On three ethical aspects involved in using agent-based social simulation for policy-making

Antoni Perello-Moragues[1,2,3], Pablo Noriega[1], Lucia Alexandra Popartan[4,5], and Manel Poch[4]

[1] IIIA-CSIC, Barcelona, Spain
{tperello, pablo}@iiia.csic.es
[2] Aqualia, Spain
[3] Universitat Autònoma de Barcelona, Spain
[4] LEQUIA, Universitat de Girona, Spain
{luciaalexandra.popartan, manuel.poch}@udg.edu
[5] Cetaqua, Spain

Abstract. The use of agent-based social simulation for policy-making ethical considerations of three different kinds: (i) in the agent-based policy model itself: the choice of values that are to be imbued in the simulated agents and in the policies; (ii) in the functionality of the system that is designed to support a policy-making process; and (iii) in the use of the system to design, negotiate, deploy and monitor an actual policy. In this paper we propose a value-driven framework to elucidate the corresponding ethical concerns of these kinds and then outline some guidelines to address them. We use the water policy domain to motivate and illustrate the proposal.

Keywords: agent-based simulation · policy-making · values · socio-cognitive technical systems · water policy

1 Introduction

Agent-based Social Simulation (ABSS) has been acknowledged as a useful tool to support policy-making [7], although not without misgivings, as any other type of model whose purpose is to inform policy decisions [3]. Besides, agent-based modelling (ABM) may be based, unconsciously, on errors and artifices if modelling processes are not appropriate [6]. Hence, decision-makers and modellers should be aware of the limitations, since these tools may have substantial influence in policy processes. For instance, models can become "black box" tools [24], informing decisions despite ignoring the underlying assumptions, or they can contribute to crystallise the way to address social phenomena, inhibiting the exploration of alternative models and explanations. In the worst case, such tools may lead decision-makers to the abdication of their responsibility. Consequently, the design of agent-based models should take into consideration the uses that are meant for the system, so that users are properly informed of the limitations and concerns. Thus, designers are responsible not only for eliciting the

user requirements, but also for reflecting design issues that are specific to policy modelling.

We suggest to work with value-driven models. Values are useful for clarifying whether a policy, besides effective, is good (see [18]). And they allow to shed light on how to contend with the aforementioned inconveniences that lead to ethical concerns when using ABSS for policy-making.

In this paper, we focus on how can values be imbued in a model using a concrete case of urban water management. We also suggest how this process is related to the design values of agent-based models for policy-making and the values associated with their use. Given these purposes, we characterise agent-based social simulation for policy-making as type of socio-cognitive technical system, which has values as a first-class entity (i.e. *value-driven policy-making support systems* [17]). In particular, values are imbued (i) in the social space through a policy-schema (that is, the set of means and ends that define a public policy); and (ii) in artificial agents by providing them with value-driven reasoning models.

The paper is structured as follows. First, we distinguish three perspectives to contextualise the ethical concerns involved in ABSS for policy-making in Sec. 2. Second, we abstract features that characterise *value-driven policy-making support systems* in Sec. 3. We then illustrate how these considerations may be addressed in modelling a policy for urban use of water in Sec. 4 and build on that example to suggest how to contend with those ethical concerns (Sec. 5). Finally, we sum up our proposal in Sec. 7.

2 Background

Conceptually speaking, policy-making is an ethical space. Policy-makers intend to improve a fragment of the world (the policy domain) and device policy means to achieve the improvement. When policy-makers decide to support their task with agent-based models, they face ethical considerations in three levels. First, in the *policy enactment level*, where policy-makers must decide how to use agent-based simulation to back their policy decisions. Second, in the *policy support level*, when policy-makers decide to build a model of a relevant part of a policy domain and intend to use that model to design, negotiate and perhaps monitor their policy proposals. Third, in the *modelling level*, where policy-makers build an agent-based model to simulate policies for a given policy domain.

The class of ethical considerations involved in the three levels are different but they all essentially amount to moral judgements (decide whether something is "good") and ethical dilemmas (choosing the "right" thing to do). Values are involved in such judgements, as they serve to evaluate the "goodness" of states and outcomes, and to decide whether one action is preferable to another [21,9]. Accordingly, "values are concepts or beliefs, about desirable end states or behaviours, that transcend specific situations, guide selection or evaluation of behaviour and events, and are ordered by relative importance" [21]. Noteworthy,

values are involved in individual decisions in everyday life [20,16], and in organisational settings and public affairs [25,11].

2.1 Values in policy models

In general, in policy-making values are involved in two types of uses: (i) in assessing the worthiness of a state of the world, and (ii) in determining whether some policy means lead to a good state. Moreover, since in principle several combinations of policy means may bring about the desired ends, policy-makers face ethical dilemmas in choosing the particular set of means that will be part of the proposed policy. Furthermore, those target groups that are affected by the policy also behave according to their own values, and choose actions that best serve their interests.

In the case of *policy modelling*, we need to make these ethical aspects operational. For this reason, we take a *consequentalist* view of values where the value itself is defined through its consequences [23]; in other words, we assume that there are some observable facts of the world that can reflect that value. In practice, this means that one defines a value with indicators or indexes (i.e a combination of indicators) that can be observed in the world at any time. The consequentalist understanding of moral judgement allows one to say that one state of the world is better than another —with respect to a value— when it has a better scoring for the indicator of that value. This fact also allows one to decide when an action is better than another —with respect to a value— by comparing the effects each one would have in the state of the world. Moreover, when more than one value is involved in these ethical behaviours, one can make these values *commensurable* by assuming that stakeholders have *value aggregation models*. It does not mean that they are, necessarily, functions that aggregate multiple values to return a score that represents the overall *utility* [1], but rather that individuals are afforded to consider multiple values and solve value conflicts. Thus, in a particular situation, *value aggregation models* enable stakeholders to aggregate multiple relevant values and eventually make a decision or perform an action. Besides aggregation functions (see [19,2]), these can be, among other options, satisficing combinations [22].

2.2 Values in policy support systems

One can see agent-based modelling as part of a wider process of policy-making. In this context, the model itself is just one component of a larger socio-technical system that supports the policy-making process: *value-driven policy-making support systems* (VDPMSS) [17]. For this purpose we adopt the value-sensitive design (VSD) approach [5,19]. In particular, we adopt the *conscientious design* framework [15], that organises design values in three categories: (i) *thoroughness*, that includes classical technical values (like robustness, correctness, reliability, efficiency); (ii) *mindfulness*, that reflects the personal values of the users (like privacy, reciprocity, generosity); and (iii) *responsibility*, that includes those values related to the interaction of the system with the wider socio-technological

environment where it is situated (like data ownership, liabilities, legal status and institutional effects).

2.3 What values?

The ethical questions, in this context, are partly associated with the *epistemic* aspects of the agent-based model. Thus, they refer to the abstract representation of the relevant part of the world and the type of insights the model may support. Other ethical questions involve the *rhetorical* uses of the model. These are, for instance, the awareness of the limitations of the model, the characterisation of scenarios and the ergonomics of the system. While these ethical questions may apply to all model-based decision-making, we postulate that the critical point in VDPMSS is how *values* are handled in the representation and the usability of the model.

In the case of individual agents one may choose different value systems and value aggregation models. For instance, *value aggregation models* may be based on the Schwartz universal values [21] (i.e. value systems) and "satisficing" combinations [22] (i.e. aggregation model). The way these two elements are modelled in the agents' decision processes may follow different strategies [8,12]. Both matters are outside the scope of this paper.

For policy-makers (and policy-making) we propose to use "public values" to guide public decisions of policy-makers and imbue public policies and public services. Public values apply to complex phenomena in political and socio-economic spheres. For instance, citizens may prefer public services that are ostensibly managed according values like fairness or justice, rather than being treated as consumers in a service market regulated by the "invisible hand" [13]. As we shall see in Sec. 4, we rely on Witesman and Walters' Public Service Values (PSV) [25] to account for values that are more likely to be invoked to justify decisions in public affairs.

3 ABSS with value-driven policy-making support systems

We propose to support agent-based social simulation for policy-making with socio-cognitive technical systems that are value-driven (VDPMSS) [17].

Socio-cognitive technical systems (SCTS) are situated, on-line, hybrid, open regulated multi-agent systems [14]. They consist of two first-class entities: a *social space* and participating *agents* who have opaque decision models that guide their actions. This distinction makes modelling policies quite natural: first, *values are imbued in simulated agents* by providing them with value-driven reasoning models; second, *values are imbued in the instrumentation of a policy* within a social space (by making values observable in the state of the system and instrumenting them as means to drive agent behaviour towards some ends). Such modelling is facilitated by a metamodel for VDPMSS [17].

The point of a metamodel is to facilitate the expression of the affordances that need to be modelled in a system [14]. The distinctive affordances for VDPMSS

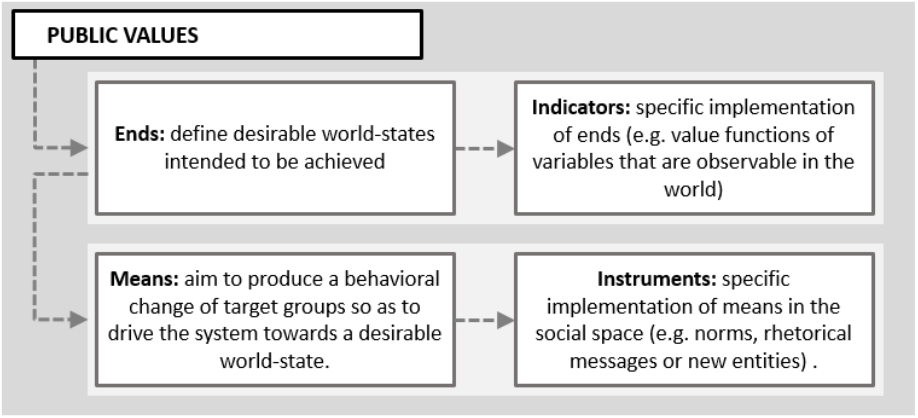

Fig. 1: Instantiation of values into a policy-schema [17]

are (i) the inclusion of *values*; (ii) the possibility of *subcontexts* that correspond to the phases of the policy cycle; (iii) a set of *stakeholder roles*; and more significant for modelling, (iv) the definition of a *policy-schema* and (v) the availability of *value aggregation models*. In particular, a *policy-schema* is an explicit expression of the use of values and how they are made operational and assessed with two main constructs (Fig. 1).

(i) *Policy means* aim to produce a behavioural change on policy-subjects so as to drive the system towards a desirable world-state, and are implemented with *instruments* (like norms, messages, etc.) that guide the social activity towards the policy objectives.
(ii) *Policy ends* define desirable world-states intended to be achieved, and are expressed through *indicators* and *indexes*, which are computed from variables that are observable and whose actual scores are used to assess whether policy goals are achieved or not.

4 Example: values in water policy

In this section we illustrate how to bring values in the modelling of water public services in an urban environment. For this purpose we assume that: (i) a *water utility* is in charge of providing the public water services for a city (and managing their infrastructure); (ii) the (traditional) mission of the utility is to supply good quality water, with adequate pressure and without interruptions, and ensure good sanitation, while taking into account ecological, social, and economic concerns; and (iii) the water utility is responsible for the implementation of the corresponding policies.

The point of the example is to illustrate how to answer two questions: *"what are the relevant values in a given policy domain?"* and *"how to make these values operational?"*.

Table 1: Witesman's Public Service Values [26]

1. EQUITY: Support of systems and actions that promote fairness and equality for individuals and groups.	**2. BENEVOLENCE:** Preservation and enhancement of the welfare of people.	**3. SOCIAL JUSTICE:** Preservation and protection of those who are at a disadvantage in society.
4. TRANSPARENCY: Providing visible, accurate and accessible information on all aspects of government.	**5. SELF-DIRECTION:** Independent thought and action choosing, creating, exploring.	**6. STIMULATION:** Excitement, novelty, and challenge in life.
7. CITIZEN INFLUENCE: Support of the right of individuals and groups to be heard by government and to work together to influence the institutions and policies that affect them.	**8. ACHIEVEMENT:** Personal success through demonstrating competence according to social standards.	**9. POWER:** Social status and prestige, control or dominance over people and resources.
10. SECURITY: Safety, harmony, and stability of society, of relationships, and of self.	**11. TRADITION:** Respect, commitment, and acceptance of the customs and ideas that traditional culture or religion provide.	**12. CONFORMITY:** Restraint of actions, inclinations, and impulses likely to upset or harm others and violate social expectations or norms.

In order to address these questions we have proposed to adopt a list of values that are *relevant for the domain* and instantiate these values in a *policy schema* as a set of *ends* and the corresponding *means* to achieve those ends. A policy schema is made operational —in the ABM— by choosing some specific *indicators* that interpret those ends and some specific *instruments* that implement the means (Fig. 1).

1. Policy domain values. In line with the standard understanding of personal (motivational) values, policy-makers would hold some context-dependent values that are projected onto the policy design. Assuming these are instances of more general values, Jørgensen and Bozeman (e.g. [10]), for example, proposed a list of *public values*. Witesman and Walters [25] focused on public servants that make decisions, which reflect their own values, on behalf of many citizens. The authors compared public and motivational values (e.g. [10,20]) and elicited an updated list of *Public Service Values* for decisions in the public sphere. Then, based on that work, Witesman [26] provided the descriptive list of values reproduced in Table 1. Each of these twelve values is, in turn, expanded into more specific value items [26] (pp 32–33).

2. Making values operational. We reformulate the expanded values to fit the water policy domain. For example, *Achievement* (value 8) is decomposed in three value items: *efficiency*, *economic responsibility* and *ecological sustainability*. In particular, we contextualise *achievement* to take the mission of water utilities into account: "water managers and water users should make a rational and prudent use of natural resources, considering also the financial sustainability of the water management cycle, and the status of water ecosystems". Once the contextualisation is made, one needs to define the end objectives of the policy

—that need to be expressed in terms of factual indicators— and choose appropriate means to achieve them. With regards to the water cycle, one can draw from ideas of circular economy and use indicators like the ratio of reused water, and means that are not only technological (efficient water-treatment plants) but also social like encouraging citizens to not waste water or to accept reclaimed water.

3. Instantiating abstract values. This contextualisation process is more subtle when dealing with less technical values. For instance, *social justice* (value 3) is defined by Witesman [26] as "preservation and protection of those who are at disadvantage in society" and expanded into *advocacy* ("people who work for government should promote the interests of society's least advantaged"); *social justice* ("government workers should seek justice for everyone, even people they do not know"); and *protection of minorities* ("government should consider and protect the rights of those who do not have the greatest voice in society").

One may form a crisper interpretation of these value items: *redistribution of wealth* and *equal opportunities*, and contextualise them as "treat people differently in line with their (water use) needs in order for them to live a decent life, distributing costs and benefits accordingly" and "ensure that the right of water users to access water supply and sanitation is protected". This contextualisation is reflected in some means and ends that are made precise in the form of instruments and indicators of the policy-schema as illustrated in Table 2.

The choice of such indicators is key for agent-based models for policy-making. First, because they determine the *ontology* of the model. Second, because they establish the *meaning* of the values embedded in a policy-schema by identifying and modelling those instruments that are involved or involve those indicators, and by using those indicators to specify value aggregation models.

One may follow a recursive approach to this selection process starting with a list of (expanded and contextualised) relevant values: from values to ends, from ends to a list of indicators, that is build in a circular way (start with performance metrics for the ends, for each indicator, find instruments that involve it —stakeholder actions, norms, agent reasoning knowledge and resources—; identify missing indicators in these instruments; and update list of indicators until no new indicators are found), and then from indicators back to a set of instruments that are implemented in the ABM.

5 Approaching ethical concerns when modelling public policies

As we suggested before, a focus on values may be useful to throw light on sensitive ethical aspects in three levels of ABM for policy-making. The previous section illustrated how to make values operational in the model-building level; we now discuss how to approach them more systematically.

Model-building level. Modelling processes imply choices that have ethical implications with respect to the domain of interest. On the one hand, they are present in the *representation* of the policy domain. Indeed, the designer commits

Table 2: Making public values operational for policy models

Value	Ends	Means	Instruments	Indicators
Social Justice	Redistribution of wealth	Financial instruments for social aid	– Subsidies for vulnerable households (lower water cost) – [...]	– Relative utilities cost on household income (%) – Vulnerable households due to low income (%) – Households with poor home water systems (%) – [...]
		Economic instruments to ensure proportionate water service funding	– Specific tariffs for large and industrial users (higher water cost) – [...]	
	Equal opportunities	Financial instruments to empower households	– Scholarships for training in water sector funded by water companies (lower cost of education) – [...]	– Population without basic access (%) – Households whose water use is under 100 L/p·d (%) – Population exposed to harmful water pollutants (%) – [...]
		Technological solutionism	– Digital water meters will notify when anomalous low use is detected (new action for an artificial agent). – [...]	
	[...]	[...]	[...]	[...]

to a specific notion of what is the *state of the world*: an ontology for the policy domain that defines a set of observable facts, a set of functions that may modify the state of the world (i.e. agent actions and external events), a set of roles that agents may play, and the institutional framework that regulates roles and determines the feasibility and consequences of events and actions. On the other hand, they are present when characterising agents that populate the model, which are provided with (value sensitive) decision-making models, including their value aggregation models.

The key ethical issue is to choose the relevant values in the policy domain and to make them operational by identifying those variables that are pertinent for each of those values. Then, following the recursive procedure at the end of Sec. 4, there are two more choices. The fist one corresponds to the need to choose

some of these variables to be used as indicators of the values or to be combine into indexes that reflect the values. The second one is to identify those actions and events that involve those variables and may change them, since they are key when modelling policy means and the decision-making models of simulated agents. Finally, the combination of the indicators and indexes of the relevant values are articulated as aggregation models for each simulated agent and to evaluate to what degree the policy is *effective* (i.e. its outcome is consistent with the policy declarations) and *good* (i.e. its outcome improves the state of the world in line with the values of stakeholders) (see [18]).

Model-validation level. It has to do with ensuring that the model supports an ethically responsible use for policy-making. The designers of the VDPMSS should refine the model to back the three types of *conscientious values* [15] proposed in Sec. 2:

1. *Thoroughness:* classical technical values like appropriate level of abstraction, crisp delimitation of simulated phenomena, reliability, robustness, resiliency of the actual model.
2. *Mindfulness:* expressiveness of the model to adequately represent the needs of the policy-maker and the interests of all relevant stakeholders. Are disclaimers explicit? Are all relevant public domain values properly expressed in the model? Are relevant assumptions well justified? Are all stakeholders taken into consideration?
3. *Responsibility:* functionality that supports the (responsible) use of the system: Does the system support the relevant questions that its intended uses may pose? Does the system contribute to uphold all the relevant public policy values? Is the system accessible? Does it enable auditing? Are system liabilities known and addressed? Is the model robust enough to defend its outcomes in a public hearing?

Enactment level. Policy-makers will use the ABM bound to the ethical responsibility of their role. The values involved may be subsumed in the notion of responsibility that should imbue the ethical choices that policy-makers face while using the model during the policy cycle. We find it convenient to separate the concerns that are implicit in their choices:

1. Awareness of the *limitations* of the system (scope, assumptions, validation, etc.).
2. Awareness of the *impact* of the model (cost/benefit analysis —opportunity, misalignment—, public values compliance, etc.)
3. Awareness of the *purpose of the use* of the model (and hence of the relevance of the other two concerns associated with these uses): the *epistemic* faithfulness of the model (mostly during agenda setting, negotiation and monitoring phases); the *predictive* accuracy of the system (mostly in the negotiation and monitoring phases); the *rhetorical* appeal of the model (mostly for policy negotiation and enactment).

6 Uses of value-driven public policy agent-based models

Value-driven ABSS for public policy may be a useful tool for policy-assessment exercises by having the specific assessment concerns explicitly represented in terms of values in the ABM. Hence, this can clarify the pertinence and extent of the model results. Noteworthy, the European Commission considers necessary to conduct an Impact Assessment (IA) for those policies that are expected to have significant economic, environmental or social impacts (see [4]); which requires, among other topics, to set the policy ends and the policy means according to how the policy problem has been defined, and to establish indicators to compare, evaluate, and monitor the effects of alternative options.

Value-focus requires to make explicit what values are deemed relevant, how they are interpreted and what is the fragment of reality involved in the simulation. This clarifies the scope of the model and should also reduce the "black-box effect" for the use by policy-makers.

The ABM may be used (in different ways) in different stages of the policy cycle: the design of the model can be part of the agenda-setting phase; refinement and calibration could be part of the policy definition phase; a working model may be used to negotiate a policy and a working model may also provide the basis for monitoring (and value-feedback) of a running policy.

Finally, another use of value-based modelling is to provide a metamodel for sociological research of different sorts (empirical detection and interpretation of values; value-based reasoning; policy acceptance; etc.)

7 Closing remarks

In this paper we propose to use values as a salient modelling construct. The purpose of this focus is twofold: (i) to elucidate the moral commitment implicit in ABSS for policy-making; and (ii) to make more explicit those values that are involved in the formulation of the problem in the specific policy domain and in the policy-making exercise.

In this last respect, we believe that our proposal is conducive to a crisp characterisation of the extent to which a policy may be effective and good —in line with the values of stakeholders. Moreover, a value-driven ABSS for policy-making may be a useful tool for policy-assessment exercises by having explicit representations of the assessment concerns.

We illustrated how to elucidate ethical choices in three levels of responsibilities, taking into account the expected uses of ABSS in the policy process (*epistemic*, *rhetorical* and *predictive*). Our driving concern is the fact that agents in the ABM stand for "real people" and that their simulated behaviour will inform decision-makers. Given that ABM for policy-making are designed to transcend the virtual world, *engineers* (e.g. modellers, developers, designers) have an ethical responsibility.

Furthermore, we think that a value-driven approach can stimulate contributions in policy understanding. A type of intelligence that agents must exhibit

is ethical reasoning, as it is unavoidable in some political domains. This would make more explainable their individual and collective decisions in such contexts, and therefore it would contribute to understand the social outcomes.

Finally, we believe that the design of value-driven ABM for policy-making is a worthwhile effort from a conventional AI perspective, as it may constitute a very pertinent sandbox for the value-alignment problem. The problem of imbuing values in autonomous entities is decomposed in ABM for policy-making as two design problems:

(i) imbuing values in the system as a whole: it regulates the behaviour of the autonomous entities that it contains, and its own behaviour as a whole, in order to foster value-aligned problems; and
(ii) developing agent models whose decision-making models are aligned with intended values.

Acknowledgements. The first and third author are supported with the industrial doctoral grants 2016DI043 and 2016DI042, respectively, which are provided by the Catalan Secretariat for Universities and Research (AGAUR).

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