A Policy Design Framework Using Agent-Based Social Simulations

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Abstract. In this paper we propose the development of a policy design framework using agent-based social simulations (ABSS). ABSS enable us to clearly articulate the problem(s) that we want to solve with policies and simulate the proposed policies to remedy the problem. One important aspect that we see in current policy development is the lack of awareness regarding context, perspective and bias. When a policy is developed, for instance, within one ministry it will usually have the context of that ministry, ignoring other perspectives in which the problem can be seen. This causes a (unintended) bias during the policy development and in the resulting policy. By creating an ABSS multiple contexts and perspective can be incorporated into one model to explicitly articulate these perspectives and biases. It also enables policy developers with expertise in a single context to add their insights to the model and see how this interacts with other contexts during the simulation. The emerging behavior in the ABSS gives insight in the different policy contexts.
The proposed framework enables policy makers to match their policy problem with different ABSS design methods to see which best fits their needs. At the same time social simulation experts can gain more insight in the applicability of ABSS to policies.

Keywords: Policy development, Social simulations, Agent-based social simulations, Emerging behaviour, Simulation comparison, Model, Framework

1 Introduction

Policy making, in all its forms, is extremely complex. This realization is repeatedly discovered, something that was already pointed out a few decades ago [1]. Developing policies is often done without clear goals, stakeholders, ideal processes, (evaluation) metrics or open mindedness to new ways of working, according to academics and governmental reports [1,2,3]. Not only is it complex, it is also done in a dynamic world where political or societal surges in attention can cause unexpected pivoting of the policy development direction. One way to deal with this complexity is to use models in order to simplify problems, analyze them and predict the effect of policies. In the past decade more types of models and approaches to policy making have become computational feasible, thus giving us more options to deal with the policy design complexity.

One of the new approaches that seems to be a promising way to deal with the complexity is agent-based social simulation (ABSS) [4,5,6,7,8,9]. Creating an ABSS enables us to articulate a problem, make it explicit and look at it from many different angles. By doing so we expect to be able to improve the policy making design process. The applicability of this idea is illustrated by different examples [10,11,12] from different perspectives and disciplines.

While we see the use of agent-based social simulations in these different use-cases we see no general approach for policy makers to use ABSS as design tool. A framework that uses ABSS in a policy design process enables policy makers to use this new approach in their work. The framework can also help the academic research field of social simulations, that is shared by many different disciplines, to further the understanding of ABSS and their application to policy development. This research project is sponsored by the Dutch Ministry of Economic Affairs and Climate Policy. As such we will focus on (socio-)economic and climate related policy development.

In this paper we will first describe the problem more thoroughly, define the problem domain and research field. We will reflect on the state of the art and the related literature. After this the research question and research method is considered together with the means to accomplish our goals. We conclude with the proposed approach for this research project and a short discussion on our expected contribution.

2 Problem Statement and Related Work

In the introduction we touched upon the complexity of policy making and the use of models to deal with this complexity. The ability to make models of reality is very powerful as it enables us to come up with solutions for problems that would otherwise be too complex or big to comprehend. But the use of models not only brings us bliss, it has its limitations as well. Models are created in the context of a perceived problem that manifests itself in reality; thus the model has a perspective, a point of view, a bias, a *context*. While the initial creators of the model mostly know the context of a model this context is often forgotten or ignored by other users. Especially when a model seems to be working well in the original context the attention for the context of the model is quickly lost.

The importance of context is easy to overlook when using seemingly good models, but will result in situations as shown in Fig.1. Here the initial model is created to take different aspects of problem A into account such that the generalizations in the model match the context of the problem. Once this model produces good results other users adopt it for their own problems. Only a part of the modeled aspects apply to problem B, resulting in a weak connection between the model and reality.

One of the reasons for this is the difficulty in having a good insight in the context, limitations and scope of a model. While policy development frameworks like the Dutch integrated impact assessment framework (IAK) [13] are used in the Netherlands to guide the general policy development process it is still hard to see
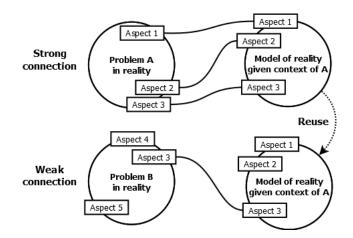
Fig. 1. A model with a strong or weak connection to reality depending on the context

the actual problems deep down in the used models to make such assessments. One could take the example of macro-economic models. These are based on micro-economic models that are based on *rational agents*. Unfortunately the core assumptions of rational agents can be questioned [8].

The existence and the challenge of this complex, context dependent, biased, world of models is voiced by academics and policy makers more and more often [14,6,15,9]. The current "state of the art" solution is the thought that more research needs to be done in the area of using ABSS for policy development [7].

In ABSS one is able to explicitly model goals and means of agents, representing humans. This could include interaction with other agents, changing preferences of an agent, ways of reasoning of an agent and much more. Depending on the context an agent can have different goals and means. This enables policy makers to add elements to the simulation given their own context. Other policy makers can add their insights, from a different context, to the same model. When we run the simulation the interaction between the different contexts can be analyzed by studing the agent's behavior.

2.1 Problem Domain, Research Field and Literature

Problem domain: Policy development We define our problem domain as "policy development", something that we have describe up to now as a complex process. While policy development cycles and other approaches are defined in literature, real policy development isn't as nicely structured. Yet some trends are visible despite the fact that each policy department (within Dutch ministries) has its own way of making policies. One trend that we see is the increased focus on quantitative analysis and evaluation, see [16] for an example from economics. Designing an ABSS forces a policy developer to articulate the problem and quantify it, thus improving the potential evaluation and the use of quantitative data. Another trend is the digitalization of society and government.

Research field: The social simulation community The idea of using ABSS for policy development is not a new one, but there has been no structured work on a general approach to use ABSS as a policy development tool. As such we identify the need for a framework that uses ABSS as a policy development tool. Others in the field of ABSS have identified this need as well [17]. Just like policy makers, the academics working with ABSS come from many different research fields. They come from, and this is very limited set, fields like computer science, economics, psychology, social science and philosophy. Each field works in a very different context and has different biases and goals. Yet all of them see ABSS as a promising topic. A framework for using ABSS for policy development could improve the understanding of other ABSS research and help the maturing of this research field.

This is also represented in the literature that should give us a better understanding of the current state of the art. As discussed the current status seems to be that the need for research in this direction is needed [4,7,9] and others are proposing similar approaches [17]. This could answer the need for new ways towards policy development [16,2,18,15] Recent published works such as "Simulating Social Complexity: A Handbook" [19,6] enables us to get quickly acquainted with the current techniques. Modeling and context importance is treated in [20,14] among others. Examples of ABSS like [21] can be further studied as well.

3 Research Question

Our main goal is to build a framework for policy development using agent-based social simulation design principles, this is reflected in *RQ2*. This framework will require a way to compare possible solutions to be able to say something about a proposed design, as stated in *RQ3*. Through answering *RQ1* we will gain the knowledge and tools needed to answer *RQ2* and *RQ3*.

In Section 4 we will use the research questions to formulate our proposed approach for this research project in order to answer the research questions.

– RQ1: What does the current policy design world look like? (Knowledge problem)
  • RQ1.1: How does the literature support the problem statement? (Knowledge problem)
  • RQ1.2: What would the goal be of a policy design framework? (Knowledge problem)
  • RQ1.3: Can we identify a useful use case for explorative work and validation? (Knowledge problem)
– RQ2: What does a framework for the design of agent-based social simulations for policy development look like? (Design problem)
  • RQ2.1: How can we characterize a problem that can be solved with ABSS? (Design problem)
  • RQ2.2: How can we characterize a type of ABSS design? (Design problem)

- RQ2.3: Can we match the characteristics of a problem with the characteristics of an ABSS in an *effective* way? (Design problem)
  - RQ3: How can we compare ABSS's? (Design Problem)
    - RQ3.1: How are ABSS evaluated? (Knowledge Problem)
    - RQ3.2: Is a general *measure* possible for the *quality* of an ABSS? (Knowledge Problem)
    - RQ3.3: Is a *richer* ABSS a *better* ABSS? (Knowledge Problem)
  - RQ4: Does the policy design framework improve the policy design process? (Knowledge Problem)
    - RQ4.1: What is the stakeholders' perception when using the policy design framework? (Knowledge Problem)
    - RQ4.2: Are context, bias, and perspective made more explicit by using the policy design framework? (Knowledge Problem)
    - RQ4.3: How do developed policies using the policy design framework compare to other policies? (Knowledge Problem)

Words such as *effective*, *measure*, *quality* and *richer* are all representations of the word *utility*. At this stage of the research project we know that these words are not accurate enough but also regard a straightforward interpretation far from trivial. Once we have a better understanding of the problem we will use more appropriate terms for them.
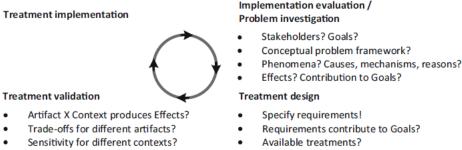
3.1 Research Method

For this research we conduct a design science project [22]. As such the research questions are categorized in knowledge questions (where we answer questions by *looking at* artifacts in a problem context) and design questions (where one *designs* an artifact to improve the problem context).

The design science engineering cycle in Fig.2 guides us in placing our research questions in the appropriate phases. We can place RQ1 and RQ3 in the problem investigation, RQ2 and RQ3 in the Treatment design, RQ4 in the Treatment validation phase. This guides us into the next Section (4) where we will discuss the approach of this research project using the design cycle.

4 Proposed Approach and Preliminary Ideas

Phase 1: Problem Investigation. In our stakeholder analysis we have identified policy makers as main stakeholders. Their goal is to develop improved policies in order to satisfy their own stakeholders, which can be numerous. At the same time some of these stakeholders can be directly involved with this research project: government management, operations management, policy implementers or politicians.

Another set of stakeholders are academics. They can further their insights in the applicability of ABSS for policy development and the comparability of ABSS.

Treatment implementation

Implementation evaluation /
Problem investigation

- Stakeholders? Goals?
- Conceptual problem framework?
- Phenomena? Causes, mechanisms, reasons?
- Effects? Contribution to Goals?

Treatment validation

- Artifact X Context produces Effects?
- Trade-offs for different artifacts?
- Sensitivity for different contexts?
- Effects satisfy Requirements?

Treatment design

- Specify requirements!
- Requirements contribute to Goals?
- Available treatments?
- Design new ones!

Fig. 2. Engineering cycle taken from [22]. The question marks indicate knowledge questions, and the exclamation marks indicate design problems.

We first plan to increase our understanding of the goals and needs of the stakeholders with two courses of action. First we continue our literature research on the following topics:

- Policy development
- Comparing problems and solutions
- ABSS design
- Framework design

But literature can not teach us everything. Next to literature review we will construct an ABSS toy case with Repast. This will be more informative as we get to experience what it actually means to build an ABSS. This also means that a deeper understanding of policy development is needed if we wish to apply the ABSS to policy development.

Phase 2: Treatment Design. During phase 1 of the research project we have started with some requirement gathering by learning more about the problems we face. We also expect to have learned more about the available treatments that might be applicable to our problem statement and use these to create our own policy design framework. The work in phase 1 will identify what the most interesting initial approach will be for the creation of the framework, RQ2. While working on RQ2 we will gather more information and insight for RQ3. RQ3 has a major impact on the effectiveness of the solutions made for RQ2.

To make the requirements more concrete we will select a use case with policy makers to use for the validation (phase 3).

Phase 3: Treatment Validation. We will test and validate the framework by designing a policy based on the use-case found during phase 1 and 2 using the policy design framework. The resulting policy and design process will be

evaluated with the policy making stakeholders and will provide input for RQ4. With this feedback we expect to be able to validate and improve the framework, as a good design cycle would do. The questions posed in RQ4 are still imprecise, we expect to learn what the important questions are during phase 1 and 2.

We do like to note that the three phases are part of the engineering *cycle*, as such we expect phase 3 to be input for a new phase 1 in this project and continue to cycle through these phases.

4.1 Preliminary Ideas

Now that we have recounted our approach for this research project we can discuss our preliminary ideas for a framework. In Fig.3 we can see a possible representation of the characteristics of a problem (or policy) and an ABSS (design process). Each of these have n aspects, approaches or characteristics that can be matched. The aspects can be modeled using ontological modeling which gives us a structured but flexible way of modeling. Each of the ontologies has its own context and creators, making it a social constructs. In the matching process we can compare (RQ3) a match with other matches and select the matching set that would be most useful for a problem.
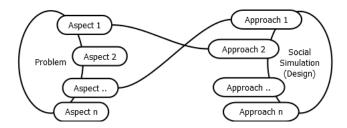

Fig. 3. Example of aspects of a problem that can be matched to certain design approaches. Each of these can have its own context.

To compare matchings we can use approaches like TraceME [23] for software comparisons (Δ-measurement). The analogy here is that both software and policies describe rules and interactions, especially if we represent a policy in an ABSS. With the TraceME approach we might also be able to answer RQ3 and its subquestions, but this is something we will discover during the research project.

For the use-case we are working with the ministry to find an interesting topic with a focus group. We will use an action research [22,24] approach for the use-case. Once a use-case is found and the development of the ABSS has started the plan is to work in a short cyclic manner to be able to adjust the direction of development quickly. This short cyclic way of working might be one of the aspects of the framework: if one finds a new aspect of the problem due to the design work done on the ABSS it might be best to choose a different design approach for this new problem aspect.

4.2 Means

In order to bring this research project to a successful end we have a number of means that are available to us. A hybrid civic servant and PhD-researcher position: my positions both at the Ministry of Economic Affairs and Climate Policy and Utrecht University enables us to easily use the networks of relevant experts in both the policy development world and the academic world. Supervisor expertise: the experience of Marcela Ruiz in Δ-analysis and the expertise of Frank Dignum in inter-disciplinary social simulations. Diverse personal background: while my main background is in computer science I also have a background in basic philosophy, social geography, urban planning and multiple advisory and management roles. This mix matches the diversity of the ABSS and policy design field.

5 Conclusion

In this paper we have elaborated on our current understanding of one of the problems at hand in the policy development world. ABSS seems to be well suited to deal with context dependency issues of policy development and as such we propose to use ABSS as a policy design framework. With this contribution we expect to improve the policy development process and the quality of policies. At the same time the framework can be used by other academics to gain more insight in the applicability for policy development for their own work on ABSS. This research project fits well in the current maturing process of the field of social simulations as it focuses on the applicability and takes a step back to look at the field of social simulations. I also like to thank my supervisors, Dr. Marcela Ruiz and Dr. Frank Dignum, for their continued advice and expertise.

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