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Artificial Polity: Anticipatory Modelling and Simulation of Political Systems. Applications to Democratic Polities in Eastern Europe¹

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Abstract

This paper introduces a political methodology approach on polity modeling and simulation called *artificial polity* which combines political systems and political culture theories. It aims at introducing anticipatory systems as the modeling framework for the organization, operation, and dynamics of political systems. Anticipatory systems provide for the conceptual modeling of polities as self-referential systems which embed internal models. Agent-based systems provide for the simulation and experimental research of artificial polities which embed political culture as internal models. *Artificial Polity* is the outcome of a long-term political methodologic research project aimed at developing research frameworks and instruments for the study of state and governance with anticipatory dimensions. Eastern European democracy case studies are presented with the goal of evaluating the anticipatory performances of the *Artificial Polity*. Post-communist Eastern European countries case studies are presented with the goal of evaluating the anticipatory performances of the Artificial Polity Model. Relevant applications of the political anticipation framework as presented in this paper could further enhance research on (i) political systems resilience against various types of threat, (ii) political regime dynamics in specific economic and cultural contexts, and (iii) political systems stability and security issues.

Keywords: anticipatory system, artificial polity, political methodology, agent-based modeling and simulation



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1. Introduction

Political culture theory (Almond and Verba, 1963) has provided theoretical support to the idea that political culture plays a fundamental role in the relationship between the citizens and the state. Policy dynamics is explained by means of two fundamental concepts: the *open polity* as a research methodological paradigm of the state as governance in a democracy, and the *political attitudes* as a research methodological paradigm for the interaction of the individual citizens as well as the mass of citizens with the state.

For a theory in comparative analysis, political culture theory identifies two main background methodologies which have dominated the social and political research in the second half of the 20th century: system theory and attitude measurement. In Almond and Verba's theory there is a fundamental dimension of comparison between any two democracies or any two polities and which has the advantage of receiving substantial empirical support from the attitude survey research: it is the classic reactive (behavioral) paradigm of *stimulus-response* which has been associated with the notion of cybernetic feed-back in control theory and with structural-functional paradigm in system theory. Political culture theory introduces in this respect a reactive view over both the citizens and the state. This reactivity is expressed and evaluated in terms of *attitudes*, which are themselves assumed to be the outcome of a bilateral reactive relationship between the citizens and the state. Attitude measurement thus provide for the means to evaluate the effects determined by each term of this relationship onto the other.

2. A Political Methodology Point of View

Political culture research has proved a fast process of intensive employment of the research methodologies which are based on the advanced technologies of the artificial and simulation, big data and web semantics, data mining and machine learning. The process has revealed a wide range of methodological approaches which are concerned with the relationship between the citizens and the state.

While classic political culture theory (Almond and Verba, 1963; Converse, 1964) is based on the attitudes measurement methodology for assessing the degree of acceptance or rejection of the governmental policies by the society (Judd and Krosnick, 1989; Krosnick and Smith, 1994; Katz, 1960; Thurstone, 1928), the later evolutions of the political culture research proved significant changes especially in what regards the research methodologies and the research issues (Johnson, 1999). Beside political attitudes, the research issues have progressively included values, emotions and beliefs

thus extending the range of studied expression and manifestation of the citizens with respect to the governance performances, efficiency, responsibility, and responsiveness.

Advanced methodologies employed in the attitude dynamics modeling research have evolved and increased the complexity of models. Thus, a cleavage emerged between the classic operationalization of attitudes as binary outcomes (accept/reject) of evaluation processes based on information processing, and the operationalization of attitudes as complex dynamic outcomes of interaction processes based on both information processing and sophisticated cognitive as well as reflexive processes in complex systems endowed with self-organizational and self-referential characteristics.

The study of the dynamics of this relationship between the citizens as individual agents, on the one hand, and the state as a political organization based on institutional agents, on the other hand, has started to increasingly require a change in its conceptual and methodological approach and to deepen the cleavage between them. Political culture theory has been dramatically challenged by this cleavage: its comparative analysis status has remained attractive, while its explanatory power drastically diminished because of the weak ontological and epistemological grounds.

The theories about anticipatory systems have revealed an interesting way out of the political culture theory's dilemma between valid and useful comparative analysis outcomes and weak conceptual and operational backgrounds.

This paper is organized as follows:

Section 2 presents a brief research literature review on polity modeling and especially on agent-based polity modeling. A comparative perspective is suggested between agent-based modeling and anticipatory system modeling of social and political systems. A political culture research literature brings to the front its anticipatory dimension as introduced by Almond and Verba in their famous work (1963). **Section 3** presents the research aims and goals by providing details on how anticipatory systems could benefit the area of political anticipation research. **Section 4** describes the research issues and questions as the main dimensions of this research approach. **Section 5** and **Section 6** describe the conceptual and the experimental approach, respectively. **Section 7** provides a brief description of the conceptual and operational modelling of the artificial polity. **Section 8** describes the configuration and the experimental setup and the case studies and the empirical research. **Section 9** provides preliminary results. **Section 10**

draws the conclusions and provides a view over further developments of this research project.

3. Paradigmatic Issues: Polity Modelling and Simulation

Polity modelling is as well an old as a new research issue. For many years, polity modelling has been approached from an international relations point of view with concern to the modelling of conflict issues between nation-states. Polity modelling area has been mainly concerned with the capacity of a state actor to act in a conflict scenario. Modelling approaches are based however on several paradigms.

3.1 Modelling approaches of state/polity

State modelling and simulation has approached the state as both complex structure and dynamic functionalities. Some of these modelling researches have acquired large recognition, like for example, models of state dynamic behavior in conflict scenarios in the System Dynamics (SD) paradigm (Choukri et al.), ABM models of relationships between states (*Axelrod's Tribute Model*, 1995, 1997), state emergence and conflict (Cederman's *GeoSim Model*, 1997; Cioffi-Revilla and Rouleau, *RebeLand Model*, 2010), models of state and governance dynamic operation (Cioffi-Revilla's *SimPol*, 2009). Governance models, like the *open polity* model (Almond and Verba, 1963), are based on a conceptual approach on the relationship between the citizens and the state / government which can be best defined within the classic system theory, behaviorism, and control theory. The model of the open polity has been employed in the modelling of governance as a dynamic system (Cioffi-Revilla, 2010).

Mathematical models describing the polity as complex dynamic system (Lang and DeStaerck, 2012) with two main components: government and society (see: Voinea, 2016: Figure 20.1, p. 278).

The qualitative models include the Embedded Democracy Model (Merkel, 2004) The Model of People Empowerment (Welzel, 2013) concern the relationship between the citizens and the state as a means for the self-development and empowerment of the individual citizens given an increasing level of support from the Government (that is, policy, economic development, services, political and civil liberties, etc.). The model describes a sequence of people empowerment (Welzel, 2013: p.38) (see **Figure 1**).

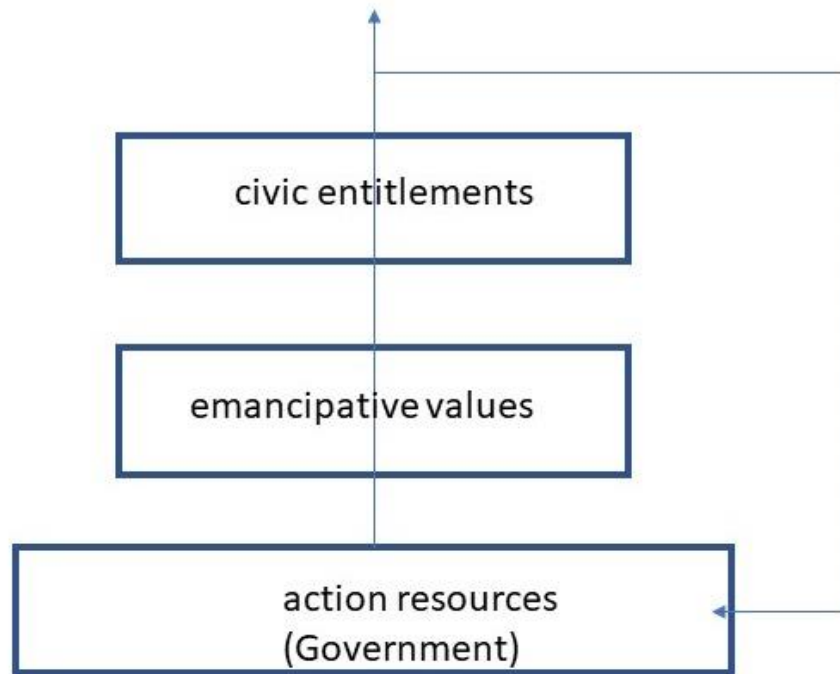
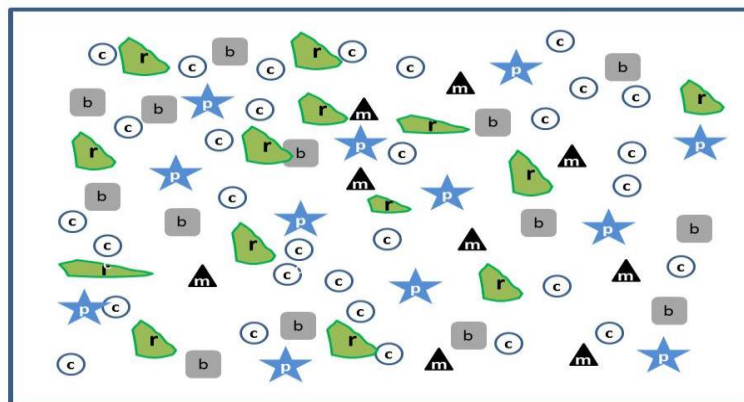
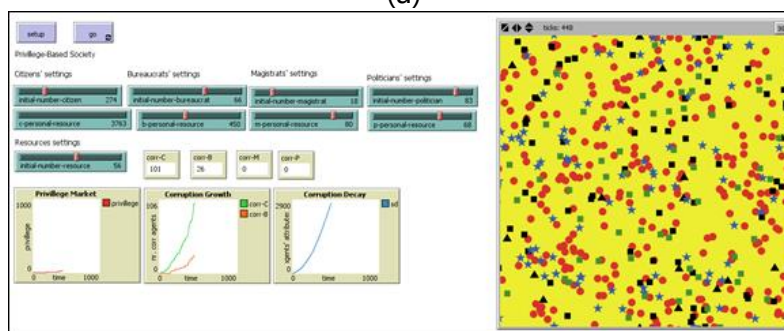


Figure 1.
People Empowerment Model (Welzel, 2013)

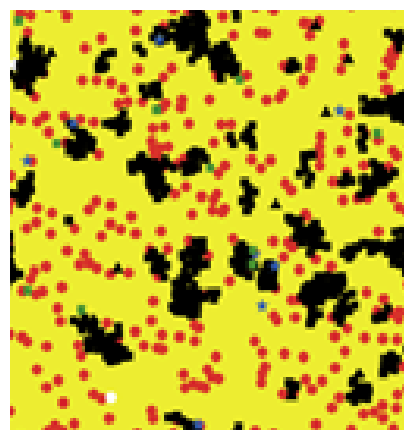
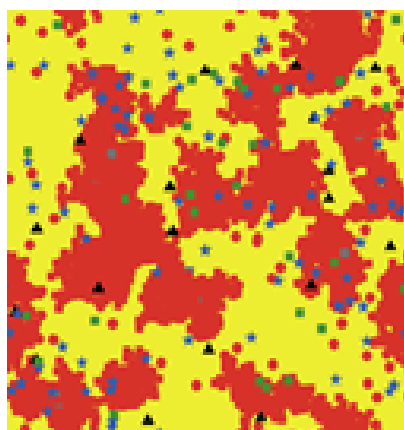
Models of corruption, like *Briberyscape* and *Baronscape* (Voinea, 2013), view the governance model as decisively influenced by a certain type of access to public resources in both autocratic and democratic types of political systems. These models prove that agents and their interactions can be approached on multiple levels and with different representations of the agents and the interaction structure and dynamics (see **Figure 2**).



(a)



(b)



(c)

Figure 2.

(a) Briberyscape Model and (b) Briberyscape Simulation Model: four types of agents and public resources are represented in different colors; (c) Simulation outcomes from simulations with Baronscape Model.

4. Research Approach: Issues & Questions

This paper presents an approach to the issue of political anticipation based on defining the polity as a complex system with emergent, self-organizing and anticipatory capabilities. The research questions are as follows:

Q1: Internal structure and model(s) of a polity defined as an anticipatory system.

Defining the internal structure of a complex political system requires a descriptive specification in terms of internal sub-systems and their structural couplings.

Q2: Why is the (political) culture considered a key idea in defining and describing the internal models of a polity viewed as an anticipatory system?

My approach tries to explain the paradigmatic shift from the classic structural-functional system-based approach to a complexity-based approach of a political system. Classic approaches include the governance-based models (Marsh, 2011; Rhodes and Bevir, 2010; Sassen, 2006; Ferguson and Mansbach, 1996), and (territorial) state-based models (Agnew 2004, 1994). Our approach identifies the (political) culture as internal model.

Q3: The benefits and limitations of considering an anticipatory system as the fundamental conceptual modeling framework of polity's structure, operation, and dynamics. The anticipatory paradigm replaces the classic structural-functional approach and provide for explanations of the emergence of major political change phenomena, like the political regime change (revolution, coup) and the transition from one type of regime (autocratic/democratic) to another (democratic/autocratic).

5. Research Approach

Anticipatory systems are viewed as complex systems with internal model(s) guiding and conditioning the dynamics of the whole system. In our approach, the *polity* is defined as a complex system with an internal structure including several components and structural couplings emerging and developing amongst these components, and with one or more

internal (interconnected) models which provide for the anticipatory dimension of polity's dynamics and operation. Polity's internal structure consists of two main basic sub-systems, that is, society and political establishment, which interact and relate to one another by means of several internal models, that is, political power model, political leadership (elite) model, governance model, economic model, (political) culture model. The internal models are themselves interacting as the polity interact with its own environment.

Identifying and defining the internal models may require the re-configuration of a polity so as put emphasis on the complex relations between them and the basic structural components of a polity. Therefore, we start from the hypothesis that a polity is a complex structure consisting of several main structural-operational components operating as open dynamic loops (Cioffi-Revilla), that is, (1) society, (2) political establishment, and (3) internal models, such as the political culture model, and the economic model. While this approach views the economic model as related to both social and governance components, the political culture model is viewed as related to the cultural model, political power relation model, and economic model.

6. Anticipatory systems: Overview and Approach

An anticipatory system is defined as a system with an internal model which uses this model to specify its current state as a function of this model at a future state (predictive model). If the system is its own model, then the current state of the system is dependent on its past, present, and future state. (Dubois, 1998: p.3; Rosen, 1985: p.341).

In this approach, the political system is defined as an anticipatory system which uses an internal predictive model, namely a political culture. The current state of the system is therefore dependent on this and other sub-systems (Leydesdorff, 2008).

An anticipatory system \mathbf{s} is defined as follows:

$$s_t = as_t(1 - s_{t+1}) \quad (1)$$

In this paper, \mathbf{s} is the artificial polity system, AP, and the artificial political culture, APC, is one of its sub-systems. Other sub-systems are defined and described following the *Embedded Democracy Model* (Merkel, 2004). The APC system itself is defined as an

anticipatory system with an internal model, namely, an attitude sub-system, and several other sub-systems, like value sub-system and belief sub-system².

If the \mathbf{s} system includes several sub-systems, namely

$$(s_1, s_2, s_3, \dots, s_n),$$

then the system:

$$s_{i,t} = c_i(s_{i,t-1}, s_{j,t-1}, s_{k,t-1}, \dots r) \quad (2)$$

where: t is time in direct forward historical sequence, c_i is the codification of system's previous state, s_n with $n = i, j, k, \dots$ are the sub-systems, and meaning is provided from a hindsight perspective (Leydesdorff, 2008).

Equation (2) describes the dependence of the system \mathbf{s} on its sub-systems, and the dependence of the state of a sub-system on the current states of the other sub-systems of \mathbf{s} .

7. Artificial Polity: Conceptual, Experimental and Simulation Modelling

7 Conceptual Modelling

The preliminary research on the artificial polity as an anticipatory system employs conceptual modeling of (i) polity, (ii) political culture, and (iii) their relationship in a political (democratic / autocratic) regime. In this approach, both the *polity* and the *political culture* are defined and modeled as *anticipatory systems* in Luhmann's view (Luhmann, 1995). Each of these systems contains at least two anticipatory dimensions: (a) meaning construction and processing, (b) asynchronous operation of the differently codified subsystems. As such, *political culture* and *polity* are viewed as *structurally coupled* systems:

² The research work reported in this paper describes the situation in which all the sub-system develop horizontally, while other versions which have been studied but not reported here develop in an imbricated manner. The experiments include scenarios not fully reported in this paper, namely scenarios in which the anticipatory system AP is defined following Rosen's definition (1985), and other scenarios in which the anticipatory system AP is defined following Dubois' definition (1998).

each of them contains a model of the other, and each is (part of) the environment of the other.

The Artificial Polity models the polity and the political culture as being structurally coupled (see: *Artificial Political Culture in: (Voinea, 2021), forthcoming*). In this structural coupling, polity and political culture are two entities which share the societal environment (that is, structures and individual agents). Both have nevertheless different generative sources which keep them structurally coupled as far as their coupling is based on a structurally convergent dynamics of each coupled entity (see **Figure 3**).

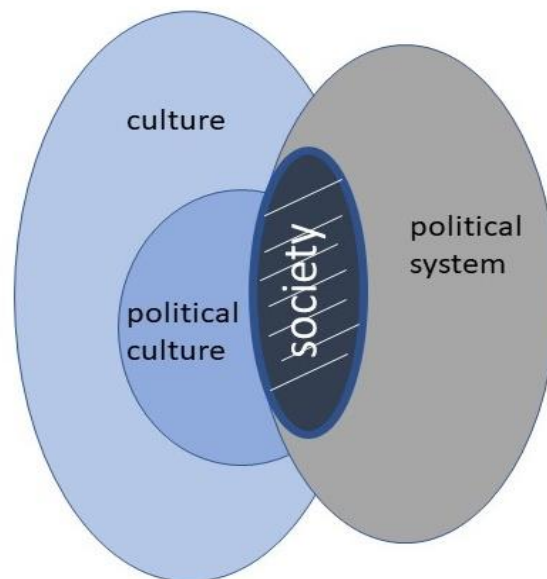


Figure 3.

Conceptual model of an artificial polity as a structural coupling of a political system and a political culture.

7.2 Operational Modelling

The artificial polity models a political system as a weak anticipatory system as defined by Dubois, 1998; Leydesdorff and Dubois, 2004). As such, it includes a political culture as an internal model of itself. The model is reflexive by means of hindsight in the sense defined by Leydesdorff (2008).

The AP system with the Artificial Political Culture Model as its internal model. The APC Model is in turn defined as an anticipatory system with Value System as its internal

model. AP system could thus be described as a system with several functionally differentiated sub-systems (Leydesdorff, 2008).

The AP Model runs for several scenarios which have been described in the research literature and for which survey data are available for all countries in the Eastern Europe.

The state of the AP system, AP(t), is dependent on the system state at previous moment of time, AP(t-1), and the current state of its sub-systems, that is, the functionally differentiated components of the political system as described by Merkel (2004: Figure 1, p.37). In turn, the state of the APC sub-system, APC(t), is dependent on its previous state, APC(t-1), and on the current state of other subsystems, that is, attitude sub-system, value system, and belief system which contribute to the environment of system AP. Each sub-system is considered to provide meaning to itself and to other sub-system, such that the equation (2) can be written so as to describe the current state of any sub-system (Leydesdorff, 2008) as follows:

$$s_{i,t} = a s_{i,t-1} \prod_{j=1, j \neq i}^n (1 - s_{j,t}) \cdot \varepsilon \quad (3)$$

For some configuration of the value orientation map (see **Figure 4**), a polity characteristic is represented as proportional to the dynamic level of belief which is based on that *value orientations map*. As value orientations map are dynamically changing during meaning communication, the polity operation is described by its degree of legitimacy.

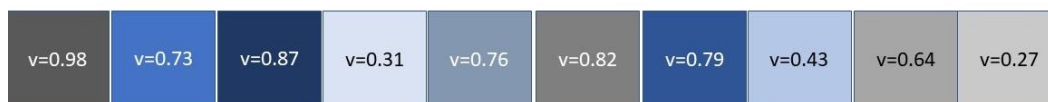


Figure 4.
Value orientations map.

The polity operation simulation scenarios are: (1) support for democracy, and (ii) satisfaction with democracy.

8 Artificial Polity Model: Configuration and Setup

The model works with a political system architecture which adapts the *Embedded Democracy Model* (Merkel, 2004: p. 37, Figure 1). As a difference from the original model, our model includes a political culture associated with the democracy model (see **Figure 5**).

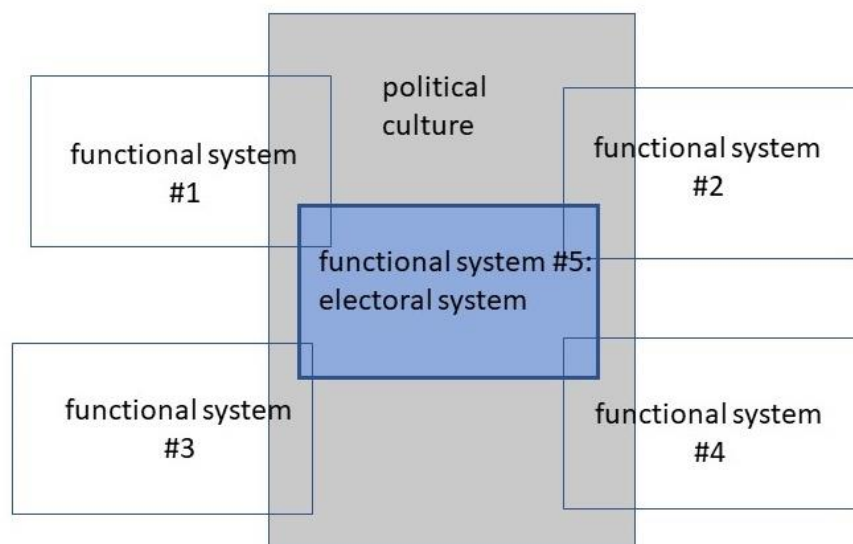


Figure 5.

Embedded Democracy Model adapted from: Merkel, 2004: p. 37, Figure 1.
Artificial Polity (AP) and Artificial Political Culture (APC) in a democracy model architecture.

An *artificial political culture* is defined itself as an anticipatory system which has a Value Model as its internal model (Voinea, 2021, *forthcoming*). The value set is defined as a set of 10 basic permanent values (Schwarz, 2012). In this set, each value is characterized by its strength: value' strength is codified as a decimal number in the range (0, 1), where the "strength" describes an informal level of attachment of the system to that value. Value' strengths are continuously updated as the functional sub-systems of the AP Model process and communicate meaning.

In order to test against the available survey data delivered by various European and international databases, the simulation setup takes into consideration a single belief (for example, “trust”) in a simulation scenario. Simulation scenarios describe a typical relationship between belief, like “trust”, and state (or institutions), like “legitimacy”. Several simulation scenarios are generated by taking into consideration the defective democracy scenarios as described by Wolfgang Merkel (2004).

8.1 Experimental Setup and Simulations

The experimental setup (see **Figure 6**) employs an agent-based system to simulate a real polity with a political culture as internal model. The artificial polity with an artificial political culture simulation setup has been designed in two versions: (1) as a political system with a democratic regime, and (2) as a political system with an autocratic regime. This paper presents preliminary results for democratic systems only.

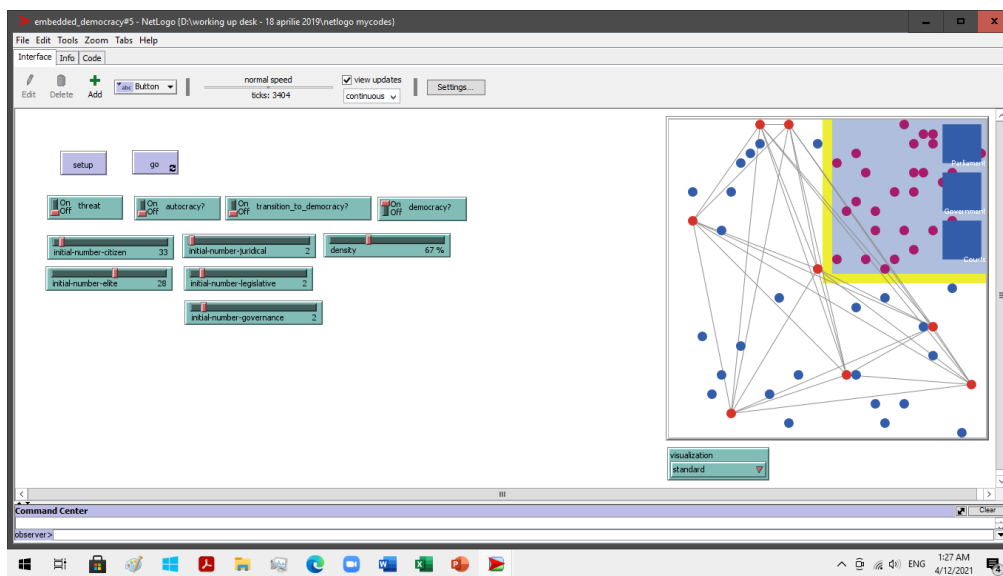


Figure 6.
Artificial Polity Simulation Model.

Artificial Polity Simulation Model has been developed on NetLogo platform. The model employs a representation with different types of agents with different political beliefs (i.e., ideologies) as individual agents and institutional agents, with different areas of interaction (that is, interaction between individual agents, interaction between individuals and institutional agents, and interactions between institutional agents), and with a network of relationships between individual agents. The system could be initialized with various number of individual and institutional agents. During a simulation run, the system lets the agents interact such that political attitudes emerge and dynamically change by means of beliefs and value orientations updates as result of repeated interactions. The value orientation maps are thus generated and employed in the meaning-processing and meaning-communication operation of sub-systems in the system of the artificial polity as an anticipatory system. The Artificial Polity Model updates its internal (operational) state by taking into consideration (a) the state of its internal model(s) at a future moment of time (Rosen's view on anticipatory systems), and (b) its own state at a future moment of time in case that the model of the system is the system itself (Dubois' view on strong/weak anticipatory systems).

The simulation scenarios include several types of architectures, as follows: (1) the APM has a single internal model, (2) the APM system is its own model, (3) APM has several horizontally distributed internal models (sub-systems) with convergent contributions to the current state of the AP system, and (4) APM has several hierarchically distributed internal models (sub-systems) with contributions to the current state of the AP system. The present approach reports few preliminary results with respect to the scenarios (2) and (3) (see Section 8). Such simulation preliminary results regard the modelling and simulation goals of reproducing the characteristics of the studied real time social and political phenomena. Modelling and simulation goals of explaining the characteristics of the studied real time social and political phenomena are not approached in the present paper.

To the aim of evaluating performances of the APM and provide a comparative analysis with survey data and analyses, several Eastern European case studies have been developed and employed with the goal of evaluating the political anticipation performances of the artificial polity with an artificial political culture.

A simulation run is based on a configuration of value orientations, beliefs, and political attitudes as defined and described in the conceptual and operational modelling aspects.

8.2 Case Studies

The Artificial Polity Model is tested against a collection of empirical data concerning several Eastern European countries after the fall of Berlin Wall in 1989 and are describing survey outcomes for: values (*source: WVS*), beliefs (*source: WVS*), state (institutions) authority, legitimacy, democracy indexes and public opinion with respect to the quality of democracy (*sources: Voter Turnout Database-IDEA, EuroBarometer*). The testing scenarios concern (i) support for democracy, and (ii) satisfaction with democracy, and follow research literature and survey analytical results reported in this research area (Klingemann, 1995).

Each case study compares the outcome of survey research and analysis reported in the European and international databases and in the research literature for a period of time of 30 years between 1990 and 2020, and the outcomes of simulating the Artificial Polity Model (APM) for the same period of time and the associated dynamic configurations of the Artificial Political Culture Model (APCM) with its internal models, that is, value orientations, beliefs and political attitudes.

Case studies have been developed for the following countries: Romania, Poland, Hungary, Estonia, Czechia, Croatia, Slovenia (1990-2020).

The main data source which has been employed is the World Value Survey (*WVS*), especially for the Welzel Emancipative Values. (Case studies are appropriately reported in the associated APC Model as presented in (Voinea, 2021, *forthcoming*). From the public database the following components have been extracted: (a) Value orientations maps, (b) beliefs: Trust in Government, and (c) Legitimacy: (1) index at country level of state institutions, and (2) legitimacy of political regime based on voter turnout.

The simulation model combines all this data and analytical models to achieve patterns of polity behavior and polity characteristics as anticipatory system depending on the chosen conceptual architecture.

Survey data from public databases

Diagram 1. Confidence (trust) in Government:

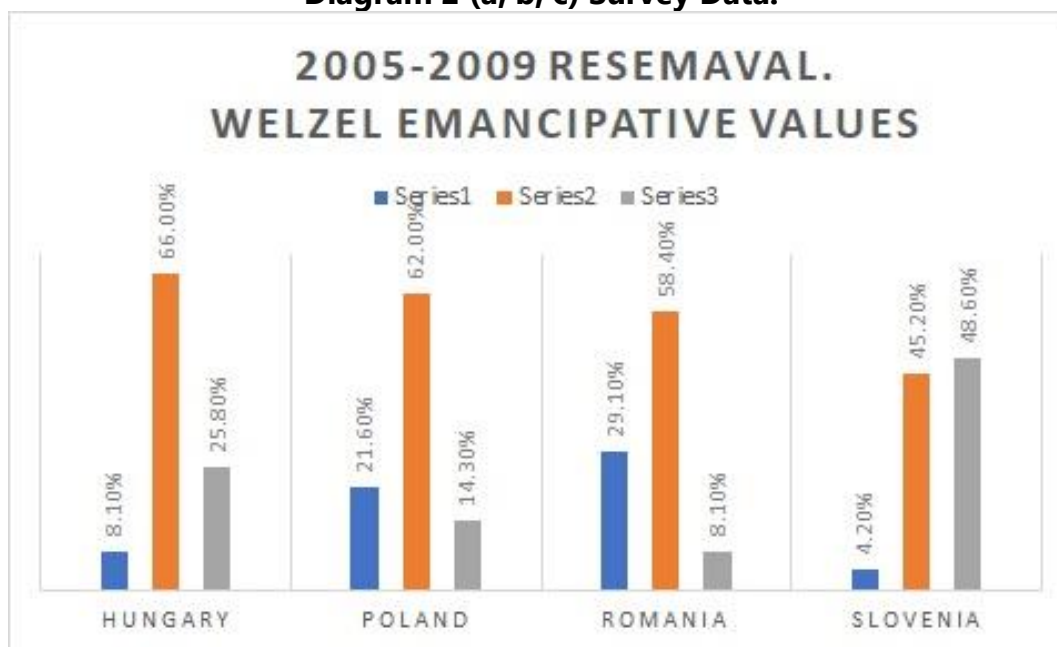
Country	Confidence in Government			
	1990-1994	2005-2009	2010-2014	2017-2020
Croatia	12.5%			0.8%
Czech rep.	1.1 %			2.0%

Estonia	6.4%	-	7.1%	3.5%
Hungary	9.5%	1.3%	-	10.4%
Poland	5.8%	2.5%	0.4%	5.3%
Romania	3.1%	2.3%	4.4%	4.5%
Slovenia	7.4%	2.2%	0.9%	1.7%

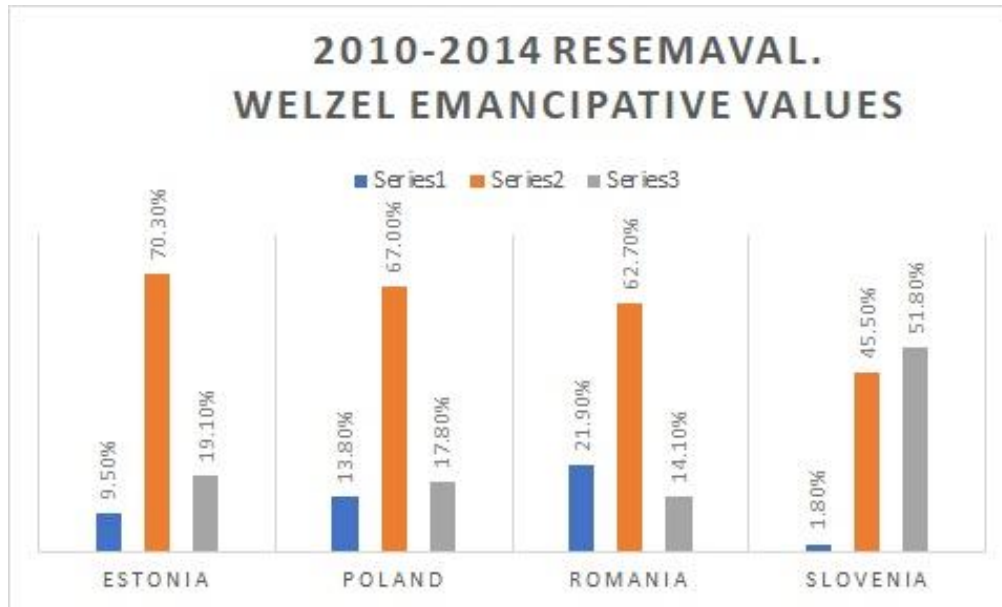
Source: WVS; values taken for "a great deal"

Value orientations maps are generated from survey data as discussed in (Voinea, 2021).

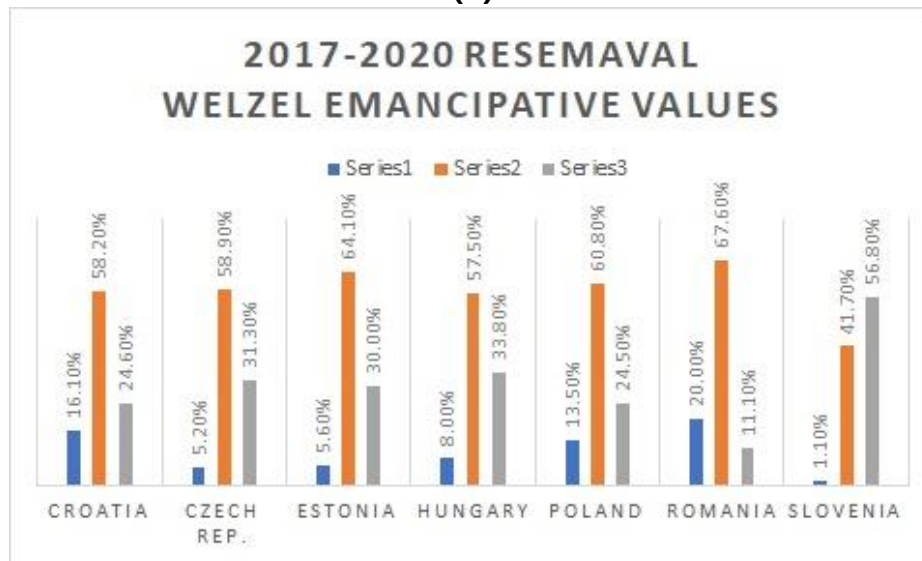
Diagram 2 (a, b, c) Survey Data.



(a)



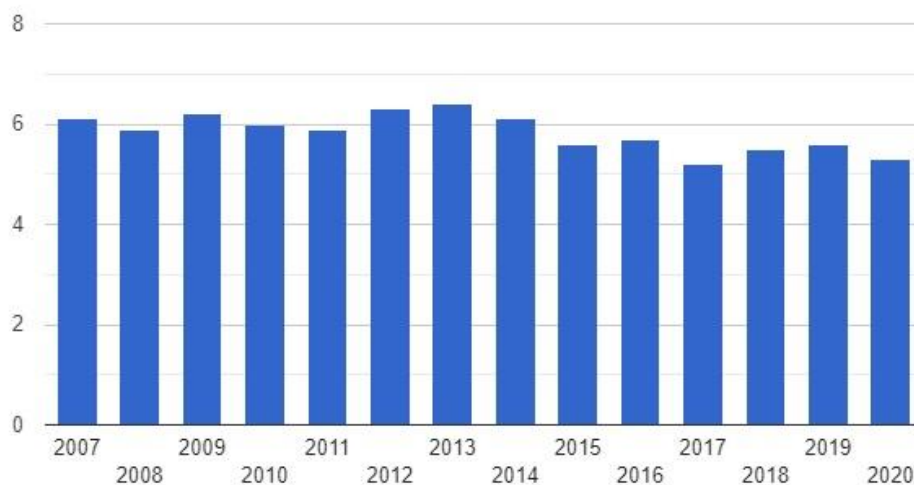
(b)



(c)

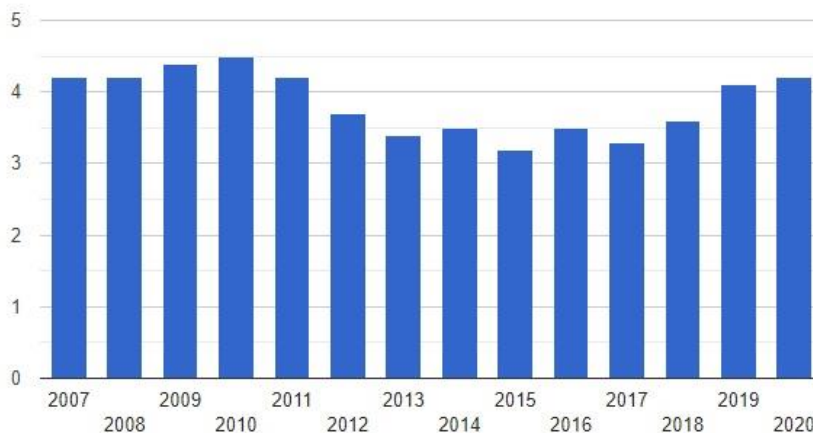
Polity operational characteristics and patterns are generated by the APM simulation model as based on the survey data concerning:

Diagram 3. Romania Legitimacy Index 2007-2020.



Source: average number of index points: 5.84 index points; max.: 6.4 index points (2013); min.: 5.2 index points (2017). TheGlobalEconomy.com, url: [Romania State legitimacy index - data, chart | TheGlobalEconomy.com](https://www.theglobaleconomy.com/Romania/legitimacy_index/)
Accessed: 4/11/2021.

Diagram 4. Poland Legitimacy Index 2007-2020



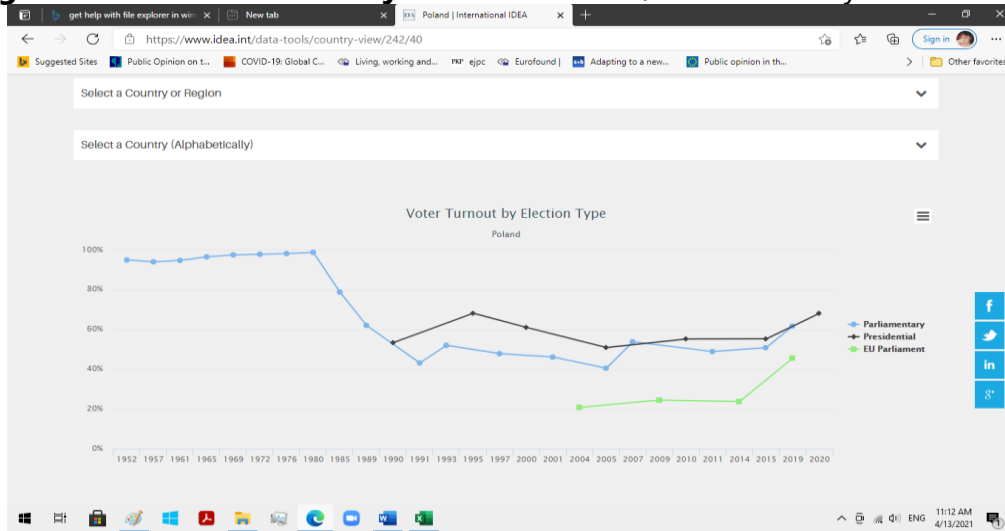
Source: average number of index points: 3.86 index points; max.: 4.5 index points (2010); min.: 3.2 index points (2017). TheGlobalEconomy.com, url: [Poland State legitimacy index - data, chart | TheGlobalEconomy.com](https://www.theglobaleconomy.com/Poland/legitimacy_index/)
Accessed: 4/11/2021.

Diagram 5. Romania Voter Turnout: Parliamentary Elections 1990-2020

Country	Elections Type	Year	Voter Turnout
Romania	Parliamentary	2020	31.84%
		2016	37.79%
		2012	41.76%
		2008	39.20%
		2004	58.51%
		2000	65.31%
		1996	76.01%
		1992	76.29%
		1990	79.69%

Source: IDEA, url: [Voter Turnout | International IDEA](#) . Accessed: 4/11/2021.

Diagram 6. Poland Case Study: Poland Turnout / Parliamentary



Source: IDEA, url: [Poland | International IDEA](#)

The simulation runs with APM as anticipatory system with an artificial political culture model have generated the simulation results for (a), (b) and (c).

Diagram 7: Romania Case Study

(left) Public survey data (Source: IDEA); (right) Data generated by simulation runs APM&APCM



Diagram 8: Poland Case Study:

(left) Public survey data (Source: IDEA); (right) Data generated by simulation runs APM & APCM



9. Preliminary Results

The research results are evaluated from a comparative perspective with the empirical data from survey research as reported by public databases. The preliminary research results reveal higher reproduction performances of the artificial polity as an anticipatory system with an artificial political culture in comparison with the performances of the agent-based artificial polity developed in previous versions on corruption (Voinea, 2013), and state capture (Voinea, 2015).

10. Conclusions

Artificial Polity Model and Artificial Political Culture Model as anticipatory systems open up a new era for this area of political methodology research. They reveal new paradigms of political anticipation which could further include big data and web semantics as well as advanced technologies and methodologies based on the sciences of the artificial able to enhance the development of new instruments of approaching research issues like that of political system resilience against various types of threat, the management of common resources as well as security risk research issues.

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