impossible to explain every little change or nuance of secularization across societies. In addition, even complex arguments in conventional language could possibly not cover all conditions of evolutionary stability; for example, when *R*, *S*, or *I* types initially constitute specific proportions of a population. Games, in contrast, permit rigorous derivations of theoretical results about a political evolutionary dialogue and the fate of a population in terms of its secularization level. They translate our arguments into formal relations and help us to deduce implications of our hypotheses.

The models represented can be enriched by casting them in terms of linear and Malthusian dynamics driven by differential equations. Another extension of the models may be along asymmetric contests, where instead of one population, two types of populations can interact, so that the population can be assumed as non-homogenous. Individuals can condition their religious strategies of *R*, *S*, or *I* on intrinsic traits, such as their beliefs about the legitimacy of differentiation between state and religious authorities and institutions. Individuals then become distinct strategically—those who adhere to any strategy being satisfied or not with the level of secularization. Naturally, one can develop evolutionary games including more than three strategies toward (de)secularization or by relaxing the random matching assumption and introducing whether similar types encounter each other more frequently than other strategy adherents, or both. Nevertheless, the increase in the number of assumed strategies can produce a mathematically unworkable framework requiring more assumptions.

Empirical data can enrich and support theoretical derivations as well. Such data sets already exist.<sup>40</sup> One can construct additional indicators or complex indices by collecting data on

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<sup>40</sup>J. Fox, 'World Separation of Religion and State into the 21st Century', *Comparative Political Studies*, 39 (2006), pp. 537–569, p. 39; B. Grim and R. Finke, 'International Religion Indexes: Government Regulation, Government Favoritism, and Social Regulation of Religion', *Interdisciplinary Journal of Research on Religion*, 2 (2006), pp. 1–40, p. 2.

whether the state grants a single religion constitutional status, encourages or individually organizes religious education, collects taxes for religious bodies, sponsors religious courts with jurisdiction over family and/or religious practices, and/or passes laws on marriage, burial, dress, speech, and other matters (such as watching foreign television series or movies, or listening to foreign radio broadcasts). By such practices, the state exercises the prerogative to promote religious purposes through legislation and judicial powers, or restricts the freedom of religion. Similarly, whether a religious body can express constitutional prerogatives or hold standing titles and have offices in state institutions, with legal privileges to appoint state officials and with veto powers over government decisions, can also indicate how organized and powerful religion is in a polity.<sup>41</sup> Overall, the games, albeit simple in their present form, shed light on processes of secularization that can help analysts predict the political fate of religious bodies and perhaps the religious fate of states as well.

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## Notes on Contributor

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## Appendix

### Proof of Result 4

$R$  is an ESS if  $E(R, R) > E(S, R)$  and  $E(R, R) > E(I, R)$ . We have  $E(R, R) = A > B = E(S, R)$  but  $E(R, R) = A = E(I, R)$ . Again,  $R$  is an ESS if  $E(R, R) = E(S, R)$ ,  $E(R, S) > E(S, S)$ ,  $E(R, R) = E(I, R)$  and  $E(R, I) > E(I, I)$ . However, we have  $E(R, R) = A > B = E(S, R)$ ,  $E(R, S) = B < A = E(S, S)$ ,  $E(R, R) = A = E(I, R)$ , and  $E(R, I) = A = E(I, I)$ .

Similarly,  $S$  is an ESS if  $E(S, S) > E(R, S)$  and  $E(S, S) > E(I, S)$ . We have  $E(S, S) = A > B = E(R, S)$  but  $E(S, S) = A = E(I, S)$ . Again,  $S$  is an ESS if  $E(S, S) = E(R, S)$  and  $E(S, R) > E(R, R)$  and if  $E(S, S) = E(I, S)$  and  $E(S, I) > E(I, I)$ . However, we have  $E(S, S) = A > B = E(R, S)$ ,  $E(S, R) = B < A = E(R, R)$ ,  $E(S, S) = A = E(I, S)$ , and  $E(S, I) = A = E(I, I)$ .

Finally,  $I$  is an ESS if  $E(I, I) > E(R, I)$  and  $E(I, I) > E(S, I)$ . Instead, we have  $E(I, I) = E(R, I) = E(I, I) = E(S, I) = A$ . It is also possible that  $I$  is an ESS if  $E(I, I) = E(R, I)$  and  $E(I, I) > E(R, R)$ ,  $E(I, I) = E(S, I)$  and  $E(I, S) > E(S, S)$ . However we have  $E(I, I) = E(R, I) = E(I, R) = E(R, R) = E(I, I) = E(S, I) = E(I, S) = E(S, S) = A$ .

### Proof of Result 5

We can propose a mixed ESS with different supports, that is, pure actions that the strategy assigns probabilities to. We first propose  $a = (P, 1 - P, 0)$ , where the use of  $R$  and  $S$  are denoted by  $P$  and  $1 - P$  probabilities, respectively. If  $a$  is a mixed ESS, then  $E(R, a) = E(S, a) = E(a, a)$ . If this condition is satisfied, we still need to demonstrate that  $E(a, R) > E(R, R)$  and  $E(a, S) > E(S, S)$ .<sup>42</sup> We have:  $E(R,$

<sup>41</sup>Philpott, op. cit., p. 507.

<sup>42</sup>Maynard Smith, op. cit., pp. 182–183.

$a) = PA + (1 - P)B$ ,  $E(S, a) = PB + (1 - P)A$ ,  $E(a, a) = P^2A + 2P(1 - P)B + (1 - P)^2A$ .  $E(R, a) = E(S, a)$  implies that  $P = \frac{1}{2}$ , and, under this condition,  $E(R, a) = E(S, a) = E(a, a) = \frac{1}{2}A + \frac{1}{2}B$ . We must now check for the stability condition. We have  $E(a, R) = \frac{1}{2}A + \frac{1}{2}B < A = E(R, R)$  instead of  $E(a, R) > E(R, R)$  and  $E(a, S) = \frac{1}{2}A + \frac{1}{2}B < A = E(S, S)$  instead of  $E(a, S) > E(S, S)$ . Thus,  $a = (P, 1 - P, 0)$  is not an ESS. Similarly,  $a = (P, 0, 1 - P)$ ,  $a = (0, P, 1 - P)$ , and  $a = (P, Q, 1 - P - Q)$ , where  $Q$  and  $1 - P - Q$ , respectively denote the use of strategy  $S$  and  $I$ , do not constitute ESSs. Concerning  $a = (P, 0, 1 - P)$ , we must have  $E(R, a) = E(I, a) = E(a, a) = A$ . We instead have  $E(a, R) = E(R, R) = A$  and  $E(a, I) = E(I, I) = A$ . As to  $a = (0, P, 1 - P)$ , we have  $E(S, a) = E(I, a) = E(a, a) = A$ ,  $E(a, S) = E(S, S) = A$  and  $E(a, I) = E(I, I) = A$ . Finally, take the mixed strategy supported by all three actions:  $a = (P, Q, 1 - P - Q)$ . We have  $E(R, a) = Q(B - A) + A$ ,  $E(S, a) = P(B - A) + A$ ,  $E(I, a) = A$ , and,  $E(a, a) = 2PQ(B - A) + A$ . While  $E(R, a) = q(B - A) + A = E(S, a) = P(B - A) + A = E(a, a) = 2PQ(B - A) + A = \frac{1}{2}A + \frac{1}{2}B$  for  $P = Q = \frac{1}{2}$ , we have  $E(I, a) = A$ . Hence it is impossible to obtain the equality condition of  $E(R, a) = E(S, a) = E(I, a) = E(a, a)$ .

### Proof of Result 6

We have  $A > B$  by assumption. As  $C = s(pV - a(1 - p)) + (1 - s)(qV - b(1 - q))$  and  $B = qV - b(1 - q)$ , we have  $C > B$ . We also note that  $s(pV - a(1 - p)) + (1 - s)(qV - b(1 - q)) = C > D = s(pV - a(1 - p)) + r(1 - r)(1 - s)^2(qV - b(1 - q))$  as  $1 > r(1 - r)(1 - s)$  for  $0 < r, s < 1$ . As to the relation between payoffs  $B$  and  $D$ , the following holds:  $B > D$  if  $B > sA + (1 - s)^2rB$ ,  $B = D$  if  $B = sA + (1 - s)^2rB$  and  $B < D$  if  $B < sA + (1 - r)(1 - s)^2rB$ . We do not need these payoff relations, however. The diagonal entry  $A$  in the first and the second columns strictly exceeds other payoffs in these columns, although the diagonal entry  $D$  is smaller than  $C$  in the third column. Therefore, the symmetric Nash equilibria of  $R$  and  $S$  constitute ESS, while  $I$  is not an ESS.<sup>43</sup> The relation between  $B$  and  $C$  and the one between  $B$  and  $D$  do not matter for the ESS in the game.

The inequality  $C > D$  implies that  $I$  is not an ESS. In fact,  $I$  is a pure-strategy ESS if  $E(I, I) > E(R, I)$  and  $E(I, I) > E(S, I)$ . Yet we have  $E(I, I) = D < C = E(R, I) = E(S, I)$ . As for  $R$  and  $S$ , they are ESSs: we have  $E(R, R) = A > B = E(S, R)$  and  $E(R, R) = A > C = E(I, R)$ , and,  $E(S, S) = A > B = E(R, S)$  and  $E(S, S) = A > C = E(I, S)$  for  $0 < s < 1$ . As all inequalities are strict, there is no need to verify the second condition of the ESS.

### Proof of Result 7

Let  $a = (P, 1 - P, 0)$  be the mixed strategy with the support of  $R$  and  $S$ . We need first to demonstrate that  $E(R, a) = E(S, a) = E(a, a)$ , and, if this condition is satisfied, we have to show that  $E(a, R) > E(R, R)$  and  $E(a, S) > E(S, S)$  for  $a = (P, 1 - P, 0)$  to be a mixed ESS. The equality  $E(R, a) = E(S, a)$  implies that  $P = \frac{1}{2}$ . We then have  $E(R, a) = E(S, a) = E(a, a) = \frac{1}{2}A + \frac{1}{2}B$ . Checking for stability, we find that  $E(a, R) = \frac{1}{2}A + \frac{1}{2}B < A = E(R, R)$ . Thus  $a = (p, 1 - p, 0)$  is not an ESS. The mixed strategy  $a = (P, 0, 1 - P)$  with the support of  $R$  and  $I$  is not an ESS either. We have  $E(R, a) = PA + (1 - P)C > PC + (1 - P)D = E(I, a)$  for all  $P$ , as  $A > C > D$ . Similarly,  $(0, P, 1 - P)$  is not an ESS. We have  $E(S, a) = PA + (1 - P)C > PC + (1 - P)D = E(I, a)$  for all  $P$ , as  $A > C > D$ . Therefore, the mixed strategy supported by  $S$  and  $I$  does not constitute a mixed ESS. We are then left with the final possibility, the mixed ESS with the support of all three actions:  $a = (P, Q, 1 - P - Q)$ . We have  $E(R, a) = PA + QB + (1 - P - Q)C$ ;  $E(S, a) = PB + QA + (1 - P - Q)C$ ;  $E(I, a) = PC + QC + (1 - P - Q)D$ ;  $E(a, a) = (P^2 + Q^2)A + 2PQB + 4C(1 - P - Q)(P + Q) + (1 - P - Q)^2D$ . The condition  $E(R, a) = E(S, a) = E(I, a) = E(a, a)$  implies that  $P = Q$ . Suppose, for example, that  $a = (1/3, 1/3, 1/3)$ . The condition  $E(R, a) = E(S, a) = E(I, a) = E(a, a)$  is satisfied for  $P = Q$  and  $A + B = C + D$ . We remark that if  $A > C > B > D$  or  $A > C > D > B$ , we can have  $A + B = C + D$  but not if  $A > C > B = D$  as  $A > C$ . Suppose then  $A + B = C + D$  and either  $A > C > B > D$  or  $A > C > D > B$ . The second condition implies, for example, that  $E(a, R) > E(R, R)$ . However, we have  $E(a, R) = 1/3(A + B + C) < A = E(R, R)$ . Consequently,  $a = (1/3, 1/3, 1/3)$  is not a mixed ESS.

<sup>43</sup>P. D. Straffin, *Game Theory and Strategy* (Washington, DC: The Mathematical Association of America, 1993), p. 96.