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An evolutionary game theory approach to cooperation among political elites

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Abstract:

Political elites are the foundation of contemporary representative democracies. This reality highlights the unique scientific and practical significance of studies on political elites. The paper presents a non-standard research approach. Some aspects of using evolutionary game theory models to study the evolution of cooperative behaviours among representatives of political elites are presented. To that end, two models of 2 × 2 games were developed: a single-population and a two-population model. The first one assumes the existence of interactions between representatives of the same population, while the second focuses on interactions among individuals from two different populations. The analyses used two interaction schemes: Stag Hunt and Chicken. Standard replicator dynamics was employed to describe the evolutionary process. The results of the analyses are presented in a graphic form in phase diagrams. The presented approach should be treated as a supplement to traditional research approaches used in social sciences rather than as an alternative.

Keywords: *Political elites; human cooperation; evolutionary game theory; single-population model; two-population model; standard replicator dynamics; Stag Hunt game; Chicken game*

Introduction

The evolution of human cooperation has been the subject of a number of scientific studies (e.g. Axelrod 1981, 1984; Bendor, Swistak 1997; Fehr, Gächter 2000; Boyd et al. 2003; Nowak, Sigmund 2005; Boyd, Richerson 2009; Bowles, Gintis 2011; Tomasello et al. 2012; Han et al. 2013). Cooperative behaviours among *Homo sapiens* are common and occur on a scale incomparably greater than in other species. It is typical of human cooperation that it is not limited only to groups in which blood ties play the dominant role. Contemporary societies are linked by a dense network of social relations based on interactions among individuals who are not relatives. Blood ties in such constructs are substituted by a sense of common identity based e.g. on believing in the same god or following the same political ideology (Skarzynski, Wajzer, Staniucha 2016). Believing in imagined orders accelerated the building and organisation of mass cooperation networks. Consequently, the ability to cooperate effectively has become a base for the evolutionary success of our species. As Yuval

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Noah Harari pointed out (2017: 80): '[…] *humankind moved from hunting mammoth with stone-tipped spears to exploring the solar system with spaceships not thanks to the evolution of more dexterous hands or bigger brains (our brains today seem actually to be smaller). Instead, the crucial factor in our conquest of the world was our ability to connect many humans to one another. Humans nowadays completely dominate the planet not because the individual human is far smarter and more nimble-fingered than the individual chimp or wolf, but because Homo sapiens is the only species on earth capable of co-operating flexibly in large numbers. Intelligence and toolmaking were obviously very important as well. But if humans had not learned to cooperate flexibly in large numbers, our crafty brains and deft hands would still be splitting flint stones rather than uranium atoms*'.

Evolutionary game theory is used to investigate a wide range of social and political phenomena. Let us just mention a few: voting (Conley, Toossi, Wooders 2001), fundamentalism (Arce, Sandler 2003), religious and ethnic conflicts (Luo, Chakraborty, Sycara 2011) and civil violence (Quek, Tan, Abbass 2009). The purpose of this paper is to present some possible uses of evolutionary game theory in studying the evolution in cooperation among political elites.[2] As an approach, it is interesting not only due to cognitive premises but also in terms of identifying the social traps, i.e. situations in which the short-term interest of an individual contradicts the long-term interest of a group. Moreover, there are technical aspects which argue for using evolutionary game theory models to study political cooperation, and they include the possibility of tracing changes in the frequency with which individuals use specific strategies and the possibility of including in the analyses those players who do not behave rationally.

Political elites

Various intellectuals have studied the functioning of exceptional humans who stand out in their societies. It was only with the development of the social sciences that it became possible to carry out systematic research that contributed to the formulation of the contemporary theory of elites. The foundations of the contemporary theory of elites were laid by Vilfredo Pareto (1935), Gaetano Mosca (1939) and Robert Michels (1915). More recently, the following scientists contributed greatly to the development of research on elites: C. Wright Mills (1956), Robert A. Dahl (1961), Suzanne Keller (1963), William G. Domhoff (1967), Robert D. Putnam (1976), Samuel J. Eldersveld (1989), Eva Etzioni-Halevy (1993), and Mattei Dogan and John Higley (1998).

This paper draws on the democratic-elite theory proposed by Eva Etzioni-Halevy (1989, 1990, 1993). According to the basic assumptions of this theory, the existence of political and social elites does not contradict the functioning of a representative democracy. Elite theory does not have to be anti-democratic or elitist. Etzioni-Halevy defines elites in categories closely related to the distribution of resources. In this light, political elites include people who control the resources that enable the shaping of the political order in a particular social and political system. Such resources are scarce, which means that the demand is greater than the supply. They include physical coercion, organisational-administrative measures, symbolic measures, material-economic measures and psycho-personal measures. The approach proposed by Etzioni-Halevy is broad enough to cover the participants of social life from outside the traditionally perceived collection of political actors.

[2] By cooperation, we mean the formation of political alliances and the resolution of political conflicts.

They include, inter alia, leaders of social movements whose actions affect the political order in the state (Rothman 2001).

Evolutionary game theory

Classical game theory is outlined in *Theory of Games and Economic Behaviour* (1944) by John von Neumann and Oskar Morgenstern. Classical game theory studies the interactions among rational players. Depending on the assumptions made in the model, they may be individuals, companies, political parties, states etc. Rational players choose behavioural strategies that maximise their benefits (and minimise losses, if necessary), bearing in mind at the same time that their opponents behave exactly in the same way.

The beginnings of evolutionary game theory can be traced to a paper entitled *The Logic of Animal Conflict* (1973) by John Maynard Smith and George R. Price.[3] Originally, evolutionary game theory was supposed to facilitate the modelling of the interactions among genetically determined individuals within specific biological populations. Individuals originating from one population tend to compete for the same resources, e.g. food, territory or females. The result of the rivalry is determined by the strategies (genetically determined behavioural traits) employed by the players. Strategies that on average bring higher payoffs (fitness) prevail in subsequent generations owing to a greater reproduction rate of the players who follow them (Maynard Smith, Price 1973: 15; Nowak 2006: 45–51).

The Nash equilibrium is the most important term in classical game theory (Nash 1950, 1951). It describes a situation in which none of the players gains anything by changing their strategy, if the others decide to stick to their choices. An evolutionarily stable strategy is an equivalent term in evolutionary game theory (Maynard Smith, Price 1973). A strategy is evolutionarily stable if the whole population uses it. Consequently, any minor group of individuals born with new phenotypic traits (mutants) or outsiders (migrants) that uses another strategy will be eliminated from the population. Replicator dynamics is another important concept of evolutionary game theory. It allows the tracing of changes in the relative frequency of occurrence of particular strategies. Standard replicator dynamics (Taylor, Jonker 1978) is calculated according to the following formula:

$$dx(t)/dt=x(t)[U_A(t)-\bar{U}(t)] \tag{1}$$

- where $x(t)$ stands for the percentage of the population which chooses strategy A in time t,
- $U_A(t)$ means fitness owing to choosing strategy A in time t,
- while $\bar{U}(t)$ stands for the average fitness of the whole population in time t.[4]

[3] They introduced game theory into evolutionary biology, and thinking in evolutionary categories into game theory.

[4] The following relationships can be observed between the fitness provided by the choice of strategy A and the average fitness of the whole population: $U_A(t) = \bar{U}(t)$ – the population is in a static state; $U_A(t) > \bar{U}(t)$ – the proportion of individuals using strategy A is increasing within the population; $U_A(t) < \bar{U}(t)$ – the proportion of individuals using strategy A is decreasing within the population.

Standard replicator dynamics is the basic model of natural selection,[5] but this does not mean that the replicator equation cannot be used for studying social phenomena. One should follow a different interpretation of an evolutionary process and, consequently, a different interpretation of payoffs. Genetic variability is the basis of evolutionary changes in biological games. Payoffs in such games are interpreted according to fitness categories, i.e. the number of offspring inheriting the parents' strategy. In the games related to social interactions, genetic variability can be substituted e.g. by imitating behaviours (norms, attitudes) of higher utility.

The following sections of the paper present the methods and research tools used in the analyses, the basic assumptions of the models, a discussion of the results of the analyses, and the limitations of using evolutionary game theory in studies on political elites.

Materials and methods

The analysis covered two models of 2 × 2 games: a single- and two-population game. As the names suggests, the first model assumes interactions within one population, while the other among representatives of two different populations. Changes in the relative frequency of occurrence of the strategies in the populations were described using the standard replicator dynamics. Calculations were made by means of Gambit (McKelvey, McLennan, Turocy 2014), R (R Core Team 2017) and Mathematica (Wolfram Research 2018). A phase diagram of the replicator dynamics in a single-population game was created using the EvolutionaryGames package (Gebele, Staudacher 2017) available within the R programme, while the phase diagram in the two-population game was plotted using the Dynamo package (Sandholm, Dokumaci, Franchetti 2012) written in Mathematica.

Models and analyses

Single-population game

Active participation in political life requires the formation of alliances. Among the factors that determine the community of interests of political entities there is the sense of threat posed by other members of political life.[6] In such a case, an alliance is established to take actions towards neutralising the common enemy. This situation can be expressed in the language of game theory as building a model of a two-player game with symmetrical payoffs in a normal form.[7] Let us assume that in the basic model the game participants choose

[5] The literature contains alternative examples of evolutionary dynamics. To mention but a few: Brown-von Neumann-Nash dynamics (Brown, von Neumann 1950), adjusted replicator dynamics (Maynard Smith 1982) (William H. Sandholm (2010) uses the name Maynard Smith replicator dynamics), imitative logit (or i-logit) dynamics (Weibull 1997) or best response dynamics (Gilboa, Matsui 1991).

[6] This can be a realistic threat or an imaginary one.

[7] The game will be based on the Stag Hunt type of interaction scheme. In a story told by Jean Jacques Rousseau, two hunters go hunting. They will come back home with a stag only when they cooperate while, acting separately, each of them can only hope to shoot a hare. Most importantly, the hunter who will cooperate when their opponent does not will come back home with nothing, while the independent hunter will bring a hare. The game, similar to the Prisoner's Dilemma or Chicken (evolutionary biologists use the term Hawk–Dove game), touches upon issues of high social significance (see Skyrms 2004: 1–4).

between two strategies: C – cooperation in fighting against a common enemy (politician who threatens the position of both players); or D – refusal to take common measures to neutralise the threat. The latter results in an attempt to solve the problem on one's own. By acting together, politicians clearly do not get instant results, but they implement a holistic plan. Independent actions will in turn bring instant but only partial results. One should note that they do not know what solution a potential ally will choose. The following game matrix includes payoffs resulting from players choosing either C or D.

	C	D
C	4, 4	0, 2
D	2, 0	2, 2

A row player and column player choose C or D independently of one another. The following combinations of strategies are acceptable:

- (C, C) – politicians cooperate and, consequently, their common enemy is defeated;
- (D, D) – in fear of being defeated by the other side and eager to achieve results as quickly as possible, politicians act individually; each of them solves the problem only partly when acting individually;
- (C, D) – the row player cooperates, while the column player acts independently; consequently, the first gains nothing, while the other only prolongs the threat;
- (D, C) – the row player acts independently, while the column player cooperates.

The game has two symmetrical Nash equilibria in pure strategies: (C, C) leading to result (4, 4) and (D, D) leading to result (2, 2).[8] Both strategies C and D are evolutionarily stable. Moreover, one symmetrical equilibrium exists in the game in mixed strategies:

$$x^* = ((½, ½), (½, ½))$$

When choosing mixed strategies, each player can expect winning two utility units. Only the equilibrium in pure strategies (C, C) is Pareto optimal, which means it is the desired game solution.

Let us now imagine that the game is played by representatives of the political elites of the fictional state of San Escobar.[9] They form a population which is numerous enough and relatively homogenous for evolutionary processes taking place in the population to be of statistical significance. Moreover, the population is non-spatial, which means that the probability of one player interacting with another player at any time is high.[10] Politicians make a decision on whether to choose C or D based on an observation of which strategy renders a higher mean utility.

[8] When choosing a strategy, the evaluation of the risk that our opponent refuses to take common actions may turn out to be extremely important. Choosing strategy C will be more beneficial when we estimate the likelihood that the opponent will also choose C as over 50%. Otherwise, it is better to choose the "safe" strategy D.

[9] San Escobar was invented in an interview of the Polish Minister of Foreign Affairs, Witold Waszczykowski (see Taylor 2017).

[10] The model assumes continuous time interactions.

The utility resulting from choosing strategy C is as follows:

$$4*x+0*(1-x)=4x \quad (2)$$

While the utility resulting from strategy D:

$$2*x+2*(1-x)=2 \quad (3)$$

Hence, the mean utility of the whole population is:

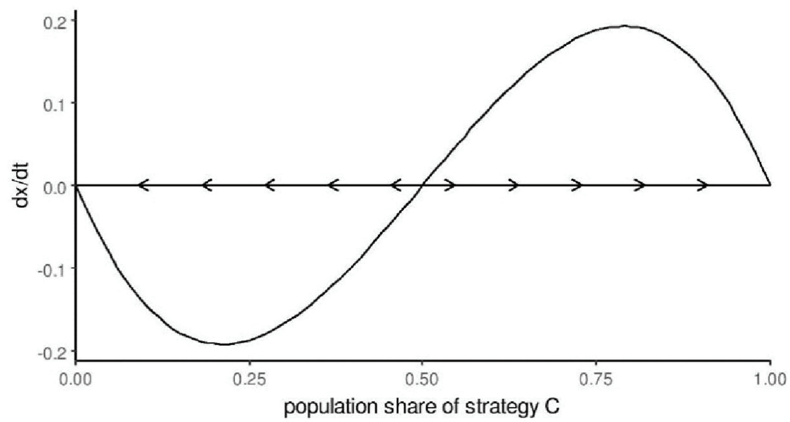
$$x*4x+(1-x)*2=4x^2-2x+2 \quad (4)$$

The replicator equation shows that the changes in the population are proportional to the difference between the utility of the politicians who choose strategy C in time t and the mean utility of the whole population in time t. It takes the following form:

$$dx/dt=x[4x-(4x^2-2x+2)]=x(1-x)(4x-2) \quad (5)$$

Since C and D are evolutionarily stable strategies, the population formed by the political elite of San Escobar will be temporarily stabilised[11] when it consists either of cooperating players or players taking actions on their own. Figure 1 presents the replicator dynamics of the reference game.

Figure 1: Graph of *dx/dt=x(1-x)(4x-2)* function and phase portrait within the *0 ≤ x ≤1* range



Source*: Author's calculations.*

The figure presents three equilibrium points: x = 0 (all politicians choose strategy D), x = ½ (half of the politicians choose strategy C while the other half chooses strategy D) and x = 1 (all politicians choose C). Once the equilibrium points have been reached, the population takes a static form. Only the equilibria x = 0 and x = 1 are asymptotically stable. The equilibrium point x = ½ is characterised by low resistance even to minor disturbances. It divides the space of all possible strategies of section [0, 1] into two basins of attraction of the same

[11] Until a new mutation (behaviour) appears.

size: basin of attraction of the (C, C) solution and basin of attraction of the (D, D) solution. This is also the critical value, exceeding which leads to the population evolving towards an alternative asymptotically stable equilibrium.[12]

Two-population game

Single-population models are far-fetched idealisations. In reality, interactions with a high relevance level are hardly ever symmetrical. Most often, one can observe games between representatives of two or more different populations. In biology, they will be individuals representing different species; in an economy, these will be buyers and sellers; and in political science, they will be e.g. representatives of antagonistic ideological camps.

Let us now imagine that, following a system transformation, a political elite consisting of two populations was developed in San Escobar.[13] The first population comprises politicians originating from the *ancien régime*, their supporters and allies (row population). Politicians who used to be persecuted and repressed in the previous system due to their political stance form the core of the other population (column population). The game is played only among the representatives of the row population and representatives of the column population. Let us assume that they randomly enter into conflicts related to values, access to goods or access to power.[14] Information about the causes of conflicts and their course are revealed to the public by the media. The collection of each player's strategies consists of two elements: a cooperating strategy (C) – amicable settlement of the conflict – and a non-cooperating strategy (D) – striving for conflict escalation using political violence. Due to their past, politicians representing the previous system are evaluated by the public opinion more severely than are the new elite members.[15] The situation is reflected in the value of the payoffs, which can be linked e.g. with the level of social trust measured in per cent points. Information about the level of trust is provided by surveys carried out periodically.

	c	d
C	1, 2	0, 3
D	1 ½, 1	-1, 0

The following combinations of strategies are possible in a game:[16]

- (C, c) – politicians strike a compromise; consequently, the column player gains one per cent point more than the row player;

[12] The solutions are not equally good. Regardless of this fact, their basins of attraction are of the same size. This observation leads to the conclusion that the evolutionary process does not always bring optimal solutions.

[13] In return for the guarantee to maintain their positions and influence on the operation of the new system, the ruling party shared their authority with the opposition.

[14] Similar to the single-population model, interactions occur continuously.

[15] It refers to the period directly following the system transformations.

[16] Both politicians play using the Hawk–Dove interaction scheme. According to a biological interpretation of the game, the conflict of two hawks denotes a fight generating high costs on both sides. The interaction of doves will result in the peaceful division of the disputable goods, while a rivalry between a hawk and a dove will result in the latter withdrawing without a fight (see Schecter, Gintis 2016: 212–213).

- (D, d) – the conflict escalates; the row player observes decreasing social trust, while the column player maintains the *status quo*;
- (C, d) – the row player makes concessions, while the column player plays in a non-cooperating way; the first one neither loses nor wins anything, while the other gains three per cent points;
- (D, c) – the row player strives for conflict escalation, while the column player makes a concession; they both enjoy higher social trust.

The game has two Pareto optimal Nash equilibria in pure strategies: (C, d) leading to the (0, 3) result and (D, c) leading to the (1½, 1) result, and one sub-Pareto optimal equilibrium in mixed strategies:

$$x^* = ((½, ½),(⅔, ⅓))$$

Using mixed strategies in their games, politicians may expect payoffs amounting to (⅔, 1 ½). Equilibria in pure strategies show that it is better to choose C, risking that the other side will likely take advantage of us rather than to go out on a limb and play D. When choosing the latter solution, one has to take into account that the result of the game may be the least favourable, i.e. (D, d).

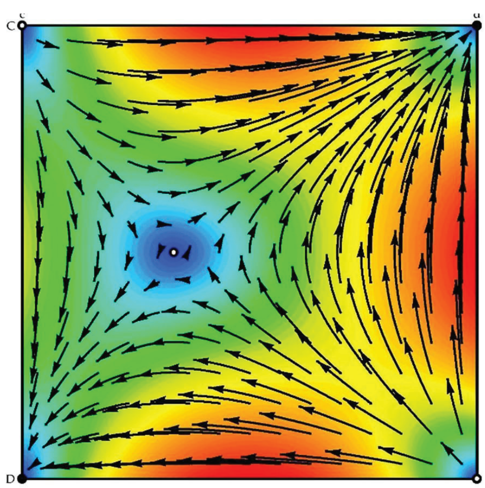
Assuming that the share of C and D in the row population will be marked as x and 1−x, while the share of c and d in the column population will be marked as y and 1−y, the replicator equation for the row population will take the following form:

$$dx/dt=x[y-(-1½xy+2½y+x-1)]=x(1-x)(1-1½y) \tag{6}$$

and the following form for the column population:

$$dy/dt=y[(x+1)-(-2xy+3x+y)]=y(1-y)(1-2x) \tag{7}$$

Figure 2: Trajectories of population evolution in a two-population Hawk–Dove game



Source*: Author's calculations*.

Note: The areas marked in red show accelerated replicator dynamics, while the areas in blue represent the replicator dynamics slowdown.

The system described by equations (6) and (7) has three equilibria points. Figure 2 shows that corner equilibria (C, d) and (D, c) are stable, while the interior equilibrium $x^* = ((½, ½), (⅔, ⅓))$, which separates the basin of attraction of the (C, d) solution (the row player acquiesces to the column player) from the basin of attraction of the (D, c) solution (the column player acquiesces to the row player) is unstable. Depending on the original strategy proportions (the point in which evolution will be initiated), the system can be expected to turn towards one of the two pure states. It is worth remembering that in a single-population Hawk–Dove game, the Nash equilibrium in mixed strategies is asymptotically stable. In a two-population game, the situation is the opposite. Such a significant qualitative change can be attributed to a long-term tendency towards the polarisation of behaviours (Weibull 1997: 183–184).

Conclusions

The paper presents selected possibilities of using evolutionary game theory for studying the evolution of cooperative behaviours among political elites. Two models of 2 × 2 games were analysed: a single- and two-population one. The first assumes that the interactions involve forming an alliance against a common enemy, while the other assumes that politicians come into conflict about values, access to goods or access to power. The studies used two interaction schemes: Stag Hunt and Chicken (Hawk–Dove). The evolution of cooperative behaviours was presented graphically in phase diagrams.

The advantages of using models of evolutionary game theory in studies on political elites include obtaining accurate results and their intersubjective communicability and verifiability. These features result from building the models in the language of mathematics. Opponents of using mathematical models in studies of social phenomena tend to point out that mathematical models oversimplify the rich world of human relations, which leads to results that are far from reality.

Limitations

An attempt to identify the accuracy with which the analysed models represent the interactions occurring in real networks of social relations would be of immense significance. Taking the above into account, one needs to remember that the theoretical constructions proposed in the paper are far-fetched idealisations. They do not show the actual course of the studied phenomenon or explain why it occurs in a specific way. They only show how it could proceed following the assumptions resulting from using standard replicator dynamics to describe an evolutionary process. First and foremost, it applies to the assumption that changes in the population occur continuously and that players do not make mistakes by imitation. An alternative variant could involve using other selective dynamics, e.g. imitative logit (or i-logit) dynamics, introducing the possibility of random errors by imitation, or a discrete-time version of the replicator dynamics.

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