Modelling norms and values

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Abstract

To create intelligent computers that exhibit human cognitive behaviour, it is beneficial to have a deep understanding of human cognitive processes. Decision-making is such a cognitive process. This thesis focuses on the modelling of social decision-making. With better modelling of social aspects like norms and values, scientists are able to gather more insights into complex social phenomena. A deeper understanding of social processes leads to better explanations of human behaviour, better policy making and better human-like autonomous agents with human-like behaviour. I reviewed several mathematical and computational modelling techniques from the perspective of modelling social processes. This thesis includes a discussion about their benefits and drawbacks regarding the modelling of social phenomena. Agent-Based Social Simulation (ABSS) is found as the best technique for modelling norms and values, mainly because it is able to capture the dynamics of social processes. The rest of the features of ABSS are then discussed and linked with an example study that models norms and values. Next, I used ABSS as a modelling technique for social aspects by replicating a model described in this study.

Keywords: norms, values, social behaviour, modelling techniques, agent-based modelling.

1. Introduction

Part of the research within the field of Artificial Intelligence is the making of machines that exhibit human cognitive behaviour [1]. The aim of this research is to create intelligent computers that act like humans. In order to achieve this aim, it is beneficial to have a deep understanding of human cognitive processing. One instance of such a complex cognitive process is decision-making.

There are a variety of factors such as values, personality, context, etc. which play a role in decision-making [2]. These factors are all in some capacity involved when making a decision. Because of the interaction between these factors, human behaviour can differ tremendously when situations are slightly different regarding one of the considered factors. This makes human behaviour highly complex and not fully understood. It has been the subject of study for quite some time, going back to philosophers in ancient Greece. The past decades have been a time of the introduction of many analytically, mathematically and computationally rigorous techniques within the sociology discipline. With these techniques, an attempt at modelling human behaviour is made. In this thesis, the focus lies on the modelling of two social aspects involved in decision-making processes: **values** and **norms**.

Value is a difficult concept to capture [3]. But, according to Schwartz [4], there is an accordance in the literature regarding the features which conceptually define a value. Figure 1 represents Schwartz's description of a set of formal features defining a value.

Following Schwartz's description of value, I take value as a particular type of internal evaluation [5] of the possible outcomes of decision-making processes [6]. Different values will prefer different actions in a situation (e.g. which transport to take to work). While the value is abstract (e.g. "wealth"), it is used as a guide for a broad spectrum of specific situations (e.g. cycling to

1. Values are beliefs
2. Values pertain to desirable end states or modes of conduct
3. Values transcend specific situations
4. Values guides selection or evaluation of behaviour, people and events
5. Values are ordered by relative importance to form a system of value priorities

Figure 1. Schwartz's description of a set of formal features which define a value [4].

work instead of taking a taxi). This aligns with the manner in which Cranefield *et al.* [6] used values in a model of agent behaviour. Cranefield *et al.* [6] defined "plan" as a possible course of action, and developed a mechanism which uses values to select between plans. In short, values were used to select between different possible courses of action. When determining how to act, an individual is influenced by (1) which values he prioritizes, and (2) how those values evaluate the different outcomes. Values are thus ordered by relative importance over other values. This value ordering characterises an individual.

Values have a prescriptive power when they are considered elements in the life of a group and its members [3]. When social individuals are discussing something (like a course of action, or state of the world), this will indirectly have an effect on their minds [3]. By communicating about what they perceive as "good" or "bad", social individuals are implicitly influencing, forming and defining the goals of their social group. If a norm dictates a goal, values are the reason an agent seeks to reach a goal [3].

Bicchieri [7] describes human norms as "*the language a society speaks, the embodiments of its values and collective desires, the secure guide in the uncertain lands we all traverse, the common practices that hold human groups together*". In short, norms are external standards within a group or society. According to Bicchieri [7], the extent of conformity to norms differs and can be subject to the types of norms. Dechesne *et al.* [3] differentiate between 3 types of norms:

- **Legal norms**: explicit rules of conduct a governing body imposes on a community. Also known as laws. Legal norms hold for the whole community.
- **Social norms**: implicit, dynamic norms which emerge among a subset of the group. Social norms are context dependent with fuzzy boundaries. According to Bicchieri [7], an individual will behave according to a social norm if (1) enough people in the group obey the rule and (2) enough people in the group expect and prefer the person to behave according to the rule, and may even sanction violations.
- **Private norms**: default standards of behaviour an individual holds for himself, which are called on when no social or legal norms apply to the situation. A private norm is a standard norm an individual holds for himself.

Following Dechesne *et al.* [3], I take norms to be social inputs which affect an individual's behaviour, depending on their values and the type of norm. These social inputs do not need to be in agreement with each other. A norm conflict is a situation where clashing norms are applicable. The existence of norm conflicts creates a breeding plumage for norm violations. The person needs to choose to comply with a subset of a conflicting set of norms, and by doing so, he violates the others. This results in complex normative behaviour.

An example of complex normative behaviour can be found in the extent of norm compliance when a ban against smoking in public places like restaurants was introduced. Norm compliance with the smoking ban differentiated enormously between countries. Dechesne *et al.* [3] investigated this smoking-ban as a case study in which they examined the complicated dynamics of normative behaviour in a nation. In this situation, people in a norm conflict have to decide to comply with a subset of the applicable norms and at the same time violate the other norms. Dechesne *et al.* [3] took the smoking ban as the introduction of a formal legal norm, which possibly clashes with different social norms. The study examined the relationship between culture (described by values) and norm compliance with the smoking ban [3]. A better understanding of the relationship between norm compliance and values will provide us with better insight into how people in different societies make decisions. This is not only beneficial for social science, but also for practical issues, like policy-making.

Thus, a better understanding of how social aspects like norms and values influence decision-making processes is important. Modelling is a way to gather more insights into a problem. Modelling can be done in quite a lot different ways. Each modelling technique has its benefits and issues. Not every technique is suitable for modelling a particular type of phenomenon. Therefore it is necessary to review which modelling technique is more suitable for the modelling of social phenomena.

This raises the main research question of this thesis: which technique is best suitable for modelling norms and values? This is relevant because equipped with the best suitable technique, scientists may be able to model the dynamicity of a society and the complex nature of heterogeneous individuals. These models could provide us with insights into the invisible forces which drive human social behaviour. With more accurate modelling of social aspects like norms and values, scientists have increased clarity in the workings of this social system. They are able to explain this social system more accurately and make better predictions about behaviour.

A better understanding of human social behaviour is also valuable within the field of Artificial Intelligence. Artificial agents will be able to act more appropriately in certain situations because the agent is better able to comply with the applicable social or legal norms. Thus, an artificial agent will be better able to uphold the societal and legal values of the society. The similarity in social behaviour between artificial and human agents will have a positive impact on the interactions between artificial and human agents.

To answer the research question, we need to know which techniques are used to model norms and values. The sub research question is thus: what are the techniques used for modelling norms and values? For this purpose, a subset of mathematical and computational modelling techniques will be reviewed from the perspective of social processes.

In short, this thesis aims to review which modelling technique is best suitable for modelling the social aspects norms and values. This thesis is structured as follows: the next chapter reviews various modelling techniques from the perspective of modelling social processes. Chapter 3 discusses the benefits and drawbacks of ABSS (the technique found most suitable for modelling norms and values) in further depth. In chapter 4, I describe my own implementation of a model involving norms and values described by Dechesne *et al.* [3]. The results are discussed in chapter 5. Chapter 6 discusses my findings and makes suggestions for further work.

2. Review of various modelling methods

Essentially, a "model" is a simpler version of reality that leaves out a large number of details in order to offer insights into a problem. This chapter focuses on some techniques used to model norms and values. It restricts itself to a subset of mathematical and computational modelling methods. The following techniques will be discussed: Structure Equation Modelling, Multilevel Modelling and Agent-based Modelling.

Mathematical methods

Mathematical social science is recognised as the subfield of sociology which applies mathematics to sociological problems. Mathematical sociology aims to express sociological theory (which is strongly intuitive but weak from a formal point of view) in formal terms. Statistics is used as an indispensable tool by quantitative sociologists, just as the application of linear models in order to establish relationships among variables. With these techniques, mathematical sociologists construct models to implement a theory about a social phenomenon.

Structure Equation Modelling

Structural Equation Modelling (SEM) is used to try to fit networks of constructs to data. SEM uses observable variables to attribute relationships between unobserved constructs (latent variables).[1] It does this by defining a measurement model that defines latent variables using observed variables, and by invoking a structural model that imputes relationships between latent variables. An example of the use of SEM applied to the modelling of norms and values can be found in the study of Ahmad, Bazmi, Bhutto, Shahzadi, and Bukhari [8]. Ahmad *et al.* [8] used SEM to analyse how different independent variables affected the recycling behaviour of students, with recycling behaviour as the dependent variable. Ahmad *et al.* [8] found people's attitude towards recycling to be largely subject to norms and values.

SEM as a mathematical modelling technique of social aspects is commonly justified in sociology because it's able to impute relationships between unobserved variables from observable variables [9]. SEM's ability to impute the relationship between unobserved variables and observed variables is valuable because social aspects like norms and values cannot be directly observed and measured. According to Hancock [9], it is a technique suitable to explore the influences and interdependencies of different parameters in a social process.

That being said, SEM can hardly represent all the non-linear interactions between units inside a complex social system. It is very difficult to formulate complex social processes as an equation. SEM is a macro modelling technique which views data as a structure that can be characterised by a number of variables. It is thus a modelling technique operating at system-level which uses

[1] *Unobserved, latent* or *unmeasured* variables are variables which cannot be directly observed (like "intelligence"), but need to be inferred from observed variables (like "SAT score").

aggregates. For this reason, SEM does not permit a substantial diversity of agents. Seeing as the complexity of the dynamics of social phenomena is the result of the interlocking behaviour of individuals [10][2], SEM is not the best technique for modelling social aspects like norms and values [11]. So, while SEM is suitable for modelling the averaged characteristics regarding a social phenomenon [11], [12], it is not able to capture the complex dynamics of social processes.

Multilevel Modelling

Multilevel modelling (MLM) is a statistical regression analysis method, which analyses parameters that vary at more than one level. A multilevel model consists of a series of equations representing the levels of analysis. By solving the equations, different kinds of results can be found. These results range from solely obtaining an average, to modelling differences within the dependent variable [13]. An example of the use of MLM applied to the modelling of norms and values can be found in the study of Baizan, Arpino, and Delclos [14]. Baizan *et al.* [14] assessed the extent to which completed fertility varies across countries. They applied MLM to individual-level data and country-level data. They found that to some extent, fertility levels can be predicted by the prevalence of gender-equity norms.

The group-based approach of MLM seems intuitive when modelling social aspects. After all, in the real world, individuals are embedded within groups like countries or regions. MLM is thus able to model contextual influences, which is an important factor in the decision-making process. Not to mention, the modelling of these contexts seems very logically and intuitively justified because the hierarchical structure of societies is well represented when using this technique.

Still, it is a purely mathematical modelling technique, which again views data as a structure that can be characterised by a number of averaged variables. MLM uses averages of critical system variables [11] This causes disadvantages in verisimilitude [11]. Even though individuals in real social systems are often highly heterogeneous, some level of homogeneity is assumed by averaging over individuals. This assumption obstructs the non-linear dynamics resulting from heterogeneity. These non-linear dynamics are important because they result in local variations from the averages, which can cause notable divergences in overall system behaviour.

While MLM recognises that the examined relationships among variables are caused by the interlocking behaviours of individuals, it has no explicit representation for these behaviours. MLM only implicitly describes these behaviours with equations that relate observables to each other. The modelling of the relationships between variables is thus the starting point, instead of the result of the modelling [11]. Because the individuals that cause small variations are not represented explicitly, local idiosyncrasies (which can significantly alter overall system behaviour) are lost. So, even though MLM is able to model the causality of parameters differentiating at different levels, MLM isn't the best suitable technique for modelling social aspects. Because, it is not able to fully capture the complex dynamics of social phenomena. At least, not in a way which is "simple" enough so we can understand, interpret and analyse it, as the equations would become intractable.

[2] Schelling found that how small decisions by individuals may seem, they often lead to significant unanticipated and unintended consequences for a large group.

Computational methods

Computational sociology is a subfield of sociology which analyses and models social phenomena using computationally intensive methods. It aims to develop and test sociological theory by modelling social interactions, using a bottom-up approach. Computational social science uses computers to model, simulate and analyse social phenomena. Many different techniques are used to construct models which implement a theory about a social phenomenon. Computational sociology focuses on social relationships and interactions in networks. Hereby, it aims to achieve a better understanding of social agents, the interactions between these agents and the influence of these interactions on the social aggregate.

Agent-based Modelling

Agent-based modelling (ABM) is a computational micro modelling technique used for simulating the actions and interactions of autonomous agents. Its main aim is to assess the effect of the agents on the system. This means it is able to have explanatory insight into the collective behaviour of agents which act according to a set of "simple" rules. The simultaneous actions and interactions of the agents in the model are an attempt at recreating and predicting the manifestation of complex phenomena. An agent-based model typically consists of a number of agents, learning rules, decision-making rules, a network structure which specifies interaction and an environment.

Agent-based Social Simulation (ABSS) is a modelling technique based on ABM. Whereas ABM is used in a wide variety of scientific domains, ABS is solely used for simulating social phenomena. Within an ABSS model, an agent represents a human individual or a group of humans. ABSS thus places artificial human-like agents in an artificial society, to observe the behaviour of the agents. An example of ABSS used as a modelling technique of norms and values can be found in the study of Dechesne *et al.* [3]. Dechesne *et al.* [3] used the agent-based modelling approach to model the relationship between culture (described by values) and the compliance with norms. The models showed that different societies (represented by agents with different value orderings) reacted differently to the introduction of the anti-smoking legislation.

The emphasis ABSS puts on interconnectivity is extremely valuable when modelling social aspects. Because, the complexity of social phenomena is much related with the interrelatedness of social encounters [10]. This makes ABSS a suitable technique for modelling social aspects: it is able to handle the relationships between possibly many parts of a social system. ABSS is able to represent agent interaction by modelling repetitive competitive interactions between agents, hereby exploring dynamics which cannot be examined by purely mathematical methods [15].

Unfortunately, this is also the cause of one of the major issues in ABSS. ABSS looks at a system at the level of its constituent units. This means it simulates the individual behaviour of every single constituent unit – which can be many. The simulation of all the constituent units can be very computation intensive. Consequently, the simulation can be very time consuming when modelling large systems. This issue is thus a practical issue. While computing power increases at a great pace, ABM requires significant resources when modelling large systems and this will remain a problem [16].

Overview of modelling techniques

Different modelling techniques are suitable for modelling different facets of social aspects. SEM may be your technique of choice when you're specifically focusing on discovering global relationships between latent variables which play a role in a social process. Or when you do not especially care to analyse the influence of social context or the influence of local interactions. MLM may be your technique of choice if the focus of your study lies specifically on group-based data. ABSS, however, is the best all-round technique for modelling social aspects like norms and values. By describing agent behaviour and analysing the patterns, it is not only possible to analyse relationships between latent variables and observables, but also to analyse group-based studies by specifying different types of agents (i.e, specifying different groups of agents).

Because ABSS is able to capture the dynamics of social processes (which are the root of the complexity of social phenomena), it is the most sound technique for modelling social aspects. Neither one of the discussed mathematical methods is able to do this in a way understandable and interpretable for humans. The equations would have to represent all the local interactions, the if-then statements for every possible (synchronous) interaction, etc. We would not be able to understand, interpret and analyse these equations. So, in theory, it would be possible to use mathematical modelling techniques, but it is not practical at all. See table 1 for an overview of the features of the discussed modelling techniques.

Table 1. Overview of features of SEM, MLM, ABM.

	SEM	**MLM**	**ABSS**
Constituent unit	Equation	Equation	Agent
System representation	Set of relationships between variables	Set of relationships between variables	Set of behaviours
Best used for	Analysing relationships between latent variables and observables	Analysing group-based data	Analysing phenomena marked by high complexity due to a lot of local interactions
Simulation level	Macro	Micro/macro	Micro

3. Benefits and drawbacks of ABSS

In the previous chapter, it was noted how ABSS is able to capture the dynamics of social processes. This is a huge benefit when modelling social aspects like norms and values. This chapter discusses the advantages and disadvantages of ABSS in further depth.

Emergence

When decentralized local interactions between heterogeneous autonomous agents cause a regularity, it is called emergence [17]. When it is possible that a phenomenon will become emergent, one may want to use ABM [16]. Figure 2 represents the situational properties which can cause emergence, according to Bonabeau [16]. Social processes exhibit these properties

1. Individual behaviour is nonlinear and can be characterized by thresholds, if-then rules, nonlinear coupling.
2. Individual behaviour exhibits memory, path-dependence, non-markovian behaviour.
3. Agent interactions are heterogenous and can generate network effects.
4. Averages will not work, because aggregate differential equations tend to smooth out fluctuations. This is not apt because fluctuations can be amplified under certain conditions, resulting in significant deviations from predicted aggregate behaviour.

Figure 2. Boneabau's list of properties which can cause emergence (Bonabeau, 2002)

[16], making social phenomena potential emergent phenomena. According to Epstein [17], ABSS is well-suited to model emergence because the following features are characteristic to ABM:

- **Heterogeneity**: ABSS allows for each agent to be modelled individually, as such permitting considerable diversity among agents, for example in biology, psychology, and demography.
- **Autonomy**. While there will be feedback from the macro-level to the micro-level, individual behaviour is not centrally ("top-down") controlled.
- **Explicit space**. ABSS manages to effectively model social and physical space. Because agents are able to interact in an explicit space, the context[3] which controls agent interaction can be modelled. Since the context is very important when determining by whom an individual is socially influenced, this is a very import feature and advantage for modelling social aspects.

Because an ABM consists of autonomous entities that pursue their own goals, they may act differently than expected [18]. It's precisely these irregular agent (inter)actions which cause (emergent) events and makes prediction of the overall system behaviour based on its constituent units very hard [18]. While ABM may be well suited for modelling emergent processes, this does not mean it is an easy task to construct a good model. Dense webs of interactions between a lot of agents have extremely complex dynamics and are in many instances chaotic. That's why some researchers argue that these webs should be avoided [19].

Natural representation

Parunak *et al.* [11] argue that because the individual is the natural unit of decomposition, ABM is suitable for modelling social processes. This differs from mathematical modelling techniques, which are better suited to processes where the observable or equation is the natural unit of decomposition [11]. Parunak *et al.* [11] argue that ABM is best used for modelling processes which are characterised by 1) a great amount of distribution and localization, and 2) discrete decisions. This description fits the sociological domain. Also, Parunak *et al.* [11] argue that because of the natural representation, the behaviour is fairly easy (at least, easier than with equations) translated back into practice. It is just a matter of translating the terms of the desired behaviours into policies/guidebooks/task descriptions etc.

[3] Shoham [20] defines this context as: "the specific form and structure of social networks and geography"

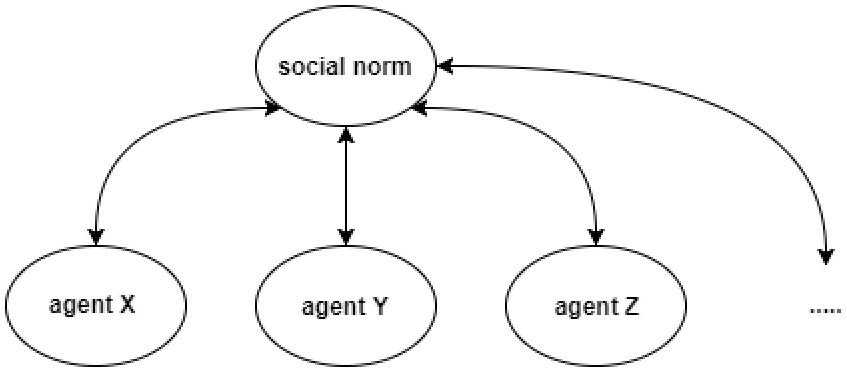

Figure 3. Example of a feedback loop between micro-behaviour and macro-outcomes. Agents are influenced by a social norm at time t, and contribute to changes in the state of the social norm at time t+1.

Feedback

Models constructed with ABM represent agents directly at the micro-level and capture dynamic changes at the macro-level. Because of this, ABM as a modelling technique permits the studying of co-evolving individual behaviour and context, in situations with reciprocal feedback [20]. ABM is thus able to describe two directions of feedback between micro-behaviour and macro-outcomes. Shoham *et al.* [20] give an example of agents being influenced by social norms. The model also captures how these social norms change because of the behaviour of the individual agents. So, a social norm can have an impact on an agent's behaviour at time t, and at the same time being shaped by the agent's behaviour (along with others) at time t+1. ABM is thus able to capture how social structures and systems which are the result of the activities and interactions among individuals, give feedback on those individuals. This is partly due to top-down emergent processes [21].

Flexibility

ABM is flexible along multiple dimensions: from adding more agents, to changing the agents rule-set, to changing the agent's degree of rationality, to altering the levels of aggregation or representation [16]. This freedom is very valuable if you don't know up front how complex the model needs to be. Also, the flexibility of ABM provides opportunity for more direct experimentation [11]. By playing "what-if" games, desirable behaviour can be tested and analysed.

Validation

Bonabeau [16] argues that one may want to use ABM when expert judgement is critically important for the validation and fine-tuning of the developed model. According to Bonabeau [16], a lot of the times ABM is the best way of describing the real-world situations. As a result, the experts in the area of research are better able to connect with the model.

Another advantage is the extra level of validation which ABM provides. Both mathematical techniques as computational techniques are able to validate models at system-level by comparing the output with the real world system data. ABM however, provides not only macro-level validation but also micro-level validation. Researchers are able to compare encoded agent behaviour with the real-life behaviour of the underlying physical entities [11]. So, ABM makes it not only possible to monitor and verify the effects on macro-level, but also to monitor and verify the effects on micro-level. One drawback is that more detailed and complex encoded behaviour results in longer code. Longer code is possibly more prone to representational error compared with the typical equations in mathematical modelling.

One issue with validation is that the field of social simulation does not yet have standards for model comparison and result replication [17]. Epstein notes it is important to have standards for reporting assumptions and procedures. Having set standards like how agents need to be updated in different kinds of models, would be greatly beneficial to the field of social simulation. Another issue with validation is the difficulty of verifying results. Verification is difficult because of the heterogeneity of the agents and because it is possible that unexpected macro patterns will emerge which are caused by micro behaviour [18].

Interdisciplinarity

Most social processes do not consist of wholly separated subprocesses whose isolated analysis can be meshed together to get a correct analysis of the whole system. However, this is precisely the manner in which the field of sociology is organized [16]. Social science is divided into departments like anthropology, demography, etc. According to Bonabeau [16], there is an agreement among social scientists that this division is artificial. But, it is also agreed upon that no "natural methodology" exists which can study all these processes together, seeing as they interact which each other. However, Bonabeau [16] argues that ABM is a very natural technique which is well-suited for this purpose. Because, ABM provides possibilities to model an entire artificial society with links to demography, economics, environment effects, etc. As Epstein [17] puts it: "*Because the individual is multi-dimensional, so is the society.".*

4. Example study: aim, interaction scenario, simulation design

I used ABSS as a modelling technique for social aspects by replicating the first model described in the study of Dechesne *et al.* [3]. This study has been discussed in chapter 1 and 2 but will be discussed in further depth in this chapter. First, the aim of the study will be discussed. Second, I will discuss the interaction scenario of the model and why ABSS is a suitable modelling technique for this scenario. After that, the simulation design of the model will be discussed.

Aim and link to reality

The aim of the study of Dechesne *et al.* [3] is to model the relationship between culture (in terms of values) and norm compliance. In order to link the model results with real data regarding the smoking prohibitions in different countries, it is necessary to postulate a connection between the modelled culture and culture in real life.

Dechesne *et al.* [3] model culture in terms of values. In the first model, Dechesne *et al.* [3] model culture by using a norm type preference as a structure meant to abstract from values (this structure will be explained later in further depth). Dechesne *et al.* [3] suggest some possible relations between these norm type preferences and Hofstede's cultural dimensions [22]. Hofstede [22] characterised a framework for culture, in which he identified six dimensions along which a culture can be characterised.

Dechesne *et al.* [3] suggest some possible relations between Hofstede's dimensions and the norm type preference. These relations are the link between the known characterisation of culture and the norm type preferences. With this link, the results can be analysed and compared with real data regarding the smoking prohibitions in different countries. The result of the simulation can thus be linked to the reality of the outcomes of the smoking bans in different countries.

Interaction scenario: ABSS is a suitable technique for this scenario

Dechesne *et al.* [3] modelled a system consisting of a population of agents, interacting in an environment which represents a public venue like a café. An agent is characterised by a set of values and an ordering over these values. This ordering determines their actions regarding their location and their smoking-behaviour. The aim of the study is related to the social perception of smoking in public areas. This social perception is subject to the social constraints imposed by other agents (i.e, social norms), or the law (i.e, a legal norm). Altogether, this study is an excellent example study of the modelling of values and norms.

So, the simulation models values and norms. The two key requirements which are needed for modelling the norms and values described in the brief interaction scenarios are:

- ❖ Agents need to have their own private value ordering. As discussed in chapter 1 and in the interaction scenario, individuals are characterised by their value orderings. So, the heterogeneity of the society and agents needs to be represented. From a practical point of view, the value orderings also need to be able to be configured easily and quickly when a different society needs to be examined.
- ❖ Social norms need to be able to be derived from the agents *at the public venue, at a given time*. As indicated before, social norms emerge among a subset of the group. In this particular case, this means that they are location-specific and time-specific.

These requirements are met. The first requirement is met because ABSS allows for the modelling of heterogeneous agents and because ABSS allows for flexibility in trying different scenarios. The second requirement is met because explicit space can easily be modelled.

This interaction scenario demonstrates the importance of behavioural modelling when modelling values and norms. The modelling of behaviour is important because the behaviour of an agent is both influenced internally (through his values) and externally. After all, the agent is externally influenced by the behaviour of other agents by taking into account the external current social norm. As the behaviour of an agent depends on other agents, agent behaviour cannot be clearly defined with equations. The complexity of differential equations grows exponentially as the complexity of behaviour grows [11]. Equations will become intractable.

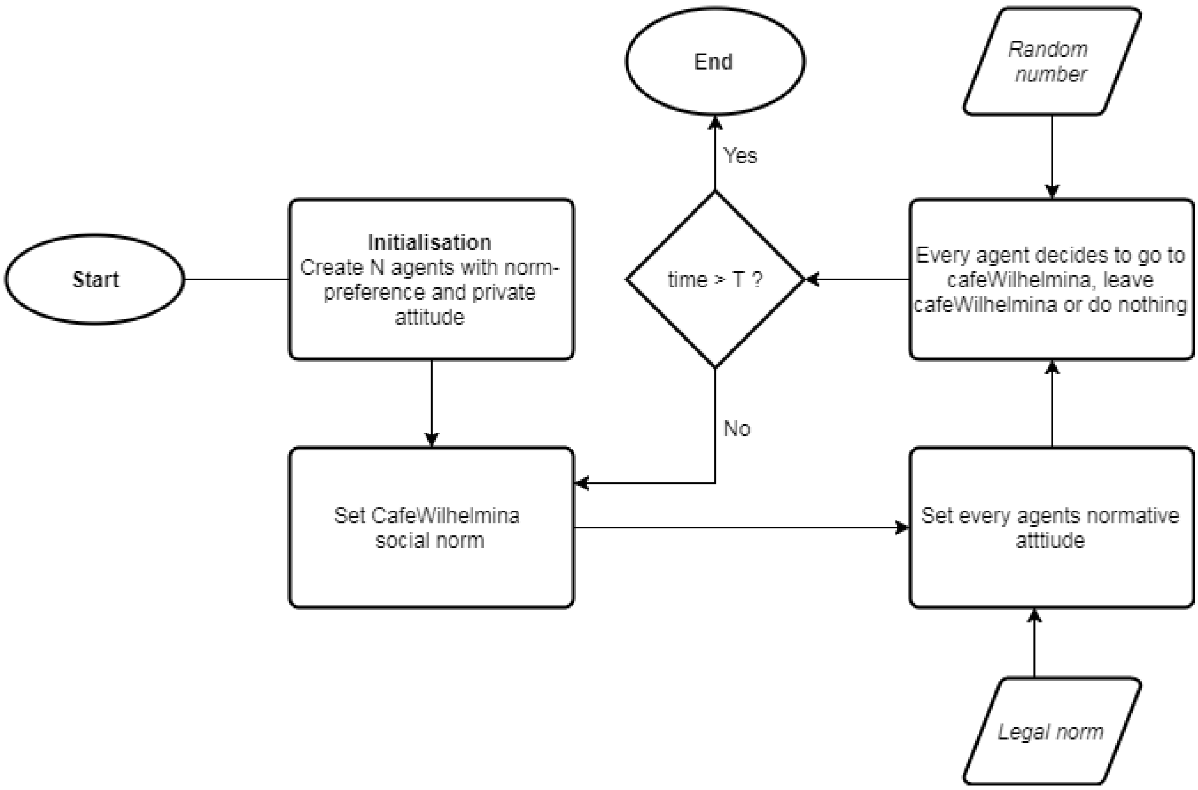

Figure 4. Visualisation of the model developed by Dechesne *et al.* [3].

Simulation design and implementation

Following the description of the first model, I have developed an environment "CafeWilhelmina" that simulates a group of people that visit a public venue regularly. Every agent can either be visiting the café or not. Besides their presence in the café, every agent is characterised by a private attitude regarding smoking in public, a preferred norm type and a normative attitude against smoking (this term will be defined later). The model is also visualised as a flowchart in figure 4.

As mentioned earlier, the environment has a social norm and a legal norm. The social norm makes smoking in public either socially acceptable or not. The legal norm either allows or prohibits smoking in public places. The social and legal norm are set every clock tick. The social norm is set to smoke-positive when more than half of the agents present in the café have a smoke-positive normative attitude (algorithm 1). The legal norm allows smoking during the first half of the simulation and prohibits smoking the second half of the simulation.

Algorithm 1: set social norm

Input: **int x =** accepting agents in cafeWilhelmina, **int y** = agents in cafeWilhelmina

```
if (x > y/2) then
        SN <- smoke
else
        SN <- not-smoke
end if
```

So, every clock tick during the simulation, the cafés social and legal norm are set. Following, the agent's normative attitude is set. A normative attitude is determined by the agent's norm preference and either the legal norm, the social norm or his private preference against smoking, as described in algorithm 2. Next, the agent decides to go to the café, leave the café or stay wherever he is. His behaviour depends on the current social norm, the agent's normative attitude and some probabilities which are described in the parameters section (algorithm 3). Both algorithm 2 and algorithm 3 are executed synchronously for each agent.

Algorithm 2: set agents normative attitude towards smoking

Input: **SN** = social norm, **LN =** legal norm, **A** = agent

```
if norm-pref(A) == lawful then
    if LN == smoke-negative then
        norm-attitude(A) <- LN
    else
        norm-attitude(A) <- private-preference(A)
else
    if norm-pref(a) == social then
        if in-café(A) then
            norm-attitude(A) <- SN
        else
            norm-attitude(A) <- private-preference(A)
        end if
    else
        norm-attitude(A) <- private-preference(A)
    end if
end if
```

Algorithm 3: agent decides to go the café, leave, or stay wherever he is

Input: **norm SN** = social norm, **int C =** agents in venue, **int Csp =** smoke-positive agents in venue, **A** = agent, **double PGN** = probability an smoke-negative agent goes to venue, **double PGS** = probability an smoke-positive agent goes to venue, **double PGL** = probability an agent just leaves, **double r** = random double between 0 and 1

```
if (not(in-café(A))) then
    if (normative-attitude(A) == smoke and r < PGS) then
        in-café(A) <- true
    else
        if (normative-attitude(A) != smoke and r < PGN) then
            in-café(A) <- true
        end if
    end if
else
    if (r < PL) or normative-attitude(A) != SN then
        in-café(A) <- false
    end if
end if
```

The agent's norm preference is assigned in the initialisation phase. For simplicity, the agent only has 1 preferred norm type instead of a whole preference order on the three types. This preference structure is meant to abstract from values. Values are thus not used directly. The preference regarding which norm he considers the most important is a guide for his behaviour:

1. Lawful norms → the agent is law-abiding. Hence, when the legal norm prohibits smoking, this agent will have a smoke-negative normative attitude. In the other case, the agent is free to follow his private attitude.
2. Social norms → the agent acts the same as most of the agents present in a shared context. The agent has the same normative attitude as the current social norm.
3. Private norms → the agent acts according to his own beliefs. This means the agent acts according to his private attitude against smoking.

The agent's private attitude against smoking is randomly set at initialisation. So, a private attitude is either smoke-positive or smoke-negative with 50% chance. Both the agent's private attitude and norm preference are never changed during the simulation!

The effect of the smoking prohibition is measured by the average number of clients in the café and the number of those clients that have a smoke-positive normative attitude. These two measures are measured at the end of every tick and regarded as the output of the simulation.

Just as Dechesne *et al.* [3]., I have implemented this simulation scenario with the Repast simulation toolkit [23].

An agent is characterised by these parameters:

- Private attitude – their personal attitude towards smoking in public (either smoke-positive or smoke-negative), randomly assigned at initialisation with 50% chance
- Norm preference – which norm type they would primarily follow, assigned at initialisation (either legal, social or private)
- Normative attitude – their behavioural attitude towards smoking, set at every clock tick
- In-café – whether they are in the café or not, initialised with *not(inCafe)* and after that set at every clock tick

Other parameters:

- N = 100, the amount of agents
- T = 200, the amount of clock ticks per run. A clock tick does not correspond with real time but is imaginary in this sense
- LawT = 100, the tick when the smoking ban is enacted
- LegalNorm – either smoke-positive or smoke-negative. It is initialised at smoke-positive and changes to smoke-negative when T >= LawT
- SocialNorm – either smoke-positive or smoke-negative, set at every tick depending on the behaviour of the current clients present in the café
- PGN = 0.15, the probability that agents with a smoke-negative normative attitude visit the cafe
- PGS = 0.45, the probability that agents with a smoke-positive normative attitude visit the cafe
- PL = 0.25, the probability an agent just leaves the cafe

5. Example study: results

I ran the simulation with different norm preference distributions. Each distribution varies in the percentages of agents with a certain preferred norm type. Each population composition model has been ran 20 times. The averages of the bar attendance over these 10 runs are discussed in this chapter. The three norm preference distributions that represent a uniform society will be discussed first and in depth. In the private society, every agent has a private norm preference. In the lawful society, all agents have a lawful norm preference. In the social society, every agent shares a preference for the social norm. After that, the results of the mixed societies, in which not every agent shares the same norm preference, are discussed.

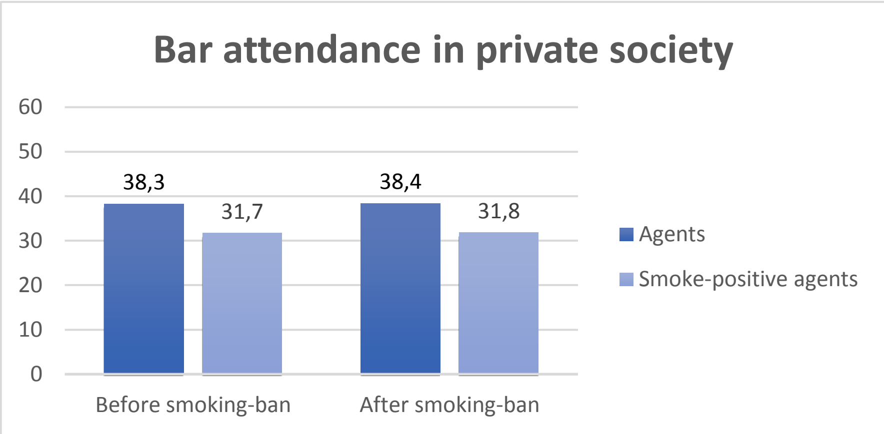

Figure 5. Average bar attendance of the private society, before and after the introduction of the anti-smoking legislation.

Private society

In a society where every agent is private, the smoking ban doesn't have any impact. This corresponds to Dechesne's *et al.* [3] conclusion that in societies without any lawful agents, the introduction of the law will have no effect.

Figure 5 shows the averages of the bar attendance at the café. The left column in the graph shows the situation before the introduction of the anti-smoking legislation. The right column shows the situation after the introduction of the smoking ban. Every agent follows his private attitude, so around half of the agents have a smoke-positive normative attitude and the other half is against smoking. Because smoke-positive agents are three times more likely to go the café, more smoke-positive agents are present at the café: this results in the social norm being smoke-positive. An accepting social norm will make smoke-negative agents leave the café almost immediately because their normative attitude does not match the social norm (see algorithm 3 described in the previous chapter). As a result, the café population exists of smoke-positive agents, as can be seen in figure 5.

As expected, no significant changes occur when a smoking ban is introduced in a society where every agent has a private norm preference. Every agent will continue to behave according to his own private attitude regarding smoking, so the change of the legal norm does not have any impact. These results match up with the results obtained by Dechesne *et al.* [3], except their averages are a little bit higher. The general trend, however, is the same.

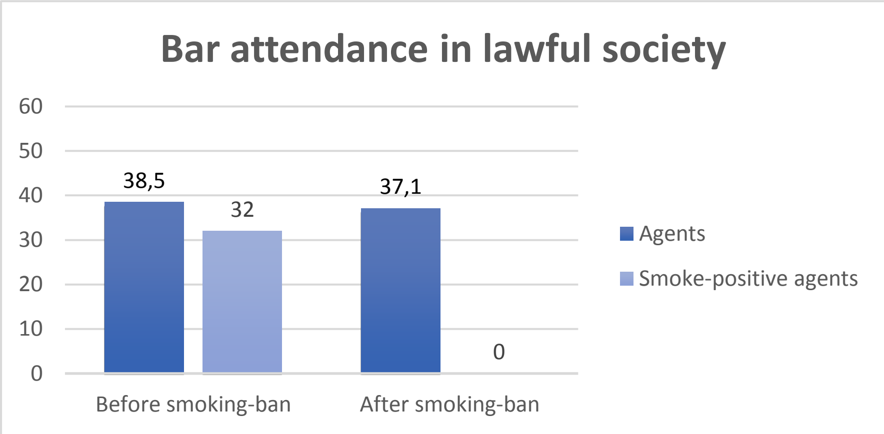

Figure 6. Average bar attendance of the lawful society, before and after the introduction of the anti-smoking legislation.

Lawful society

In a society where every agent is lawful, the smoking ban does have an impact. After the smoking-ban has been introduced, bar attendance drops slightly and zero smoke-positive agents are present. This can be read from figure 6, which represents the bar attendance before and after the introduction of the smoking prohibition.

Before the ban, an agent's normative attitude corresponds to his private attitude. The agent is free to follow his private beliefs because smoking in public is permitted. The bar attendance before the introduction of the anti-smoking legislation is thus similar to the bar attendance in the private society.

After the introduction of the smoking ban, the normative attitude of every agent is consistent with the legal norm. Because smoking is prohibited, the society contains only agents with a smoke-negative normative attitude. Smoke-negative agents are three times less likely to go to the café, so you would expect a great drop in bar attendance. However, this is not the case. As described by Dechesne *et al.* [3], because the social norm now always matches the normative attitude of the agents, no agent will leave unless they are bored. This is a huge contrast when compared to the situation before, where half of the population leaves the next clock tick after entering the bar.

Both in my result and the result of Dechesne *et al.* [3], the café composition before the smoking-ban exists largely out of smoke-positive agents. The proportion of accepting agents and total agents is also in accordance. Although in both results, zero accepting agents are present in the bar after the smoking-ban, there is a difference in the shift of the bar attendance.

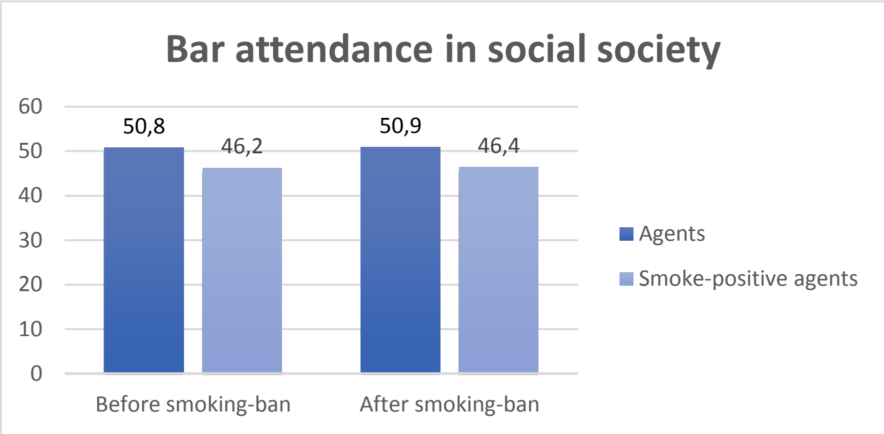

Figure 7. Average bar attendance of the social society, before and after the introduction of the anti-smoking legislation.

Social society

In a society where every agent is social, there is no significant change in bar attendance when introducing an anti-smoking legislation. This can be read from figure 7. This again corresponds to the conclusion of Dechesne's *et al.* [3] that in societies without any lawful agents, the introduction of the law will have no effect.

Figure 7 shows the averages of the bar attendance at the café. Just as in the private society, the introduction of the smoking ban has no effect, because no agent's decisions depend on the state of the law. Instead, decision-making only depends on the social norm (when present at the café) and the agent's private attitude (when not present at the café). Because smoke-positive agents are more likely to go to the café, the social norm is set to smoke-accepting at the first clock tick. This results in a vicious circle where the agents will adapt their normative attitude to the social norm, which will result in this normative attitude becoming the social norm, and so on. The venue will thus have a smoke-positive atmosphere from the very beginning.

A social agent will always adjust his normative attitude during the next clock tick before he has to make decisions regarding his location. As a result, no one in a social society will leave the café because he does not feel comfortable at the venue. So, individuals in a social society will only leave because they are bored. This explains the high average amount of agents present at the café.

My result again differs from the result of Dechesne *et al.* [3]. The bar attendance obtained by Dechesne *et al.* [3] is a little bit higher, and it only consists of smoke-positive agents, while in my results an average of 5 smoke-negative agents is present at the café. The presence of some smoke-negative agents is explained earlier: agents adjust their normative attitude at the next clock tick after arriving at the venue. The smoke-negative agents are thus "newcomers" with a smoke-negative private attitude who have not yet had the time to adjust their behaviour according to the social norm. Because it takes time before an agent has accustomed himself to the social context, they are briefly measured as smoke-negative agents present at the café.

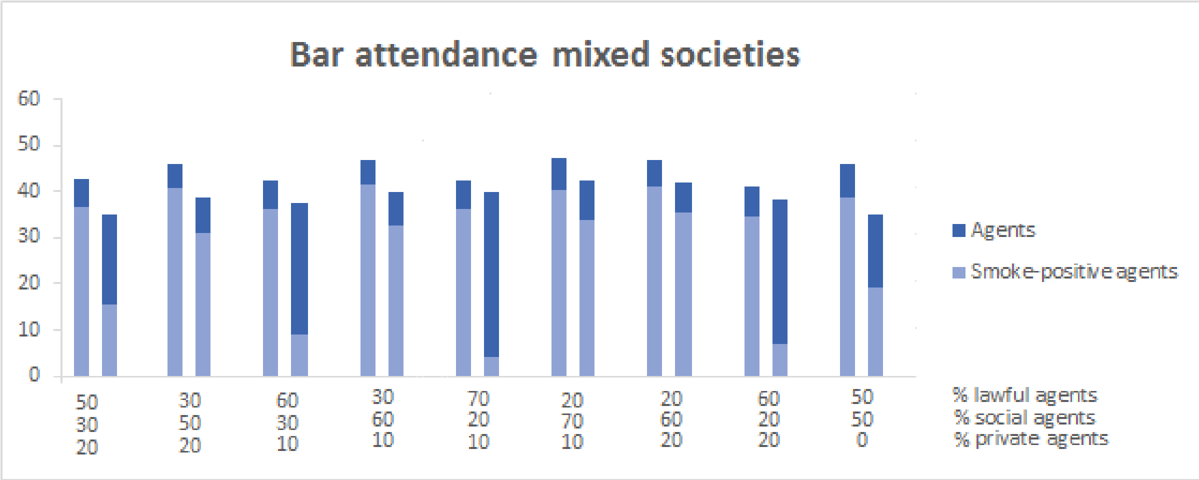

Figure 8. Average bar attendance of societies with different compositions. The bar attendance of every society is represented with two bars. The left bar represents the bar attendance before the smoking ban, and the right bar represents the bar attendance after the introduction of the anti-smoking legislation.

Mixed societies

Figure 8 shows the averages of the bar attendance in societies comprising different proportions of the agent types. The percentages of the agent types can be read from the x-axis. The general trend and shift in bar attendance of the results match with the results obtained by Dechesne *et al.* [3], except the results of the societies with a majority of lawful agents.

In these results, the bar attendance after the introduction of the smoking ban is considerably lower than in the results of Dechesne *et al.* [3]. This difference can be explained by the difference in the results of the lawful society, seeing as it was also observed in the result of the absolute society comprising only lawful agents. Because the societies are mixed and contain agents who are not lawful, the difference is less extreme than in the absolute lawful society.

6. Conclusion

The main research question this thesis tried to answer is: which technique is best suitable for modelling norms and values? The sub research question is: what are the techniques used for modelling norms and values?

So, in order to answer the main research question, I reviewed a subset of mathematical and computational modelling techniques which are used for modelling norms and values. Both the benefits as the drawbacks of these modelling techniques were discussed. Overall, ABSS was found to be the most appropriate technique for modelling norms and values. This is due mostly to its ability to capture the complex dynamics of social processes. ABSS is able to capture this complex dynamicity because it provides a natural representation of the system by modelling heterogeneous autonomous agents in an explicit space.

ABSS has some issues, however, mostly regarding validation. Validation is difficult because of the heterogeneity of the agents and because it is possible that new, unexpected macro patterns will emerge which are caused by micro behaviour. Also, no standards for model comparison and result replication have been established yet. Future work is needed to establish these standards, including standards for reporting assumptions and procedures.

To show which features of ABSS are key when modelling social aspects, I linked them with a practical example of modelling norms and values. This practical example of the modelling of social aspects is a study of Dechesne *et al.* [3], which involves the modelling of norms and values to examine the relationship between culture and norm compliance. ABSS proved to be a well-suited modelling technique of norms and values.

During the writing of this thesis, I started to realise the importance of not only considering *what* you are doing, but *how* you are doing it. The tools one uses may have notable effects on the results, for example in the kind of information you can gather from them. It is thus important to research the methods that are out there and find the best suitable technique. Armed with the best possible tool for your purpose, you are able to gather the best possible results, whatever the purpose may be. And in the case of modelling norms and values, I think ABSS is the best technique you could use.

7. References

[1] Russel, S.J., & Norvig, P. (2009) 'Artificial Intelligence: A Modern Approach'. New Jersey: Prentice Hall.

[2] Ferrell, O. C., & Gresham, L. G. (1985) 'A Contingency Framework for Understanding Ethical Decision Making in Marketing'. In: *Journal of Marketing*, 49(3), pp. 87-96. doi: 10.2307/1251618.

[3] Dechesne, F., Di Tosto, G., Dignum, V., & Dignum, F. (2013) 'No smoking here: Values, norms and culture in multi-agent systems'. In: *Artificial Intelligence and Law*, 21(1), pp. 79–107. doi: 10.1007/s10506-012-9128-5.

[4] Schwartz, S. H. (1994) 'Are there universal aspects in the structure and contents of human values?'. In: *Journal of Social Issues*, 50(4), pp. 19–45. doi: 10.1111/j.1540-4560.1994.tb01196.x.

[5] Miceli, M. & Castelfranchi, C. (1989) 'A Cognitive Approach to Values'. In: *Journal for the Theory of Social behaviour.*

[6] Cranefield, S., Winikoff, M., Dignum, V., & Dignum, F. (2017) 'No Pizza for you : Value-based plan selection in BDI agents'.

[7] Bicchieri, C. (2006) 'The grammar of society: the nature and dynamics of social norms'. New York: Cambridge University Press.

[8] Ahmad, M. S., Bazmi, A. A., Bhutto, A. W., Shahzadi, K., & Bukhari, N. (2016) 'Students' Responses to Improve Environmental Sustainability Through Recycling: Quantitatively Improving Qualitative Model'. In: *Applied Research in Quality of Life*, 11(1), pp. 253–270. doi: 10.1007/s11482-014-9366-7.

[9] Hancock, G. R. (2003) 'Fortune Cookies, Measurement Error, And Experimental Design'. In: *Journal of Modern Applied Statistical Methods*, 2(2), pp. 293–305. doi: 10.22237/jmasm/1067644980

[10] Schelling, T. C. (2006) 'Micromotives and Macrobehavior'. New York: W. W. Norton & Company.

[11] Parunak, H. V., Savit, R., & Riolo, R. L. (1998) 'Agent-based modeling vs. equation-based modeling: A case study and users' guide'. In: *Proceedings of Multi-agent systems and Agent-based Simulation MABS 1998*, pp. 10–25. doi: 10.1007/10692956_2.

[12] Davidsson, P. (2000) 'Multi Agent Based Simulation: Beyond Social Simulation'. In: *Multi-Agent-Based Simulation* pp. 97–107. doi: 10.1007/3-540-44561-7_7.

[13] Nezlek, J. B. (2008) 'An Introduction to Multilevel Modeling for Social and Personality Psychology'. In: *Social and Personality Psychology Compass*, 2(2), pp. 842-860. doi: 10.1111/j.1751-9004.2007.00059.x.

[14] Baizan, P., Arpino, B., & Delclos, C. E. (2016) 'The Effect of Gender Policies on Fertility: The Moderating Role of Education and Normative Context'. In: *European Journal of Population*, 32(1), pp. 1–30. doi: 10.1007/s10680-015-9356-y.

[15] Axelrod, R. (1997) 'The Complexity of Cooperation: Agent-Based Models of Competition and Collaboration'. Princeton: Princeton University Press.

[16] Bonabeau, E. (2002) 'Agent-based modeling: methods and techniques for simulating human systems.'. In: *Proceedings of the National Academy of Sciences*, 99 (suppl. 3), pp. 7280–7287. doi: 10.1073/pnas.082080899.

[17] Epstein, J. M. (1999) 'Agent-based computational models and generative social science'. In: *Complexity*, 4(5), pp. 41-60.

[18] Li, X., Mao, W., Zeng, D., & Wang, F. (2008) 'Agent-Based Social Simulation and Modeling in Social Computing'. In: *Intelligence and Security Informatics*, pp. 401–412. doi: 10.1007/978-3-540-69304-8.

[19] Gotts, N. M., Polhill, J. G., & Law, A. N. R. (2003) 'Agent-based simulation in the study of social dilemmas'. In: *Artificial Intelligence Review*, 19(1), pp. 3–92. doi: 10.1023/A:1022120928602.

[20] Shoham, D. A., Hammond, R., Rahmandad, H., Wang, Y., & Hovmand, P. (2015) 'Modeling social norms and social influence in obesity'. In: *HHS Public Access*, 33(4), pp. 395–401. doi: 10.1038/nbt.3121.ChIP-nexus.

[21] Conte, R., Edmonds, B., Moss, S., & Sawyer, R.K. (2001) 'Sociology and Social Theory in Agent Based Social Simulation: A Symposium'. In: *Computational and Mathematical Organization Theory*, 7(3), pp. 183–205. doi: 10.1023/A:1012919018402.

[22] Hofstede, G. (2003) 'Cultural Dimensions'. Available at: https://www.geert-hofstede.com/cultural-dimensions.html.

[23] 'Repast Organization for Architecture and Development' (2003). Available at: http://repast.sourceforge.net.