Agents with Social Norms and Values

A framework for agent based social simulations with social norms and personal values

Agenten met sociale normen en Waarden

Een raamwerk voor agent gebaseerde sociale simulaties met sociale normen en persoonlijke waarden

(met een samenvatting in het Nederlands)

Proefschrift

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Abstract

Social norms govern collective behaviour by guiding individual behaviour in the absence of a central enforcing authority, which makes them powerful self-regulating mechanisms for societies. This is in stark contrast to policy or legislative norms - also targeted at governing behaviour in society - which are issued by a central authority who also then needs to enforce compliance. Enforcing compliance is expensive. Also, these norms might come into conflict with existing social norms, which causes issues. It is therefore not surprising that much research is aimed at understanding existing social norms around behaviours connected to important issues like health or climate change. Designing policy that piggybacks on existing norms to promote behaviour is faster and cheaper than using the classic carrot-and-stick approach of most policy design.

The modelling community has invested quite a bit of effort into developing normative frameworks, models and simulations. Yet, very little of this effort has been directed towards the study of the norm life-cycle. Besides, these research efforts have omitted **explicit** representation of norms and the assessment of norm stability and reactivity in the face of some environmental changes. Values as a stabilizing factor, must be considered while studying the reactivity and stability of social norms. Without such **stabilizing elements**, modeled norms react swiftly to any change **in the environment and are mere behavioural patterns rather than social norms**.

In this thesis, I use values as drivers of behavioural choices, and Schwartz's theory of abstract values **as a basis**. As these values are very abstract, there is a need to translate them to more concrete values and assign behavioural choices to them. A theory or methodology for this step has not been developed in a way that is widely applicable. Thus, a precise way of such a translation is necessary for practical purposes. I designed a practical but formal framework that can be used to study the value-driven behaviour of agents in social

simulations. I showed how this formal design can be used in practice to implement multi-agent simulations. Then, I continued with proposing a social norm framework that is focused on finding an explanation for norm dynamics - their emergence, perpetuation, and eventual disappearance. I operationalized the framework by way of a multi-agent simulation in the context of environmental change and absence of sanctions for deviant behaviour. I showed that the values are an intuitive stabilizing factor that allow norms to persist through changes in the agents' environment and perpetuate and spread even in the absence of punishment. A norm will, however, change, evolve or disappear altogether if it becomes impossible to perform or if the value priorities of the agents change. I explained the norm dynamic and its strong connection to values by implementing various multi-agent simulation scenarios.

Summenvatting

Zonder centrale autoriteit kunnen sociale normen collectief gedrag sturen door hun consistente invloed op individueel gedrag. Dit maakt normen krachtige, zelfregulerende mechanismen voor samenlevingen. Dit in tegenstelling tot regels en wetten die zijn afgevaardigd door een centrale autoriteit zoals de overheid. Wetten en regels zijn ook gericht op het besturen van gedrag, maar de naleving daarvan moet door de overheid worden afgedwongen. Handhaving van regels en wetten is duur en kan bovendien inconsistent zijn met bestaande sociale normen, wat voor problemen kan zorgen.

Het is dus vanzelfsprekend dat veel onderzoek gericht is op het begrijpen van bestaande normen rondom gedrag dat te maken heeft met belangrijke maatschappelijke vraagstukken zoals gezondheid en klimaatverandering. Het is immers efficiënter en goedkoper om beleid te ontwerpen dat aansluit of bouwt op bestaande normen, dan beleid te ontwerpen op basis van alleen straffen en belonen.

De sociale simulatie gemeenschap heeft veel moeite gestoken in het ontwikkelen van normatieve kaders, modellen en simulaties. Echter, slechts een klein deel van dit onderzoek omvat ook de studie van de levenscyclus van normen (hoe ze onstaan, onderhouden worden en weer verwijnen). Bovendien behandelt dat onderzoek ook niet de expliciete representatie van de normen en de evaluatie van de stabiliteit en reactiviteit van normen als de context verandert. Om deze dynamiek van normen te verklaren zijn volgens ons waarden als stabiliserende factor in het onderzoek naar reactiviteit en stabiliteit van normen noodzakelijk. Zonder dit soort stabiliserende elementen zullen gemodelleerde normen reageren op elke verandering in de omgeving en verworden tot gedragspatronen in plaats van echte normen.

In dit proefschrift gebruik ik waarden als drijfveren van gedragskeuzes en Schwartz's theorie van abstracte waarden. Omdat deze waarden erg abstract zijn, moeten ze eerst vertaald worden naar meer concrete waarden en dienen er bepaalde gedragskeuzes aan toegewezen te worden. Voor deze stap is nog geen methodologie of theorie ontwikkeld die breed toepasbaar is. Daarom is een exacte wijze van vertalen noodzakelijk voor praktische doelen. Ik heb een praktisch, maar formeel kader ontworpen dat gebruikt kan worden in onderzoek naar waarde-gedreven gedrag van individuen door middel van sociale

simulaties. Ik heb laten zien hoe dit formele ontwerp ook in de praktijk kan worden gebruikt om sociale simulaties te maken. Daarnaast heb ik een kader voor sociale normen ontwikkeld dat zich concentreert op het verklaren van de dynamiek van de normen. Ik heb dit kader geoperationaliseerd door middel van een simulatie voor visserij management in tijden van klimaat verandering en afnemende visstand. Ik heb laten zien dat waarden een intuitieve stabiliserende factor zijn die er voor zorgen dat normen zich aanpassen maar blijven bestaan gedurende veranderingen in de omgeving (zoals verlaagde stand van de vis). De normen blijven en versprijden zich ook zonder expliciete straffen bij overtredingen. Normen veranderen of verdwijnen echter als de prioriteiten van de waarden veranderen (als bijvoorbeeld milieu belangrijker wordt) of als het onmogelijk is om aan de normen te voldoen (als bijvoorbeeld het inkomen zo laag wordt dat donaties voor het dorpsleven onmogelijk worden). Deze aspecten van norm dynamiek en de relatie met de menselijke waarden worden door middel van een stel verschillende multi-agent simulaties uitgelegd.

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بی تکبر بدهد هر چه که دارد هستی   درس آموز ز استاد گر عالم باشد

Samaneh, August 2022

Contents

1

Introduction

1.1 Introduction

COVID-19 was officially declared a pandemic in March 2020. Our lives have been significantly impacted by the Pandemic. In order to combat the COVID-19 outbreak, significant behavioural change was required. Governments all over the world began to take additional rules to slow down the virus's spread. People in different countries reacted differently to the new restrictions and policies, based on a variety of factors such as personal values, social norms, culture, government-citizen trust, official attitude, among others. Persons in the Netherlands, for example, quickly adopted the "1.5 meter distance," "wearing a mask in public," and "not visiting people in critical health conditions," but only 42% of the population adopted the "10 times a day hand washing" at the start of the pandemic (1). The reaction to vaccination, whether voluntary or obligatory, differs as well. According to a study, people of various ages in Italy, India, and China reacted to social distancing in different ways depending on the social structure of each country (2).

COVID-19 entered a new phase with the introduction of the vaccine. With the exception of a small group of anti-vaccination activists, many countries purchased vaccine in advance and had their populace immunize themselves against the virus on time. Some nations, such as Iran, prohibited the import of vaccines (3, 4) despite strong public demand. Tourists in Armenia were entitled to a free vaccination. As a result, more Iranian travelled to Armenia to get approved vaccines (5). To stimulate the tourist business, Armenia established a new rule requiring visitors to stay in Armenia for at least 14 days in order to receive a free vaccination. The new rule was supposed to benefit the tourism business by allowing visitors to stay longer in the country. Instead, they received more homeless individuals on the streets, which was the exact opposite of what they expected! What is the possible explanation for this? There is a disparity in personal values between vaccine tourists and other tourists. Vaccine tourists did not come to Armenia to have fun; they did not have the financial means to stay in hotels for two weeks. People from all different levels attempted to save the bare minimum of funds in order to provide their family with a vaccination tour. The new rule failed to achieve its purpose as the big difference between vaccine tourists and other tourists was not considered in it.

This example demonstrates that legislation is merely one of many factors influencing people's behavior. To ensure that a policy works as intended, it is important to analyze the elements influencing individual and societal behavior of those who must adhere to, such as social structure and economic conditions. In light of Schwartz's value system, which I will go over in more details in coming chapters, the "Security" value of vaccine tourists was severely breached, and they seek to make amends. It was so important to preserve their lives, even if it meant paying the price of being homeless for a short period in another country, despite their genteel poverty norm, which was a powerful social norm for Iranians. Policymakers could improve the issue by revoking the free vaccine rule for tourists or eliminating the need of a minimum stay in their country to receive a free vaccine.

The effects of a policy that goes against individual values and social norms, such as vaccine tourists, are not always straightforward to repair. Some of the repercussions may linger for a long time and may not be reversible. Individual transferable quota (ITQ)-based fishery management, for example, was adopted and made transferable in Iceland in 1990 with the purpose of ensuring a sustainable and profitable fishery. Rather from achieving the original goal, it resulted in the disappearance or depopulation of fishing villages as fishermen sold their shares for a variety of reasons, including the social structure, personal values of locals, economic position and ecological issues.

In this thesis, I use fishery management use cases to study values and norms and their connection to policy obedience. I use the examples of local quota for healthy fishing. Similar to the given examples above, we see in the fishery communities that they have their own community, they have their own norms and personal values. When a new policy is employed without considering the social context of the community, the outcome of the policy would be unexpected and might have irreversible side-effects. Therefore, it is important to study personal values and social norms and how those affect personal and social behavior of a society.

Fishery management use case is chosen since I received funding from the European Union's Horizon 2020 Framework Programme Marie Skłodowska-Curie (MSC) - ITN - ETN programme (project 642080) for this research. The program, named Social Aspects of Fisheries 2021 (SAF21), focused on EU fisheries, a complex system, to develop effective fisheries management strategies.

Many rules have been introduced for fishery management, however, in local level these rules worked differently. Central monitored behaviour mechanisms, such as rules, policies and regulations, will not change the behaviour unless the social structure phenomena such as norms and values are considered. The social structure phenomena have indirect impact on society. In the absence of a central enforcing authority, social norms govern collective behavior by directing individual behavior, making them powerful self-regulating mechanisms for societies. Governing behaviour in society - which are issued by a central authority - needs enforcing compliance. Not only central enforcement is costly, but also it may collide with current social norms and causes further problems. As a result, in many cases, designing a policy that takes into account existing norms to encourage certain behaviors would be a more cost-effective and faster solution than using the classic rewarding/punishment approach. As a result, many study efforts are focused on interpreting existing norms around behaviors related to important problems like health, climate change adaptation, natural resource management, etc.

1.2 Problem

The aim of policy-making is to create formal rules that people will obey, resulting in the intended collective outcome. The quality of policy design can be improved by taking into account unknown aspects such as social norms and values and providing explanations for a scenario. Such an explanation can be obtained through the modeling and simulation of norms and values. The concept of norm emergence has been studied, however, it is primarily used to describe the establishment of new norms based on individual preferences and punishments on violations. However, the study efforts have omitted implicit representation of norms and assessing norm stability and reactivity in the face of some environmental changes. Values, as an stabilizing factor, must be considered while studying the reactivity and stability of social norms. Without any stabilizing elements, modeling norms may react swiftly to any change. Many norms, on the other hand, are rather constant over extended periods of time because they are linked to fundamental values, which are by their nature common throughout groups of people and quite stable over a person's lifetime. Many agent models that include norms, on the other hand, do not include norm dynamics. Norm in these models are static structures that constrain behaviour in predetermined ways. In chapters 6 and 7, I will go through the formal definitions of values and norms, as well as how they are interconnected.

1.3 Research Questions

In order to develop an explanation for a normative behavior in a society that would benefit policy-making, I am interested in studying social norms, their emergence, transformation, stability and responsiveness, and how they affect personal decisions as well as their impact on societal level behavior. Studying norm emergence helps the decision makers introduce a policy as a social norm in a society. In addition, before introducing any policy, studying the existing norms and how the desired policies might adjust or conflict with them will benefit in the implementation of policies that are more in line with the social structure of that society. Also, studying the disappearance of norms assists authorities in eliminating detrimental norms from society.

I concentrate on the following concerns, which remain unanswered despite significant research efforts devoted to modeling and simulation of social norms in decision-making.

- **What is the factor that plays a part in determining a guiding principle for decisions or defining the boundaries of a person's behaviors?**
  It is the micro level behavior of people that shapes the macro level of a society. The micro level behavior is a decision that a person makes based on some personal factors, social factors, and environmental factors. Even though all the factors might change, there is one factor that is stable and keeps decisions following the same guideline; that factor is "personal value" which is part of the personality and remains quite steady over the lifetime. Without such a stable factor, no norm would exist and no culture would last long as people would be fully reactive to any changes in their environment. Values are closely linked to norms, according to Dechesne et al., and should be modeled along with norms in order to achieve genuine normative behavior (6).

  What is intriguing about the usage of values is that there is a universal set of abstract values that can be given to people. People differ not because they have different values, but because they prioritize those values differently. The Schwartz values are defined in the most abstract way possible, including all of the essential values of every human being on the planet. I will explain what has been done before in Chapter 2. Numerous research projects have relied on modeling values and value systems, such as Schwartz's value system. Those models, however, do not take into account the relationship between compatible and opposite values in the Schwartz value circle.

- **How does a social norm emerge in a society?**
  Discussions about how norms emerge are still open research questions among sociologist (7). For policymakers, the necessity of studying norm emergence, what causes it, what the process is, and whether it is predictable is important to take into account. Policy-makers would be better served by promoting a behavior through social norms as opposed to expensive centralized enforcement and surveillance. A social norm against smoking, for example, can reduce smoking far more effectively than smoking bans, increased tobacco taxes, and harsh punishments. Lighwood et. al reported the success of "The California Tobacco Control Program" - a programm that worked on building sustainable social norms against tobacco use rather than increasing tobacco tax (8).

  Agent models are making their own contribution to this ongoing research effort. There are many simulations and models studying norm emergence (see, for example, (9)). In Chapters 2 and 3, I will investigate existing models and simulations of social norms. In most cases, norms in existing simulations and models are implicit predefined rules that serve as constraints on the behavior of the agents. As a result, agents in such systems are unable to establish new norms that have not been preprogrammed into the system.

- **What factors keep norms stable in the face of environmental changes?**
  I explain this question with a brief example. Tax evasion is a major concern for fiscal authorities. Tax evasion is a social norm in some countries. One method to avoid tax evasion would be to increase the penalty for tax avoidance. In many countries, however, people find various techniques to avoid taxes that are not as easily identified or punished. Even when there are policies that penalise those who do not obey them. The question is what makes a social norm like tax evasion persist in society?

  Stability is another norm attribute that lacks a well-understood mechanism in research attempts. Agent models which represent norms as fixed constraints (10, 11, 12)) cannot help in finding an answer because their norms are stable by default. More flexibility is afforded by models which have norms triggered by environmental conditions, a mechanism which does create more dynamics in the system. I will explain more about the existing models and simulations in Chapter 2 and 3. In summary, the social norms that have been modeled and simulated so far are entirely reactive to the environment, but real-world social norms display relative stability across a wide range of environmental conditions.

- **What prevents norm violations in the absence of sanctions for violators?** Overall, men account for 65% of smokers, whereas women account for just 35% of smokers (13). There is no law prohibiting women from smoking, and hence no legal consequence for women who do choose to smoke. It is partly because smoking is not socially acceptable for women, especially in Asian countries that have a bigger gender disparity when it comes to smoking rates. There is also a difference in personal value between men and women, which makes women less interested in smoking, even if society is slowly moving towards treating men and women smokers equally.

  Research in sociology has shown that norms may and do exist in the absence of reinforcing rewards or penalties. Nonetheless, most agent models that contain norms include some type of utility-based decision making for adhering to/violating the norms. As a result, since there is no (obvious) consequence for violators of social norms in reality, these models cannot replicate social norms properly.

- **How does a norm disappear?** Communication using landline was a norm for a long time before the mobile phone invention. Using mobile phones instead of landlines became a norm due to its benefits. Here the norm of using landlines started disappearing while a new norm of using mobile phones started emerging. Disappearance is part of norm dynamics. In the same way that it can be beneficial to encourage the establishment of a standard, it can also be beneficial for a norm to disappear, perhaps to be replaced by a more fitting one.

  There is no set timescale for the elimination of a social norm, thus the first solution seems to be dissolving a social norm if it is no longer "useful". In most earlier norm simulations, if specific criteria are met in the system, the norms will disappear. For investigating the transformation and disappearance process, these simulation attempts are unsuitable. Studying the disappearance process and components involved in triggering norm disappearance is what I am interested in pursuing.

1.4 Overview

Given the fact that some of the above problems have been discussed in the literature (which will be discussed in chapter 2), the supplied models and simulations are either overly simplistic or only provide partial answers. Several definition exist for personal values and social norms. I will explain which definition has been chosen and why in chapter 3. Moreover, further background information related to the social norms has been explained in that chapter.

Because values serve as the foundation for all decisions and are thus connected with social norms study, I will begin my research by studying personal values. In chapter 4, a simulation of a fisheries village with fishers of two distinct values is presented to examine the influence of value distribution of fisher on fish population (ecology) and the village overall turnover (economy). Furthermore, how ecology and economy will affect each other and how those are affected by the social structure of the village (value distribution) are described. Chapter 4 is based on our publication (14).

Then, in Chapter 5, I show that economy, ecology, and social systems together comprise a complex system that affects each other with infinite feedback loops. In this chapter, social system contains only the individual values. In this system personal values are steady over time for each person (agent). The social system dynamics will be represented by promoting or degrading the priority of different values according to the conditions. When the environment is safe, for example, a person who highly values the environment, has a lower priority for universalism. The importance of universalism is not diminished, but rather the priority of satisfying universalism is. Chapter 5 and 6 will address the difference between a value's importance and its priority. These chapters are based on two publications (15, 16).

I employed the Schwartz value system, which is a well-known theory in personal values that has been implemented by numerous researchers. Using Schwartz values entails translating abstract values into concrete ones that are relevant to the case study. The fact that there is no standard means of employing Schwartz values and transforming them from generic to concrete values is a significant gap. A formal framework of personal values will be introduced in Chapter 6. This formal framework includes the relationship between Schwartz' values for each agent, allows the researchers to interpret actions from generic values, allows them to use this value implementation in the decision-making process of each agent, and offers the possibility of making a model for micro and macro analysis. This framework can be used as a reference for researchers that are interested in studying, modeling, or implementing values. In addition, it allows them to reuse prior efforts in terms of values that are made based on this framework.

After building the groundwork for values, I incorporated norms into the process. Chapter 7, which is based on our publication, published in Multi-Agent-Based Simulation workshop (17), examines norms as the embodiment of individual values. In this chapter, I study norm stability and how norms will be obeyed even without a central monitoring element for disciplining the violators. I will provide several simulations to demonstrate how values make norms resistant to minor changes in the environment, how values cause the emergence of new norms, and how values lead the transformation of one norm to another, in chapter 7. These simulations assist me in constructing a normative framework which will be discussed in chapter 8. In this framework, norms are explicit and yet not predefined in the system. Since norms and values included in the framework are interdependent, norms are not totally reactive to all changes. In other words, norms might endure, evolve, arise, or completely disappear, and analyzing all of these processes are possible using this framework.

2

Related Work

Humans are fundamentally social creatures and hence employ social concepts as a main concept according to Hofstede (18). In other words, social phenomena are part of our thinking. Since the goal of the study is to investigate the mutual effects of micro-level decisions and macro-level system behavior, social factors must be considered in studying decision-making and system behavior. I am particularly interested in investigating social norms, as they play a crucial role in governing all human societies (19). Even in the absence of a central monitor, social norms can regulate all human decisions and actions (20).

A substantial amount of research work has been devoted to constructing models, architectures, and theories about social norms in decision making. The focus of these studies on social norms, however, is on norm reactivity rather than norm stability. To put it another way, in these studies, social norms are completely reactive to environmental changes, and there is no element driving norm stability. The missing factor in the previous research on social norms is considering personal values and their connection to social norms.

Studying the reactivity and stability of social norms cannot be effective without taking into account personal values. As a result, I need to investigate personal values, their definitions, and the models and simulations that incorporate them into their research. Then I explore social norms, their definitions, their life-cycle, their connection to personal values, and the existing models and simulations that incorporate them. There are various methods to model social phenomena like social norms and personal values. Therefore, I need to research various modeling techniques in order to target the one that allow us to efficiently study values and norms.

2.1 Personal Values

A widely accepted definition of personal values is represented by Schwartz et al. (21, 22). They proposed ten basic values according to the universal needs of humans. They proposed this value system based on a huge survey, conducted on more than 60.000 individuals in 64 nations. The Schwartz values are defined in the most abstract way that includes all the core values of every human all around the world. Values and value systems, such as Schwartz's value system, have been used in many research efforts to explore the behavior of a complex system, studying human argumentation, managerial decisions, land-use behavior, adaptation to climate change (6, 23, 24, 25).

For example, we studied the effects of individual values of a society on the general behavior of a complex system (including society, ecology, and economy) (15). Bench-Capon et al. (26) show that promoting different values will lead to different arguments. Dechesne et al. (6) investigate how personal values (and other social phenomena) affect the behavior of people when introducing a smoking ban rule. Mercuur (27) categorizes the usage of values in regard to doing an action into three main categories; pre-condition, post-condition, and deliberation navigator. In other words, values might be used as a measurement function to evaluate an action (post-condition), values can be used as a motivation to do an action (pre-condition) (28), and they can be used for justifying a decision of doing an action (29, 30). Weide (30) provides a formal model that can be used for modeling value-compliant decision making. He shows how to form concrete values out of actions that can influence the abstract values.

2.2 Social Norms

Social norms are part of our daily life. We follow norms every day without noticing them. We follow norms and expect others to follow them. Social norms regulate our behavior without any central monitoring. Of course, there are some norms that eventually appear in the law. For these norms, it is clearly and explicitly defined in which situation the norm applies and what would be the punishment in case of violation. These norms are called legal norms. For example, there is a detailed law about adopting a child, or establishing a company, etc. My focus is on social norms that are not always explicitly defined. For example, smoking in the house in front of parents is not illegal but will not be acceptable in many families.

Computer scientists investigate norms in virtual environments through models and simulations. Building a model or a simulation helps explicitly present and study the assumptions and details related to an issue, as well as related implications (31). In this section, I discuss existing research on social norms, with an emphasis on their study in computer science. This section covers norm definitions, categories and life-cycle which I take from sociology and philosophy since these fields provide more insight into the social nature of social norms compared to their computational interpretations in computer science. From here, I discuss existing computational normative models and algorithms, they way they address questions regarding norms, and why they fail to give complete answers.

2.2.1 Norm definition

Norms have numerous definitions across the fields that study them, each definition emphasizing aspects that are relevant to the originating discipline. Bicchieri believes that sociologists have not agreed upon a common definition (19). I start with exploring the well-known definitions in the following. These definitions have been used as a basis for developing simulations and models.

✓Bicchieri defines norms from a philosophic point of view as “the language a society speaks”. Social norms can be defined as group agreements. Therefore, there must be a connection between individual members of a group and social norms. Bicchieri defines norms as “the embodiment of its values and collective desires of a society” (32). According to her definition, norms are behavioral rules supported by shared expectations about what should (not) be done in different situations. She refers to the behaviors as actions that people have control over them. According to her, behavioral rules will be triggered in particular social situations. Her definition gives us a clue about how norms are connected to other individual characteristics (values and desires).

✓Schwartz argues that a collection of abstract values is linked to a set of specific norms for concrete situations (33). He believes that values are abstract concepts and norms are externalization of values. This characterization of values and norms is consistent with Bicchieri’s definition of norms as “embodiments of values”.

✓Habermas as a philosopher and sociologist defines norms as a generalized expectation of behavior (34). This definition seems similar to what sociologist specify, “shared expectations” of “cultural (shared) definition of desirable behavior” (35), when defining norms.

✓The definition of norms represented by Cialdini as a social psychologist together with Trost stress norms as “rules and standards that are understood by members of a group, and that guide and/or constrain social behavior without the force of laws. These norms emerge out of social interaction with others; they may or may not be stated explicitly, and any sanctions for deviating from them come from social networks, not the legal system" (36), etc. According to Cialdini and Trost definition, norms exist without enforcing them by laws which is induced as a central authorization. Considering these definitions, the social situation in which norms are applicable and the individual understanding of social norms are important.

To develop a framework that can be used to build models that would be useful to researchers from many disciplines with their own specific viewpoints, I would need a definition of norms that is broader than - and encompasses - the ones presented above. Such a definition is presented by Gibbs which is one of the most completed definitions of social norms discussed in (37). He mentions several aspects of social norm in his research which includes all the points mentioned above from other researchers:

- Norms are agreements of group members
- Norms regulate behaviour
- Norms are group expectations about what should or should not be done in specific circumstances
- Norms are based on cultural values
- Norms are abstract patterns of behaviour
- Norms are alternative ways to achieve goals

While this definition is quite broad and help me to formalize norms, there are still some aspects of social norms that are missing. These definitions do not directly answer my questions about how a norm emerges, transforms, and preserves over time. I will cover these in the sections 2.2.2 and 2.2.3.

2.2.2 Norm categorization

Descriptive vs injunctive:
Cialdini and Trost differentiate between descriptive and injunctive norms (36). Descriptive norms refer to what people observe others doing in specific circumstances. A descriptive norm is what most people do. In other words, it is what a person assumes as normal behavior in a certain situation considering everyone else's behavior. Based on this definition, descriptive norms provides information for a personal decision about what a person ought to does (not) or what is more efficient behavior in a certain situation. An injunctive norm is a constitute expectation about what each member ought to does (not) in a certain

situation. In other words, injunctive norms refer to what people think others should do in specific circumstances.

External vs internal pressure:
Cialdini and Trost also categorize norms into subjective and personal (36). Subjective norms refer to behaviour that a person feel others expect of them. Personal norms are behaviours a person expects from themselves. In other words, perceived external vs internal standards of behaviour.

Social scope:
Dignum (38) splits norms into three levels based on the number of participants in the social interaction the norm regulates. From most to fewest, these are: social, interaction, and private.

Purpose:
Categorizing norms by purpose is fairly common. For instance, norms have been described as constitutive (new classifications of abstract facts and entities or institutional facts), regulative (ideal and sub-ideal behaviour comprising obligations, prohibitions and permissions), and procedural (allocation of rewards, costs and risks within a social system) (37, 39, 40, 41).

Each of these categories describe some additional features of social norms. Taken together with all the features presented in the definition above, these features determine the micro level and macro level effects and dynamics of the norm.

2.2.3 Norm life-cycle

Understanding the life cycle of a norm and the definitions of each stage of the life cycle is essential to find the answers of my questions about how a norm emerges, transforms, and preserves over time. The complete life-cycle of a norm has been studied in depth. Its overall structure, which is common to most research on the subject, is presented in figure 2.1. A more detailed description can be found in (42), which presents an overview of different interpretation of the norm life-cycle and comes to the conclusion that, except for terminology, the research identifies the following stages in the life of a norm: emergence (the introduction of a new norm), adoption (the norm is adopted by the agents), internalization (the norm is internalized by the agents), and disappearance (the norm dwindles and is forgotten).

For a different take on the stages a norm can go through during its life time, see Hollander and Wu's interdisciplinary review of the subject (43). According to them, the normative stages include: creation, transmission, enforcement, internalization, and disappearance. They mention forgetting as part of the norm life cycle based on the literature; though, they did not consider that in their model.

Hollander and Wu also describe emergence as the process of going through creation, transmission, enforcement and internalization, and evolution as the process of the complete normative life-cycle, from creation to disappearance. Their definition of creation, transmission, enforcement, internalization, and disappearance is explained in the following:

Transmission refers to the way that norms spread through society from one agent to another agent. Enforcement is the way some agents enforce other agents to adopt and follow a norm. Enforcement includes that agents have recognized norms and sanction violations. Norm recognition might be modeled in different ways such as observation and interactions. An agent must accept it and might modify the norm before internalizing it. During the acceptance and modification phase, the agent will consider his personal desires. If a norm is completely against his desires, he might reject it. According to Hollander and Wu's investigation, there is not much attraction to study norm internalization except for some limited works. In those works, there are two approaches about norm internalization. One approach is to internalize a norm when the group model matches the self-model. The second one is to internalize a norm when the agent has no concern about following the norm.

Norm creation is the process of introducing a norm to a system. Emergence of a norm contains transmission, enforcement, and internalization of a norm. Emergence of a norm can be explored in both micro scale and macro scale of a norm creation. Hollander and Wu categorize studying approaches of norm emergence in multi-agent systems literature into three categories: game theory, the relation between sanction and emergence, and impact of transmission on emergence.

Norm disappearance is the process of disappearance of a norm. Frantz and Pigozzi give a more completed overview of different norm life-cycle models (42). Despite a bit difference in the terminology of naming various phases, the main norm life cycle contains the stages shown in figure 2.1.

Social norm models and implementations

I am not the first researcher who described normative frameworks, of course. Some groundwork was done in (44, 45, 46, 47) and I will discuss it further in this section. I am looking for models of social norms that can cover the whole life-cycle of a norm, without making norms completely reactive or completely stable, models that can provide the possibility of implementing norms explicitly. However, there are some characteriza-

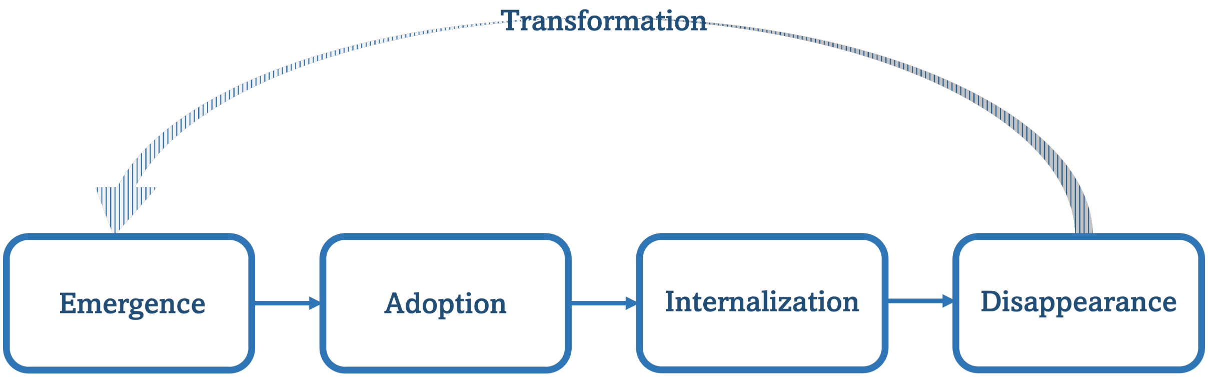

Figure 2.1: Block diagram of individual decision making process.

tion of social norms that are not covered by the existing normative simulations, models, frameworks, and software architectures.

While norms can be modelled in many different ways, I will focus on agent-based models and simulations because this approach allows a much richer representation of norms, their dynamics and their effects on the people and their environment. Of particular interest are the ways norms are functionally represented in existing models, as well as the agent decision making process. For instance, norms as constrains to filter pro-norm actions (48), norms adopted to fit in collaborative behaviors (49), norms used statically to prioritize actions and goals (50), norms adopted without sanctions by reasoning about the consistency of norms (51).

One of the more common approaches to including norms in an agent model is to represent the norm as a predefined rule that agents follow or not, depending on circumstances (e.g. see (12, 52)). In keeping with the classification presented above, these norms would fall under internalized or personal norms. The goal of these models is to study the collective impact of a norm in the system, and, as such, they are not concerned with capturing the dynamics of the complete norm lifecycle. However, as mentioned previously, different norm life stages can have different effects, which means different collective behaviours can emerge depending on how mature a norm is or behaviours can vary greatly over longer periods of time. These models cannot account for any of this. At the same time, many of these type of models use sanctions to enforce the norms. While this is not necessarily wrong, it does not account for norms that are followed/violated despite the lack of mechanisms to enforce one or the other (53).

An agent based architecture that takes matters a step further is EMIL-A introduced by Andrighetto et al. (54, 55). In EMIL-A, both micro level and macro level effects of a

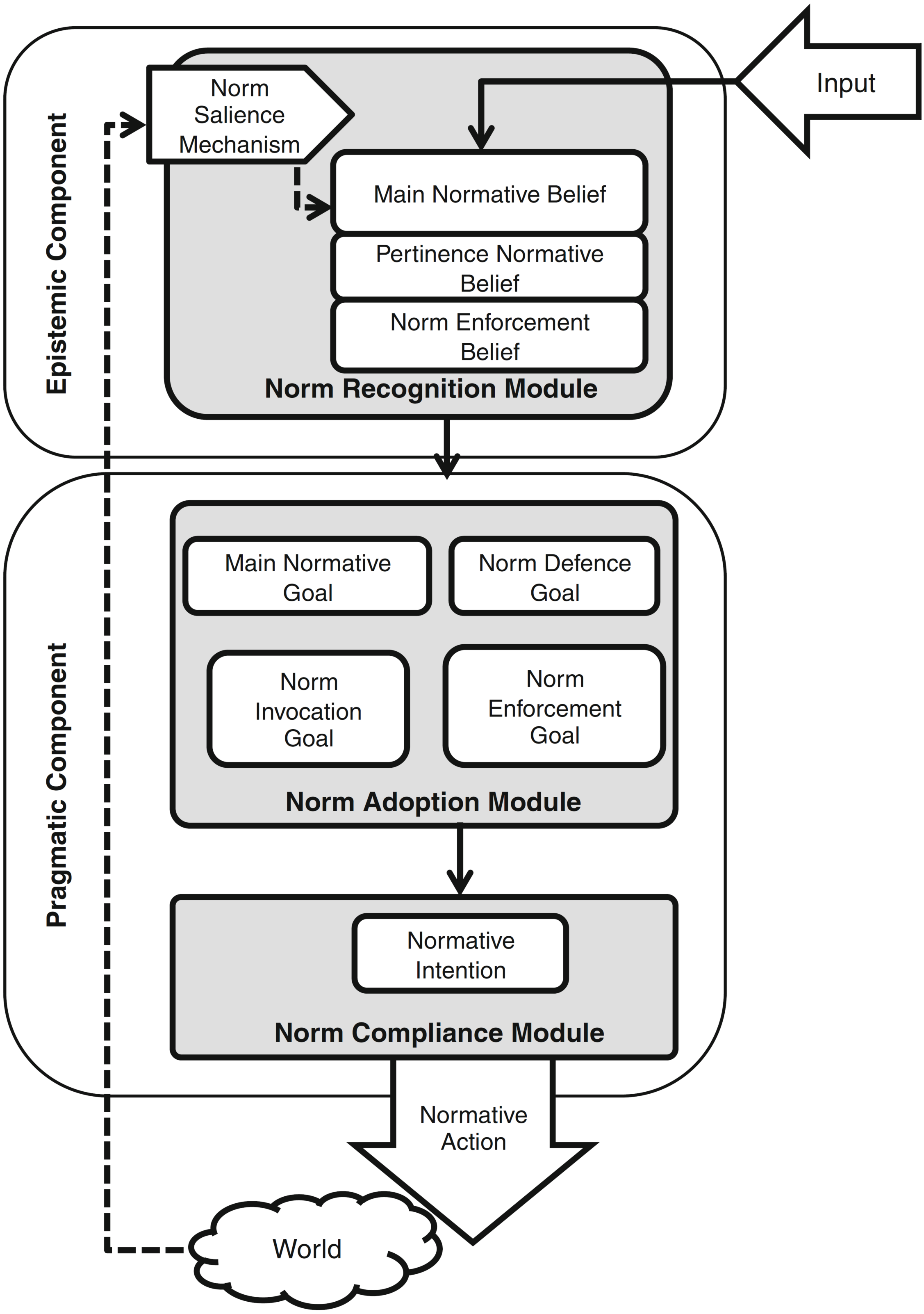

Figure 2.2: EMIL-A architecture, a normative architecture covering norm emergence (54)

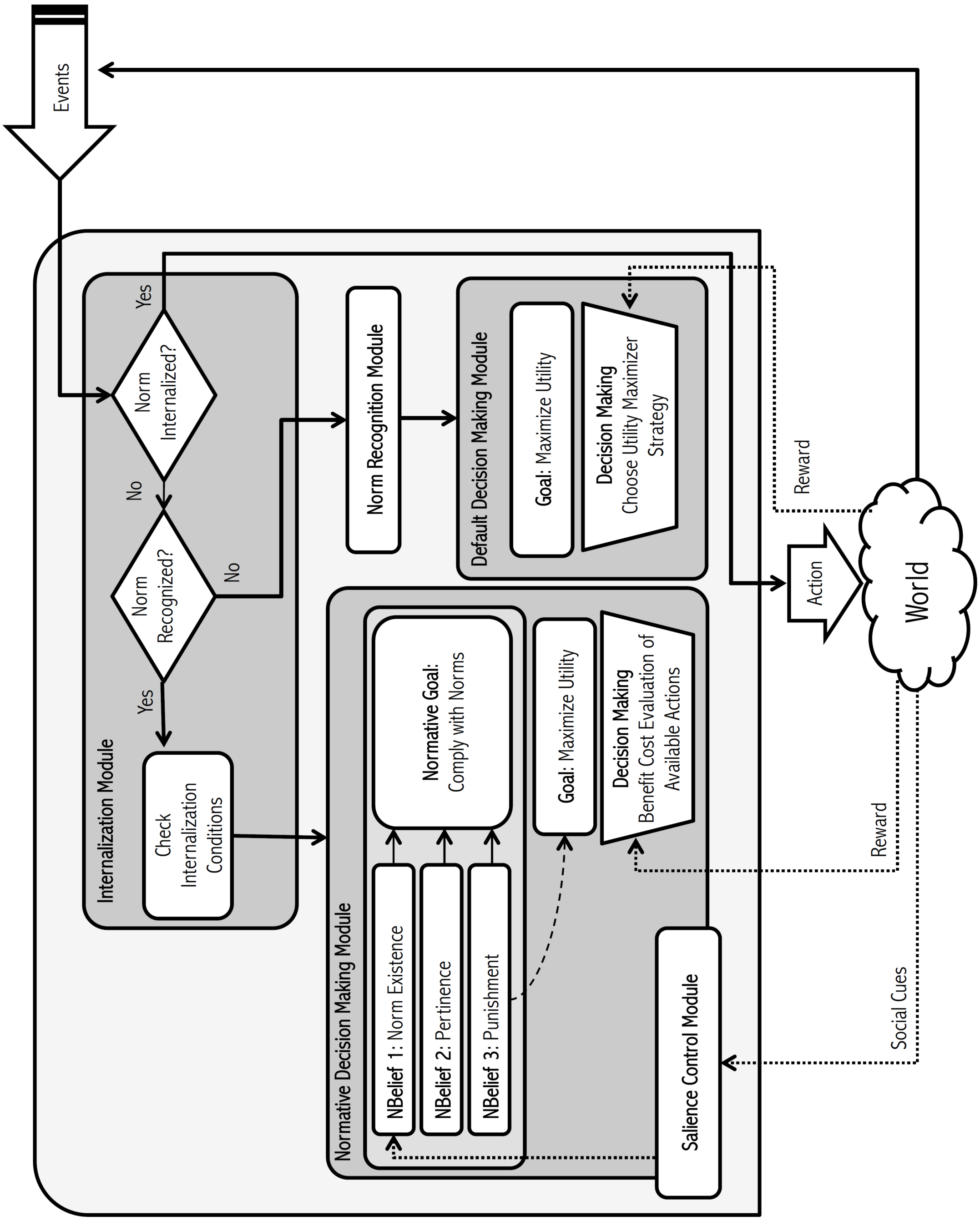

Figure 2.3: EMIL-I-A architecture, an architecture based on EMIL-A covering norm internalization (53)

norm in the behavior of an agent-based system have been considered. As shown in figure 2.2, this architecture includes two types of components, Epistemic and Pragmatic. Norm recognition is the responsibility of the Epistemic components. Norm adoption and norm compliance are part of the Pragmatic components. In this figure, the input is an action that the agent need to perform or it can be a state of the world that the agent obliged to achieve. The input has to pass through the norm recognition module to check if this is already a recognized norm or it is new. Norm recognition helps to recognize a new norm that is not in the normative memory of the agent by observing others, or through interacting with them. If the input is recognized as a new norm, then the agent decides whether ignore it or add it to its normative memory as a new norm. Deciding/reasoning about adopting a new norm might occur due to adopting another agent's goals, avoiding punishment, or gaining approval of others. This architecture is still utility based. Also, it does not cover norm emergence and norm disappearance which leads to introducing EMIL-I-A.

EMIL-I-A introduced by Segura is a normative architecture based on the EMIL-A architecture which has an explicit norm emergence and norm disappearance possibility (53). EMIL-I-A designs the normalization module considering a norm consistency, self-enhancement, urgency, and norm salience. This is a reasonable set of factors that are required for norm internalization. EMIL-I-A considers two necessary conditions to internalize a norm; either the salience of the candidate norm reach its maximum value, or the candidate norm had been selected enough times through the decision making process of the agent. Norm disappearance – deinternalization as it is called in Segura thesis – occurs either as a result of decreasing the salience of the norm to its minimum amount or because the salience of another norm which is applicable to the exact same situation exceed the salience of the candidate norm. As represent in figure 2.3, when a new event (an obliged status or an action) occurs, agent checks if it is already internalized. If the norm is already internalized, the action will be performed without any further decision. If the event is not an internalized norm, the agent will check whether it is recognized as a norm. If it is not recognized, the agent will make a decision via default decision making components. Otherwise, it will decide via the normative decision making components. Both the default decision making and normative decision making are utility based. The normative decision making considers the normative goals and normative believes into the utility based decision as well. Considering the fact that the definition of salience in this architecture contains rewards and punishments experienced by the agent or observed by the agent, norms that are internalized without punishment or rewards are eliminated from this architecture. Regarding norm emergence, EMIL-I-A architecture considers the memory size (number of actions taken by the agents in the past), population size, neighborhood size, topology, learning by interaction, and available action set. This definition considers reasonable factors for norm emergence - which we also used in our framework. This architecture covers norm internalization and norm emergence; although it is still using sanctions/rewards as the enforcement element; the authors mentioned that social norms guide behavior even without the existence of an explicit punishment system. In addition, in EMIL-I-A architecture, norms are limited to the available action set which are predefined according to the simulation experiments represented in EMIL-A and EMIL-I-A work (53, 54).

2.2.4 Causality of social norms

Schwartz argues that specific norms for concrete situations are connected to a set of abstract values (33). He introduced 10 universal abstract values that every person in the world shares (21). According to him, norms are a concrete expression of abstract values, a position shared by Bicchieri, who describes norms as the embodiment of values (32).

As "ideal worth pursuing" (6), values are used to evaluate possible actions. However, Bardi and Schwartz believe that while people act mostly according to their value system, this is mostly unconscious and does not usually play a direct role in decision making, at least not in every day decision making (22). Rather, most decision processes are influenced indirectly by the abstract values through their connected norms.

Given the close relationship between values and norms, there is a limited number of works that relate the two. Figueiredo et al. introduced an algorithm that connects norms and values (56) and identifies if values and norms have conflict. In this paper, norms regulate behaviour of agents by classifying actions as *permitted*, *prohibited*, and *obligated* which is determined based on the society preference. Values, on the other hand, are guidelines in each agents that help agents to distinguish between good from bad and wrong from right. This research focuses on identifying the possible conflicts between personal preferred actions (values) and society preferred actions (norms). If the values and norms are in line, the choice of agents are obvious. However, there are two possible conflicting situations; 1) norms prohibited an action which promotes personal values of agent, 2) norms obligated an action which demotes personal values of agent. In this paper, norms are applied on actions as well as values. However, values are abstract concepts, according to Schwartz; and norms are externalization of values. In this research, the importance of conflicting values and norms is presented. However, this research is missing some important points. For example, values and norms are pre-defined for agents and there is not a relation between the personal values and social norms, but rather they are used as measuring scales to evaluate actions and determine if they are in conflict or not; norms are stable with no change over time; values are not defined as abstract concepts that might be interpreted to different actions in various situations; values has priorities, but the relation between values as stated in Schwartz theory is not considered.

Dechesne et al. provide a theoretical framework in which norms and actions both have supporting values (6). In this paper, values are considered as "ideal worth pursuing". Each agent has its own value profile which means that the order of values' importance is different for the agents. Norms are standards within a group or a society which "are aimed at achieving certain values". Whether an agent accepts a norm depends on the number of agents in the community that accept the same norm while sharing its values. An interesting approach of this paper, which I will imply in my thesis as well, is considering norm as a connection between values and concrete actions. In other words, the generic values are interpreted to concrete actions via norms. However, this paper does not include a value system as presented in Schwartz theory.

Kayal et al. come up with a normative framework based on user data to build up a teammate system for children (57). In this study, social context, values and norms are included into the framework and the implemented model. "Activities", "concerns", "limitations" are determined a social context (e.g. family, school, etc). As shown in figure 2.4, values drives "activities", threatened by "concerns", and may not be fulfilled because of "limitations". Norms support values by obligating, permitting, and prohibiting behaviour to overcome limitations, avoiding concerns and promoting activities. In this work the relation between values and norms is studies. Still, the relational values in Schwartz value theory and the value priorities for each agent are missing. Also, norms are considered as an static rule within the group.

In all the above research, values are not considered in a value system. In other words, the relation between values are neglected. This assumption would simplify the simulation or models and it works as a reference point. However, it does not help with explaining different choices for different people in the same situation. For example, in a situation a person who has a high priority of *"Power"* will act different than a person who value *"Universalism"* when these actions are directly connected to *"Power"* or *"Universalism"* values. Even so, these agents might act the same is a situation that is related to *"Conformity"*. I will explain more the relation between the values and how I formulated it in chapter 3.

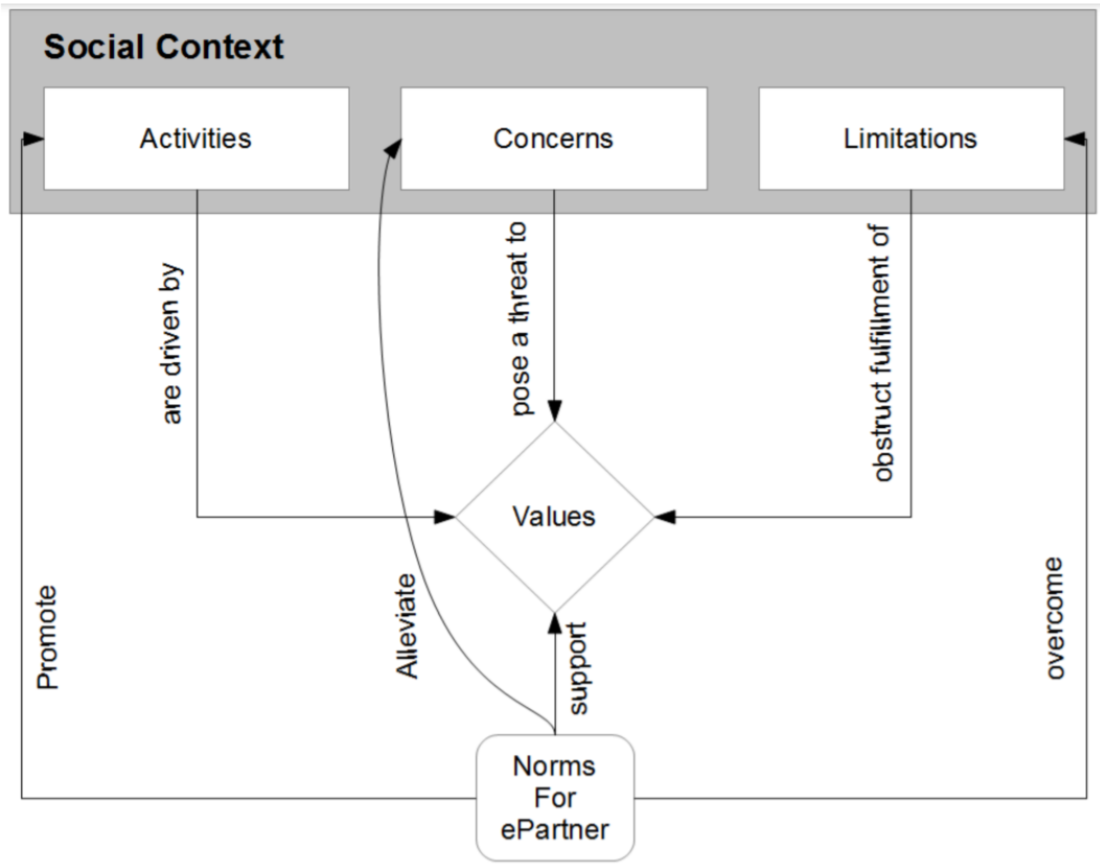

Figure 2.4: Relation between social context and values (57)

2.3 Agent Based Modeling

Different modeling methods have been proposed so far to model a broad range of systems; like economic system, GIS system, social behavior, etc. Some examples of proposed models by scientists are equation-based models (EBM), statistical model, evolutionary model, agent-based model (ABM). Each of these models has its own advantages and disadvantages which are discussed in (58). Though, EBM and ABM have been used more than others due to their wide range of application in different fields (59, 60, 61). ABM and EBM have some similarities and differences.

EBM contains several equations that are determined before starting the simulation; thought, it is possible to define questions associated with external parameters (e.g. environmental changes). But, that is the maximum dynamicity of EBM!

ABM is a set of autonomous agents that they can impact each other directly or indirectly through their environment (58), which is not possible using EBM. The other difference between these two models that the authors of (58) mentioned is the level of modeling. EBM is more appropriate for system level studies and ABM is more suitable for individual level studies (e.g. social studies). ABM has been used to model different systems, like health care, finance, ecology, sociology, complex systems, etc (62, 63, 64). For instance, authors of (62) model the vegetable and fruit consumption in a society and study the social factors that can change it. They claim that the mass media and nutrition education can affect the existing social norms of the consumption pattern of fruit and vegetable. Also, they showed that this effect is more apparent in societies with higher education. Though, they did not explain their definition of social norms.

There are a lot of researchers who modeled social norms using EBM, for example (65). However, they usually determined a cost function to measure the agents' behavior and assign a negative cost to the violent agents. With this cost function, they measured agents' behavior in a society. For example, authors of (66) modeled criminality in a society and tried to observe the impacts of social norms and values on the amount of crime. As mentioned earlier, such cost function cannot afford simulating the interconnection between social behaviour, individual values or agents, and other components in a system.

ABM has been used effectively in a variety of scientific domains. It enables the simulation of complex behavior and the analysis of the outcomes at both micro and macro scales. In other word, ABM is beneficial when the model needs to cover real behavior, dynamic relationships, and there is a need to have agents with the ability to adapt, learn, and interact with other agents. These are the causative factors of social norm development in a society (63, 67). Based on my best knowledge, those reasons can be summed up to get feedback from the environment and other agents.

Another reason of using ABM is that social norms are decentralized controller in a society. It means that norms are internal controlling factors that each individual has and external factors (e.g. police force) do not supervise or control them. Besides, when a person violates a social norm, there would be a punishment for him from other members of the society. This punishment is not universal. The severity of punishment for violating a norm could vary in different groups as well.

3

Technical Framework Design

In this chapter, we design a framework for personal values and social norm life-cycle. These frameworks are mathematical equations based on conceptual definitions introduced by other scientists. These frameworks will be required in the subsequent chapters of this thesis. Thus far, I covered the related work regarding social norm modeling and simulation. However, there are certain voids in that chapter that need to be filled with more extensive explanation. One of the most significant topic is values. Many researchers use values as a conceptual concept. However, I use it as a theory and consider the connection of values as well. The value theory is a sociological theory developed by Schwartz. I have made no contribution to the value theory. In this thesis, I translate this theory mathematically such that it may be used and implemented into any normative frameworks or simulations. Although I think this is a good way of representing Schwartz's value theory, it is essential to mention that I am not claiming it is for general use. Having values, the correlation between values, and connecting values and norms are all essential for this thesis. In other words, the implementation choices of values is irrelevant.

After describing the value theory and how it can be implemented, I explain norm life cycle. The life cycle of social norms was briefly outlined in the preceding chapter. In most of the research efforts, social norms are not incorporated explicitly. To study social norms, I need to define norms explicitly. As a result, I translate norm life-cycle mathematically that can be deployed and integrated into any normative frameworks or simulations.

3.1 Personal Values

I need agents with values to connect the social system with the economic and ecological systems. Considering the definition defined by Dechesne et. al, values are criteria to evaluate actions and events (6). I apply this definition in this thesis to build simulations and models with values. In the provided agent-based models (ABM) and multi-agent simulations (MAS), the agents' values are ordered (prioritized) differently, which affects their decision-making.

Agents have their own personal priorities of values that is private. Based on their value ordering, they will determine the optimal action in each case. For instance, if a fisher values "Hedonism" over "Universalism", he may choose to fish more expensive species, even if it is a threatened species.

It is worth noting that the salience of a value is determined by the context, whereas the value ordering for each agent remains constant across time. Consider a circumstance in which there are plenty of fish. In that circumstance, the value of "Universalism" does not particularly play a role for a fisher. Because the environment will not suffer despite of amount of fish harvested. When there are just not enough fish, this alters dramatically. In that case, the fisher must strike a balance between capturing enough fish to feed himself and not harvesting too many for the fish to survive.

I employ the values represented by Schwartz, known as Schwartz's theory of basic values (28). Table 5.1 presents the definition of each Schwartz's value. Agents in our models desire "Power", "Self-enhancement", "Universalism", "Benevolence", "Hedonism", "Tradition/Conformity", and "Achievement" values.

Figure 6.1 demonstrates Schwartz value theory, the dynamic compatibility and conflicting relation between all the value types by positioning them in a circle. Values which are closer to each other in the circle are more compatible than values on opposite sides. For example, pursuing "Tradition" and "Hedonism" are conflicting values, as "Tradition" is about restraining owns actions to conform to traditions and "Hedonism" is about self-oriented need for pleasure. However, pursuing the "Tradition" value is compatible with pursuing "Conformity" (to not violate social expectations in groups usually with close others) as both stress self-restraint and submission. In other words, as the distance between values grows in the Schwartz value circle, their compatibility increases. The shortest distance occurs between two values that are adjacent to each other in the circle, while the maximum distance occurs between two values that are on opposing in the circle.

In order to model the value circumplex of Schwartz, I define two sets. The first set is an input set which is a collection of Schwartz abstract values;
$Values = \{V_1, V_2, V_3, V_4, V_5, V_6, V_7, V_8, V_9, V_{10}\}$, where $V_1 = \textit{Universalism}$, $V_2 = \textit{Self-direction}$, $V_3 = \textit{Stimulation}$, $V_4 = \textit{Hedonism}$, $V_5 = \textit{Achievement}$, $V_6 = \textit{Power}$, $V_7 = \textit{Security}$, $V_8 = \textit{Tradition}$, $V_9 = \textit{Conformity}$, $V_{10} = \textit{Benevolence}$. The indices are important to consider the position of each value in the Schwartz circle in the framework.

Value		Definition
Benevolence	:	preserving and enhancing the welfare of those with whom one is in frequent personal contact (the ‘in-group’)
Universalism	:	understanding, appreciation, tolerance, and protection for the welfare of all people and for nature
Tradition	:	respect, commitment, and acceptance of the customs and ideas that one’s culture or religion provides
Hedonism	:	pleasure or sensuous gratification for oneself
Self-Direction	:	independent thought and action; choosing, creating, exploring
Achievement	:	personal success through demonstrating competence according to social standards
Power	:	social status and prestige, control or dominance over people and resources
Conformity	:	restraint of actions, inclinations, and impulses likely to upset or harm others and violate social expectations or norms
Security	:	safety, harmony, and stability of society, of relationships, and of self
Stimulation	:	excitement, novelty, and challenge in life

Table 3.1: A brief definition of the Schwartz’ values

The second set is the amount of importance for each $V_i \in Values$ which is defined as $Importance = [0, 100]$. Any member $V_i \in Values$ can get any value from *Importance* to indicate how often the value V_i has to be satisfied.

Assume that function $\tau : Values \rightarrow Importance$ in which $\tau(V_i)$ gets the importance of value V_i. For each $V_i \in Values$, if $\tau(V_i) = 0$, then value V_i is silent and not playing a role in the system; if $\tau(V_i) = 100$, then the agent will try to satisfy this value constantly as it has the maximum importance.

Compatibility relation To consider the compatibility relation of values, I defined the following condition that shows the importance of any member of $Values$ is more related the closer the indices are to each other.

$$\text{Condition 1: } \forall i, j \in 1..10 \ : \ 0 \leqslant |\tau(V_{\text{i}}) - \tau(V_{\text{j}})| \leqslant m_{i,j},$$

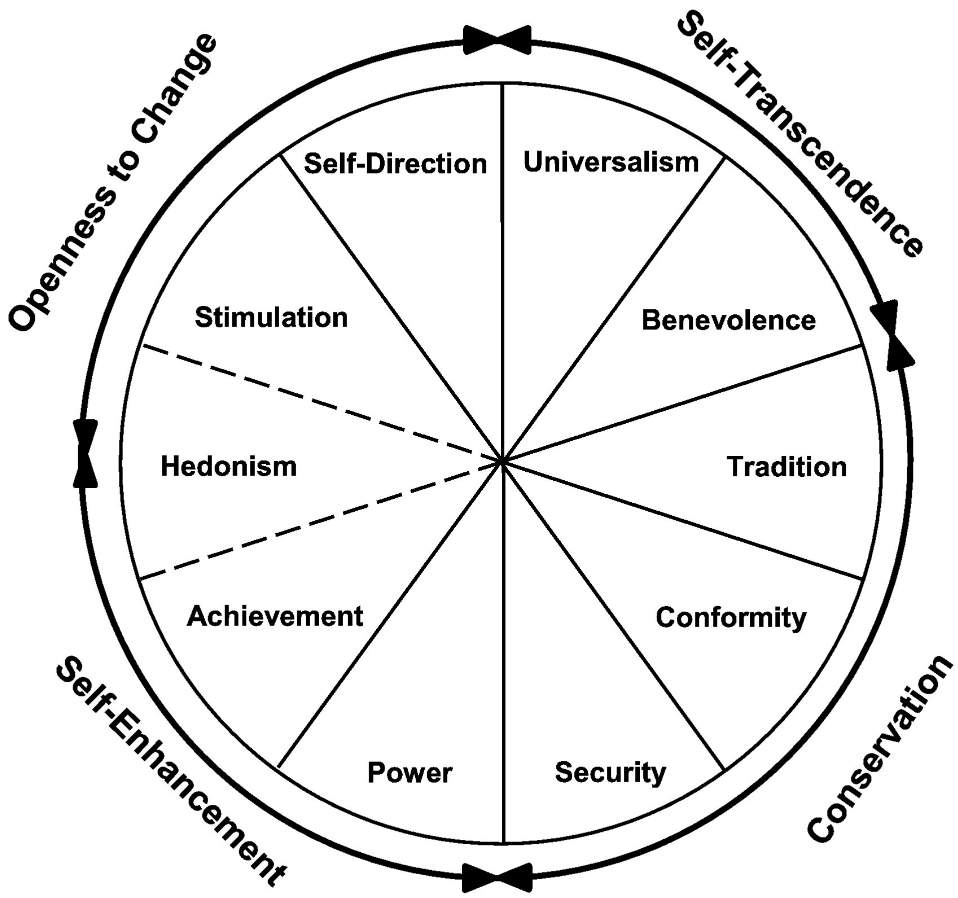

Figure 3.1: Schwartz value circle, categorization and dynamics of abstract personal values (21)

where:
$$m_{i,j} = \begin{cases} |i-j| * c & \text{if } |i-j| \leqslant 5 \\ (10-|i-j|) * c & \text{if } |i-j| > 5 \end{cases}$$

c is a constant real number between [1..100]. 5 is the number of abstract values in one half of the Schwartz circle which is the maximum distance between two values. Regarding symmetric distances of abstract values in the Schwartz circle, I slightly transform the formula by changing some variables. In this condition, c is a multiplier that shows the maximum difference of assigned values to each two successive values in the Schwartz's value circle. The greater c, the lesser co-dependencies between values exists. I preferably use $c = 20$ as it represents high sensitivity of each value in the Schwartz circle to its successive values and low sensitivity to the farther values.

Researchers used different version of Schwartz value system with various number of abstract values. For example, Schwartz used seven abstract values to study the meaning of work in different cultures (68).

In condition 1, the assumption is that each value has the same distance to neighbors. As an example, the distance between *Universalism* and *Tradition* is the same as the distance between *Conformity* and *Power*, both 3. However, when one wants to have different distances between the values, Condition 1 should also be adjusted. As an example a modeler may want the following distance relations: $|\tau(\textit{Universalism}) - \tau(\textit{Self-direction})| = 15$, $|\tau(\textit{Power}) - \tau(\textit{Achievement})| = 5$, and the distance of the other successive values remains 10. It would be the modelers preference to make such a decision according to their research requirements.

Conflicting relation the following condition can model the conflicting relation between values.

$$\text{Condition 2:} \begin{cases} \tau(V_i) > 50 & \text{if } \tau(V_j) = 0 \\ 100 - \frac{c}{2} \leqslant \tau(V_i) + \tau(V_j) \leqslant 100 + \frac{c}{2} & \text{if } \tau(V_j) \neq 0 \ \& \ \tau(V_i) \neq 0 \end{cases},$$

$$\text{where } j = (5 + i)\%10.$$

According to condition 2, when value V_j is not included in the model ($\tau(V_j) = 0$), the opposite value of it in the Schwartz circle should have an importance τ high enough to have effects on the behavior of the system; otherwise, it can be ignored. This rule is actively used when there are other drivers to select an action than values (i.e. personal goals, motives, norms, etc.), since the influences of a low importance value can be neglected. But the rule should be dropped when the decisions are only value based because then the low importance values do influence the decision making.

Additionally, condition 2 means that when value V_i and V_j are included in the model, their importance needs to be complementary to some extend. Assume $c = 20$, when we know that $\tau(Universalism) = 70$ then $\tau(Power)$ can be any number in the range of $[20, 40]$. This opens up some variation between the value distributions.

With these two conditions many different value distribution are possible. It is possible to have all values with the same importance. Also, it is possible to have some values that do not play a role in the system ($\tau(V_i) = 0$). I will use this formula in the simulations and the presented framework in the coming chapters.

For example, if we only want to have *Universalism* and *Power* in the simulation and want to initialize $\tau(V_{universalism}) = 90$. Then, according to the aforementioned conditions $0 \leqslant \tau(V_{power}) \leqslant 10$ and the importance of the other values is zero ($\tau(V_{Benevolence}) =$

$\tau(V_{Self-Direction}) = \tau(V_{Compliance}) = \tau(V_{Hedonism}) = \tau(V_{Achievement}) = \tau(V_{Conformity}) = \tau(V_{Tradition}) = \tau(V_{Stimulation}) = 0)$. As an another example, if we want to have *Universalism*, *Power*, and *Tradition* values, assuming the initial condition is defined as $\tau(V_{universalism}) = 90$, then these steps should be taken to assign importance to other values.

- The importance of *Power* relative to the importance of *Universalism* will be between 0 and 10.
- The importance of *Tradition* relative to *Universalism* would be between 50 and 100.
- The importance of *Tradition* relative to *Power* would be between 0 and 70.
- Therefore, the intersection of the new range for $\tau(V_{tradition})$ is a real number between 50 and 70.
- Finally, we randomly assign a number between 50 and 70 to the importance of *Tradition* and a random number between 0 and 10 to the importance of *Power*.

One possible setting can be $\tau(V_{universalism}) = 90$, $\tau(V_{power}) = 5$, $\tau(V_{tradition}) = 50$. For more complicated examples can be calculated using the open source code, accessible via a github repository from this link.

As mentioned earlier, the main goal of this thesis is studying social norms. Norm dynamics do not depend on value implementation, but rather how norms and values are connected (alighted, against, or not related). Therefore, I do not claim that my mathematical representation of values is the only way of representing Schwartz's value theory. This representation is one of the possible ways of modeling Schwartz value theory. Although the mathematical representation has impact on precise outcome of simulation, the overall behaviour of the system does not depend on this implementation.

3.2 Norm Life-cycle

In this section, I explain the formal design of the social norm life-cycle that I used for the agent-based simulations.

There has been much research that explains various phases of a norm life cycle. One of the famous ones has been introduced by Martha Finnemore and Kathryn Sikkink. According to Finnemore and Sikkink, three phases comprise a norm life cycle: emergence, adoption, and internalization (69).

Norms do not emerge out of the blue. Agents are all part of the development/shaping of the (non-formal) agreement reflecting the desirable behaviors in their community. (70, 71). It means that agents need to have the notion of desirable behaviors for themselves and be able to recognize and adopt such behaviors. Campenni et al. show the effectiveness of norm recognition in norm emergence (71). Agents recognize social norms through communication and/or observation. In our simulation, I consider observation as a recognition way of social norms.

Considering Finnemore and Sikkink research and the importance of considering pre-phases of norm emergence, I consider four phases in a social norm life cycle: 1-observation 2- adoption 3- internalization 4- disappearing. These phases are considered at the individual level. In other words, each agent will pass these four phases for his descriptive social norms. When an agent joins a group, it observes the norms in that group. After recognizing the norms in this group, it may affect its decision and thus behavior, by which it affects the norms in the group, i.e. the norm may adopt, which then affects its own decision making again, etc. After adoption, if the norm has been repeated enough, the agent will start internalizing the norm. Internalizing a norm implies that the agent uses the norm without deliberation (considering value intentions behind it). The norm will be followed without deliberation until there is a change in the system which makes the agent starts deliberating again.

There is a group level of norm life-cycle, which is norm emergence, norm persisting, and norm disappearance occurs due to individuals' contributions toward the group-level behavior. A norm emerges in a group if most of the agents of the group consider an action as a norm and follow it. A norm will persist in a group if most of the agents of the group internalize it. A norm will disappear in a group if most of the agents of the group abrogate the norm which implies stop following the norm.

Observation: agents continuously observe other agents' behavior (in their groups). Therefore, when a new agent joins a group, it starts observing the behavior of the group members to catch their norms (considering the average behavior). Until the new agent recognizes the norms of the group, it behaves according to its values, norms from other groups, and its internalized norms.

Adoption: if the agent observed a normative behavior has been repeated often enough, it will enter the adoption phase. When a norm is in the adoption phase, it has a higher probability of being followed compare to the observation phase.

Internalization: if the agent observes a normative behavior repeated enough times, it will enter the internalization phase. In this phase, the agent will consider the norm with a high probability of its decisions. This norm might even reduce the effect of its personal value based preference.

Disappearing: in any phase of a norm life cycle, if the agent observes that the other members of the group are not following what is assumed as a norm, it will enter the norm in the disappearing phase.

To simulate different phases of a norm, I take into account the definitions of each phase. Also, I assumed some settings that I explain in this section.

Observation-adoption-Internalization

The probability of following a norm during the first three phases (observation, adoption, internalization) of a norm life-cycle in our simulation is shown in figure 9.1. To create this curve I considered that following a norm during the observation phase is very low. In the adoption phase, the probability increases exponentially until it enters the internalization phase. In the internalization phase, the following probability stays almost stable.

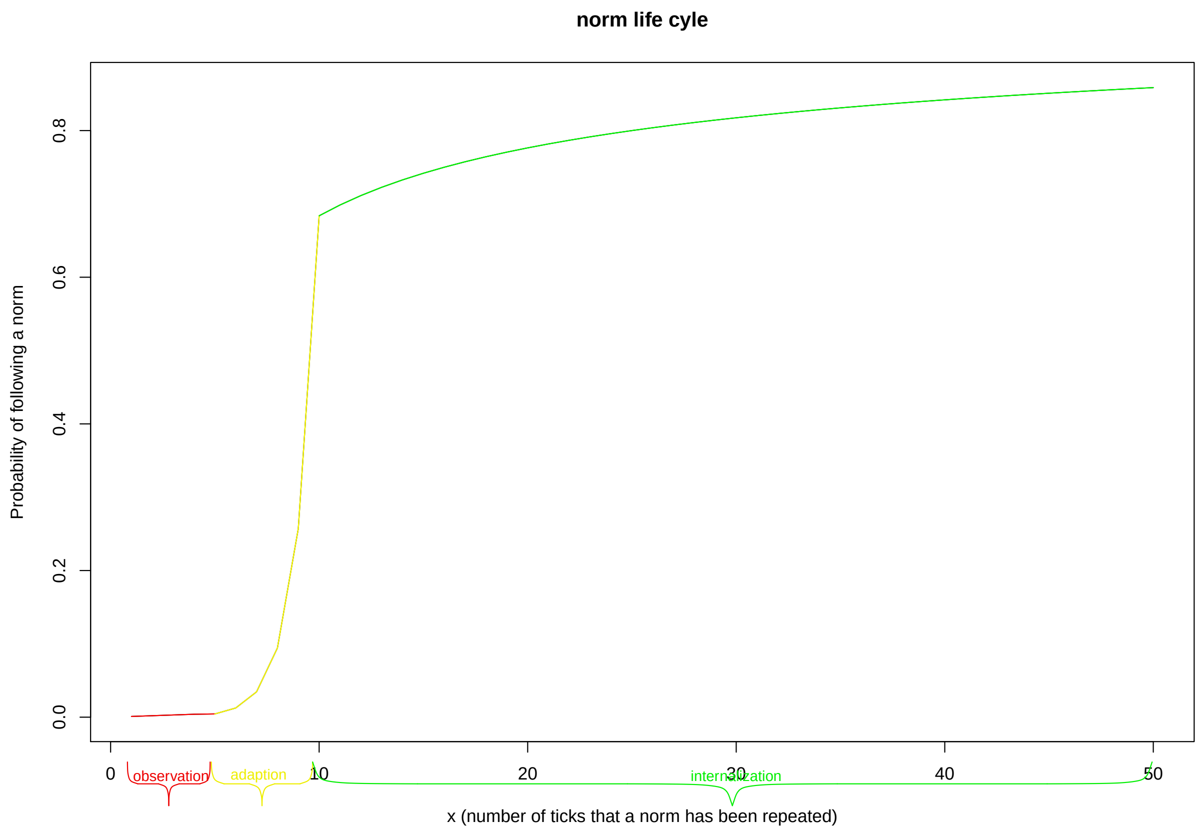

Figure 3.2: Probability of following a norm in different stages of its life-cycle for each agent

Disappearing

During any time of a norm life-cycle, a norm might stop repeating. Depending on the phase of the norm, it might take some time for an agent to forget the norm. If the norm is still in the observation phase, it takes a shorter time to forget a norm compare to a norm that has been internalized. Considering this, to design the probability of following a norm when it enters the disappearing phase, I use the Generalized Logistic Function (GLF). There are several reasons that I chose such a function. This function allows controlling:

- Convexity of the curve
- Maximum and minimum amount
- Growth rate

In other words, with changing the parameters of the function, we can obtain different curves. GLF has been introduced for growth modeling by F. J. Richards in 1959. GLF defined as:

$$GLF = A + \frac{K - A}{\sqrt[\nu]{C + Q(e)^{-B(x-M)}}}.$$

Changing the parameters of the GLF can change the curve. One example of a changing parameter B is shown in figure 3.3. I need to make some changes in the parameters the way it fits our purpose. I want to design it in a way that the starting point is a number between 0 and 1 which is the probability of following the norm in the last time it has been repeated ($P_{last-repeated}$). Also, I want to control the convexity of the curve. In a way that if the norm was internalized, it takes much longer to disappear compared to the cases that it was in the adoption or observation phase. To achieve all the purposes, first, I mirror the function about the x-axis and shift it to the right by $t_{disappearing}$ (which is an input parameter of the simulation that determines the necessary time to disappear a norm completely).

$$f(t) = A + \frac{K - A}{\sqrt[\nu]{(C + Q(e)^{B(t-t_{disappearing}-M))}}}$$

For our purposes I uses the setting for $f(t)$ represented in table 3.2. Configuring $f(t)$ using these parameter setting, the result would be the curves shown in figure 3.4. I change the parameters according to the previous probability. For example, assume that an agent internalized a norm (and it follows the norm with the probability of 95%). At this time, the norm stops repeating by the group members. Therefore, the agent starts putting the norm in the disappearance phase which starts with the following probability of 95% and

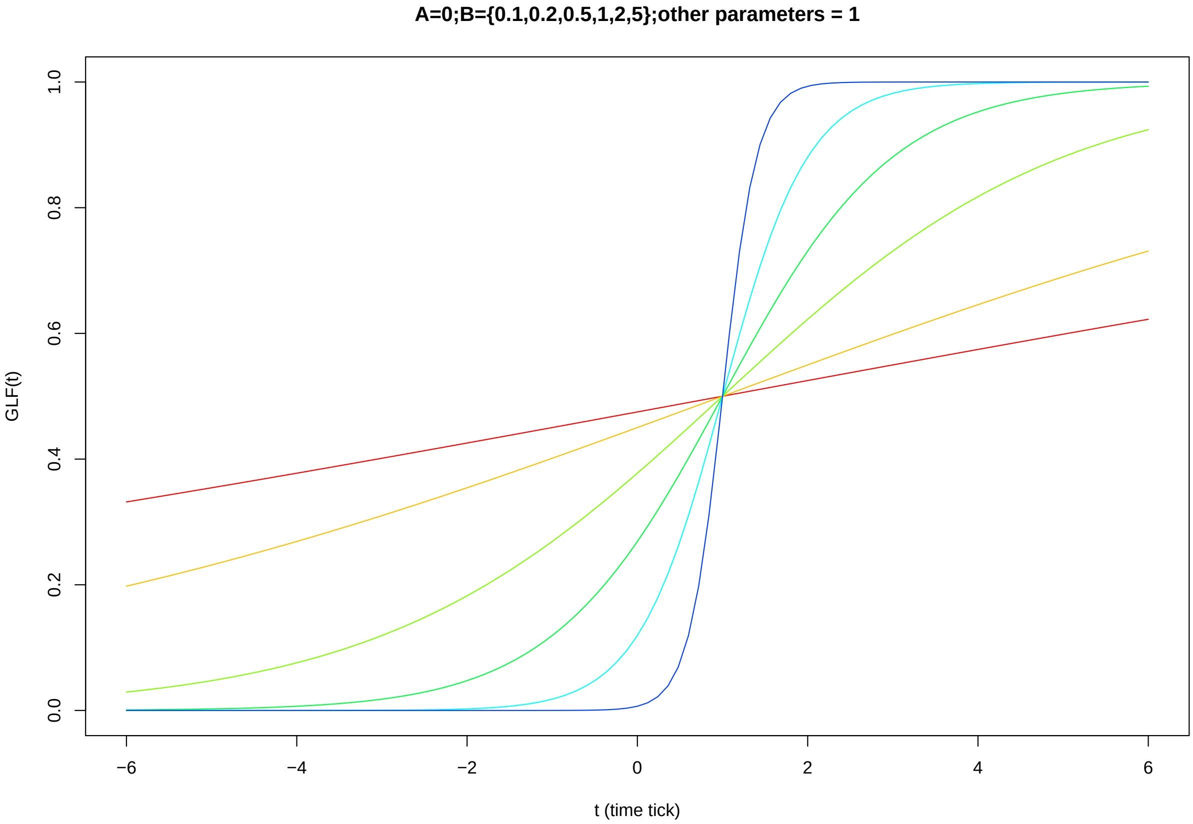

Figure 3.3: General Logistic Function (GLF) while changing parameter B which controls the growth rate of the function

decays over time (dark green line in figure 3.4). In other words, it takes a longer time for an internalized norm to be abrogated by agents. As another example, if there is an agent that just starts adopting a norm (follows the norm with the probability of 4%) and the norm stop repeating by the group members. The agent starts the disappearance phase (abrogating the norm) which starts with the following probability of 4% and decays over time (orange line in figure 3.4). In other words, it takes a shorter time for a recently adopted norm to be abrogated by agents.

The designed functions for the four phases of a norm life cycle are used as a module in our framework. These functions might be replaced by other functions according to modelers choices. I do not claim that this representation is the only way of formulating norm life cycle, but rather it is one of the possible ways of describing norm dynamics.

Table 3.2: General logistic function (GLS), parameter definition and setting

parameter	**effect**	**setting**
A	the minimum asymptote / minimum amount of f(t))	0
B	the growth rate of function and can change the convexity of the curve	$p_{lastRepeated}/2$
C	typically takes a value of 1	1
K	the maximum asymptote/ maximum amount of f(t)	$p_{lastRepeated}$
Q		1
M	the x starts from 1 instead of 0 in the simulation. M only shifts the curve toward x axis	1
ν	near which asymptote maximum growth occurs	1
$t_{disappearing}$	simulation setting	$t_{internalization}$

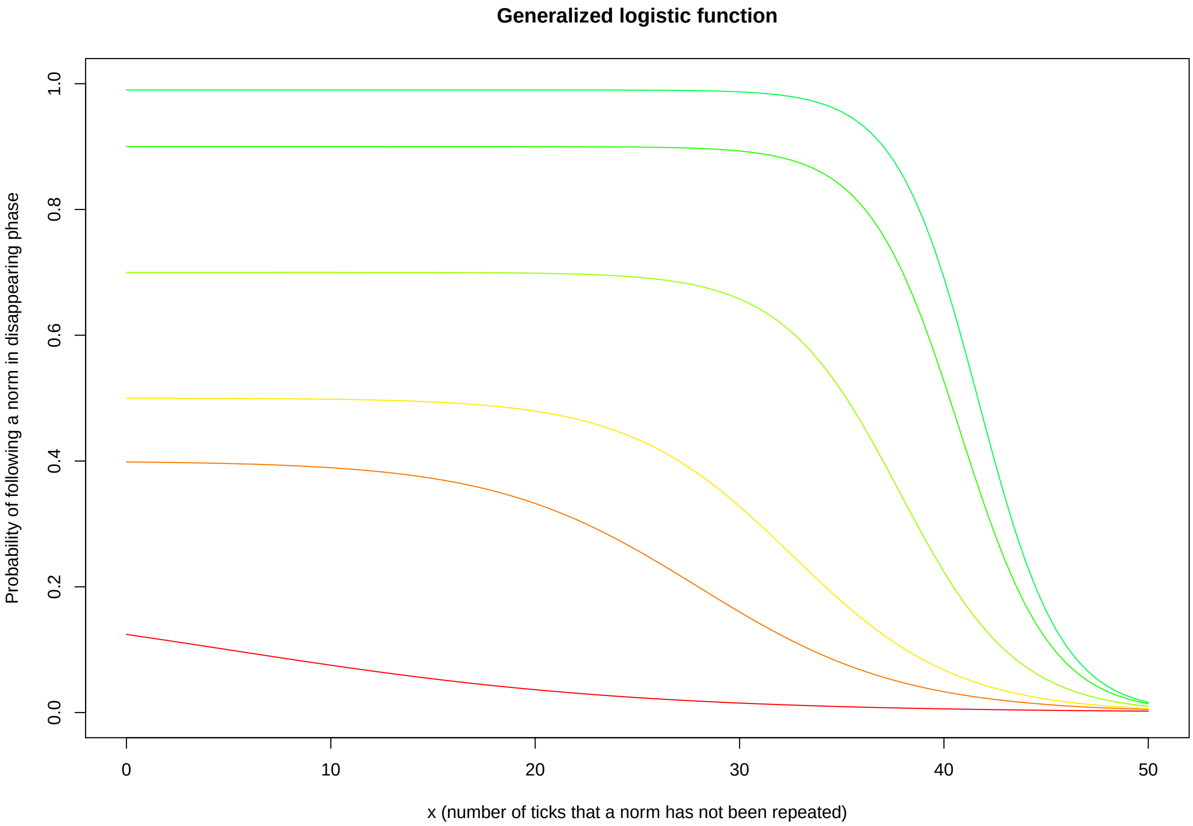

Figure 3.4: Probability of following a norm (depending on the last time the norm has been repeated)

4

Exploring Socio-Ecological Models of Fishery Management Using Multi-Agent Social Simulation

Recently, considering social aspects and its consequences on ecology and economy attracts much attention in the fields of natural resource management like fishery management. One important question is that what is the role of social aspects like values on other aspects (e.g. economy and ecology) of such a system.

Various social aspects are involved with fisheries society. For example, some studies have been considered the importance of fishers' gender as a social aspect (for example (72, 73)). Many factors can impact the role and portion of participating women and men in the whole process of fishing (pre-process tasks, on-boat fishing, and post process activities). Over time, these situations had been accepted as a norm in the fisheries society.

The daily decision of fishers can impact ecology and economy; their personal values can change their decisions; social norms are impressive to create and change personal values. Therefore, studying social norms needs studying individual values. In this research, we present a basic model using multi-agent simulation to study how individual values can impact ecology and families economical situation.

4.1 Introduction

Nowadays, policymakers and analysts are understanding that in order to improve management, they must understand the interaction between humans and ecosystems. In other words, they begin to see that fishery management entails not just catching fish (e.g., resource conditions, technology, and the economics), but also taking into account the social structure of fishing communities. To simulate such a system which contains interactive agents, complex systems can be used. One of the important aspects in the real world is that people are influenced by social phenomena such as culture and social norms. Thus, the fishery industry should be modeled as a complex socio-ecological system (CSES).

People behave and impact their environment by their actions and decisions. Much study has been conducted to investigate the decision-making process using multi-agent simulation (66). Furthermore, there has been a lot of attention in the impacts of social aspects on decision-making.

In the real world, people decide and act based on the feedback that they get from other people. For example, one of the most important individual goals of a fisherman is to preserve profit, which may be accomplished by purchasing a contemporary boat. If a fisherman purchases a modern boat in a fishing village, his neighbors will be motivated to compete and invest in new equipment. In a collectivist culture, though, a new boat may be purchased collectively and benefit everybody. Thus, the existing social norms play an important role in the development of the fishing industry, its ecological repercussions, and the effects of fishing legislation.

Gender is a social component that has various affects on society and is connected with many values, social norms, and culture. Gender analysis has been explored in several research endeavors and domains. For example, health care, economics, sociology, agriculture, policy, and so on (74, 75). Much study in this topic has focused on the current condition (socially, economically, etc.) without examining the factors that contribute to this social state. However, social norms grow and grow and do not generally emerge instantaneously. It indicates that studying the evolution of social norms cannot be done by gathering data for a short period of time.

It is important to note that gender analysis is not the primary goal of this chapter. Instead, given that gender impacts personal values and decision-making style (76, 77), I employ it as a social element to investigate social norms, values, and their implications.

I will propose a multi-agent model in the context of the fisheries sector, a basic socio-ecological complex model. This model will be useful in investigating the social, economic, and environmental aspects of such a complex system. The rate of female participation in on-boat fishing is taken into account in this model.Historically, most fishers were men, and women's on-boat activities were frowned upon; this is still valid in many places of the world. For example, Shelly et al. stated that it was difficult for Bangladeshi women to be economically independent (78). As a result, it is kind of recognized social norm for women not to participate in main fishing operations (on-boat fishing) and to focus on pre-processing or post-processing (on shore activities like preparing gears, salting fish, selling fish in the local market, etc.). There could be a lot of reasons that such norms have been evolved, such as family roles of men and women. For instance, men were in charge of making money for family and women were in charge of taking care of children and household. So, women had to do some activities that would not take them far from their living place. Another possible reason could be because of fishing methods and gears which needed more physical power and using them were more suitable for men. However, those reasons are not valid anymore. Men and women are now working together to finance their families and cover their living expenses. Furthermore, as technology has advanced, contemporary techniques and gears that do not require great physical strength have been devised.

Now, the question is, what if more women participate in offshore fishing operations or, more broadly, in fishing decision-making and policy-making? What if this norm destroys and changes to a norm which accepts women as fishers? As an example, we know that men are (on average) more competitive and women are more directed to long-term well-being. But how much effect do these personal values have on the overall system?

To answer this question, we provide an agent based model of an abstract fishery community and implement a multi-agent simulation based on the provided model. In this model, villagers have two opposing values (caring for the environment, making more money) which impact their decision regarding their fishing behavior. The distribution of the values is an input parameter for the simulation. Despite having only two values, the simulation produces interesting results in terms of the relationship between overall behavior of the society, its impact on the ecosystem, and its effect on personal happiness of the society members.

4.2 Background And Motivation

Value has an accepted definition. It is considered as an attribute for each person or each group of people. One of the favourite general definitions of value is the one represented by Hofstede (76). Based on his definition, values are metrics that people use to measure which action/situation is much more preferable to them. In other word, values are the ideals of a person that can influence his/her decisions. Also, a person can have various values, values of an individual can have conflict, and values developed unconsciously. For instance, authors of (79) mentioned an example of two conflicting values that a mother face in her life; Conflicting values in choosing whether to donate or store umbilical cord blood.

Unlike value, there are diverse definitions for Social Norms in different fields like psychology, sociology, economy, and computer science. Though, it should be noted that each definition is presented and used for a special field, particular situation, and specific conditions. For example, economists are more interested in studying the impacts of values and values on the economy; not the reasons for the creation of such norms in the society nor the impacts of values and norms on other aspects (e.g. education, global warming, etc.). Artificial intelligence researchers are more interested in well-defined definitions that are implementable. Though, a common belief about norm is that it is a standard to evaluate and measure the behaviors and actions of individuals in a society which is accomplished by other people in that society. Development and the emergence of social norms are the results of the interaction of people. People in a group can encourage, discourage, or punish the actions of other members of the group. Based on the feedbacks from the society and expectations (ideal actions/behavior), people will decide about their actions.

As a result, to represent values and norms, a model that can model interaction and influence through feedback is required. A socio-ecological complex system can be modeled in a variety of ways. Agent-based modeling (ABM) is the most practical option. In short, ABM allows us to design autonomous agents that have a direct or indirect impact on one another, making it ideal for modeling dynamic behavior and sophisticated decision-making with dynamic elements. Furthermore, considering my ultimate goal at the end of this thesis is to model social norms, ABM is the perfect approach because it allows me to model society level behavior without a centralized supervision.

Other approaches than ABM for modeling values and social norms were discussed in Chapter 2. We reviewed the advantages and disadvantages of various existing models and simulations that using different modeling approaches. We also went over existing definitions of personal values and social norms in depth.

4.3 Method

The primary purpose of this chapter is to investigate how individual values, financial circumstances, and environmental variables interact in the fisheries sector.To demonstrate this, I created a model of the fishing business that includes personal values, values-based behavior, fishing income, and fish population. This is a basic model that will be used to conduct a research on the causes for the establishment of social norms in future chapters. More details and features of this model are provided in the next section.

This model is developed using Repast which is an open source, Java based, multi-agent simulation and modeling toolkit (80).

4.3.1 Overview

Objective

The model's goal is to represent an abstract fisheries environment in which fishers have their own personal values. This model allows investigating the effects of personal values on the environment.

Variables

In the simulation model, we consider agents, ecosystem, and roles. The environment is the place that fish can live, fishers can do fishing, and it contains food for fish. We establish two roles in order to incorporate economic and ecological factors. One of them determines the market price of each species; this represents an auction or market. This role updates the market price of fish species regularly. The second role is like an advisor who tries to take care of the ecosystem (e.g. environmental advocacy NGOs). This advisor observes the system regularly and offers her suggestions to have a sustainable fishing.

There are two types of agents: fish and fishers. Every agent has its own values, behaviors, and features. Fish agents do not have personal values. They have physical characteristics, weight and age (features). As their possible actions, they can migrate, eat food, and do offspring (behavior). As it is not possible to include all the fish species in the model, we take advantage of combining micro level and macro level viewpoint represented by Bousquet et al. (81). So, the model contains three generic types of fish, small, big, predator. These generic types of species differ by migration time, weight, regrowth rate, natural age, and food.

Fish agents in the small group have the lowest weight, highest offspring rate, and eat food that exists a lot (like plankton, sea grass, etc.). Large fish agents have medium weight, medium offspring rate, and eat food, same as small fish agents. Predators are the heaviest, with the lowest offspring rate, and eat from other fish agents.

Fishers have two values (with some probability); protecting environment intention and making profit from fishing. They have physical power and fishing gears (features). Fishers can do fishing to earn money, and spend money to buy energy, new gears, and living expenses (behavior). Fishers can make choice about their behavior, how much fish they want to catch each time, which species to catch, which gears to use, and when to spend money. We consider gender for fishers; male and female. As mentioned before, gender analysis can play a significant role in sustainable resource management as women and men have different decision-making styles. Social situation, family role, personal values, environmental limitation to some extent can affect their decisions. In this research, individual values have been studied. Both men and women have the aforementioned values; though, with higher probability women are more interested in protecting the environment than making profit. It means that they need to earn some amount of money for their living expenses (as a minimum amount which is necessary for living) and are not willing to earn more than that when it is harmful to the environment. They usually think about long term goals (sustainable fishing). On the other hand, men are more competitive, they usually feel more powerful when they can earn and have more money. So, with higher probability, making more profit from fishing activities has higher priority to them.

Simulator characteristics

In Repast, time is discrete. Though the environment can be discrete or continues, we used discrete environment in our simulation. Repast makes it possible to schedule the events (agents' behavior). We simply set the scheduler to 1 (agents do their activities at each time step). For fish agents, based on the mortality rate, offspring rate, and migration season, they may or may not do any behaviour in some time steps, except swimming in the environment; same for the human agents.

4.3.2 Design

In this model, fishers behave and decide based on their personal values and their observations (feedback from the environment). Also, they consider the advisor's advice based on their personal values (to what extent protecting the environment is important to them).

Some events in the model are stochastic. Individual values (the level of importance of protecting the environment or making more profit) follow normal distribution. Though, I make the deviation and mean for each gender configurable through Repast user interface before starting the simulation.

Also, the offspring rate, age, and weight of fish agents are presented by normal distribution. All agents (fish and fishers) move randomly within the accessible area (9 cells around the current cell).

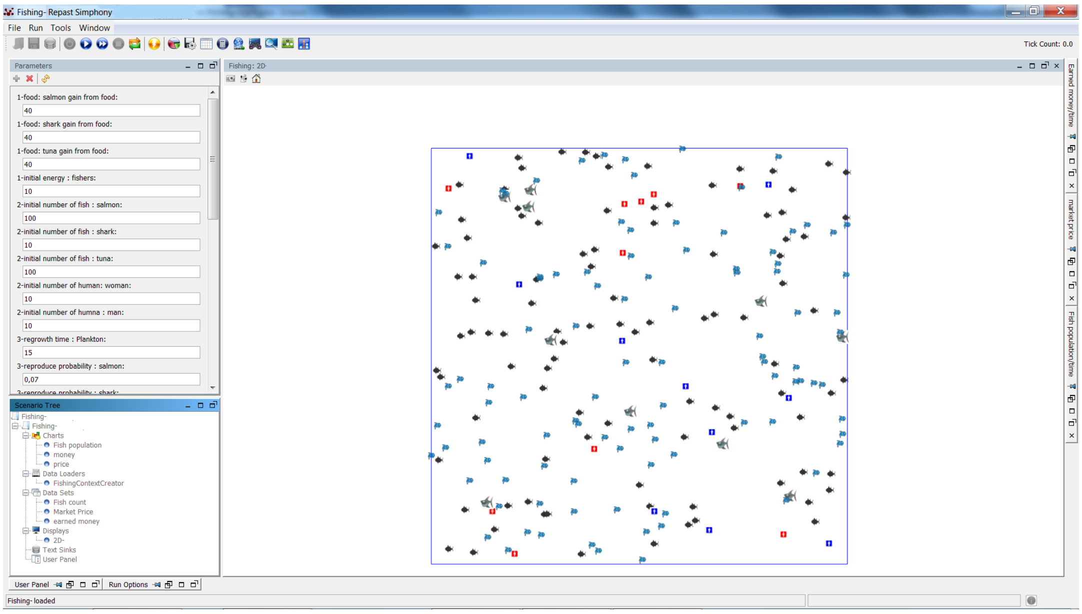

Figure 4.1: Repast has been used as MAS development tool in this work.

4.3.3 Details

Initialization

In order to make the model more dynamic and usable for various societies, we define some parameters as input parameters that users can change it. The input parameters contain:

- Initial population of agents: fishers (males and females), and fish species,
- Reproduce probability over time: offspring probability of each fish species, fishers, food for fish (plankton/sea grass),
- In/activating migration: for fish species,
- Human agents' personal value: for fishermen and fisherwomen,
- Extinction rate: for each fish species.

At the beginning of simulation, the locations of agents (fishes and fishers) are randomly assigned.

In this model, there is not any limitation in the number of agents (fishers and fish) in an area (one cell).

By changing input parameters, it is possible to study the short term and long term consequences of each parameter on fishers' income and fish population.

The simulation interface looks like 4.1.

4.4 Simulation Experiments

We define some scenarios to understand the importance of individual values, its effects on individual decision, and finally its effects on the whole environment. In these scenarios, we change the number of male and female fishers. An standard way of representing simulation results is running the simulation multiple times and show the average outcome. As making the average of the simulation outcomes can eliminate some important details, we do not present the average outcome. Instead, each simulation scenario has been ran multiple times to make sure that the general pattern of the runs are the same. All of the figures are the result of only one simulation run to have detailed explanation of the system behavior.

4.4.1 Scenario I

In this scenario, there are no fishers. The purpose of making this experiment is to see how the whole system works when there are no human activities. Also, we used it to calibrate the parameters and find a good range for each parameter that makes the model a good abstraction of the real world.

In this scenario, the system is sensitive to the amount of available food for fish. When there is enough food and fish agents do not need to compete for food, the population of fish is sustainable (4.2). When there is not enough food, species with higher regrowth rate could have more portion of available food. Then, species with less regrowth rate will extinct eventually (4.3).

4.4.2 Scenario II

In this scenario, the effects of each individual values have been considered. First, two extreme cases have been simulated; all fishers only care about sustainability and all fishers only care about making more profit without considering the situation of the environment.

Scenario II-a

When all fishers are women and care about sustainability (with some probability), the fish species population will be sustainable (4.5). Also, the amount of money that fishers can earn over time is sustainable (4.4).

Scenario II-b

In this extreme case, only men are going to fish and they do not care about sustainability of the environment. Then, after a while, some species will extinct over time. The main

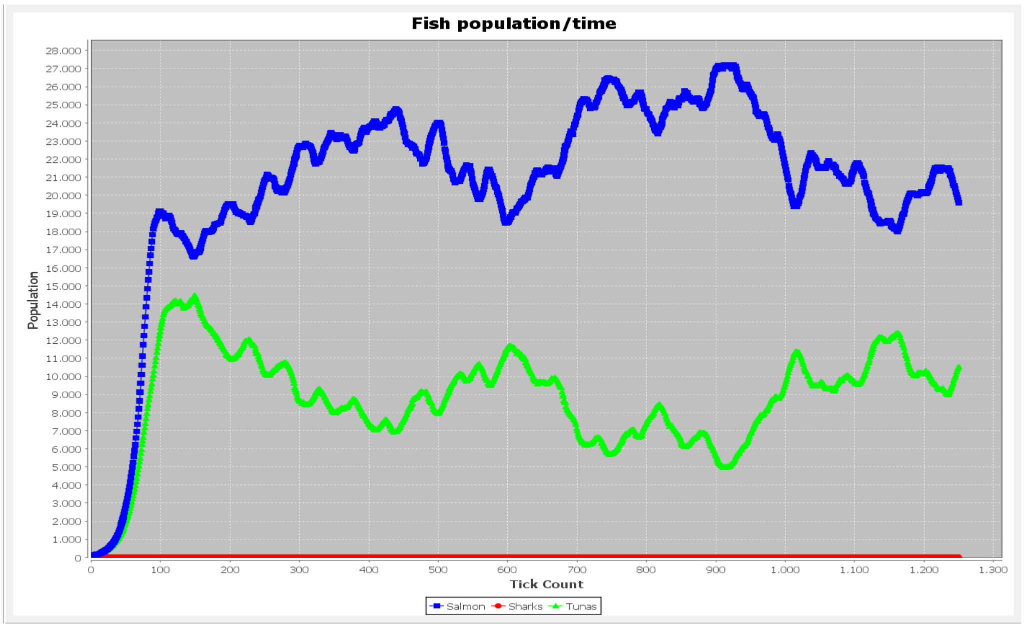

Figure 4.2: no fishers and enough food: All fish species will survive.

reason is the market price of species with less population. The following model has been used to calculate the market price of each species:

Every 12 time step, a new market price will be assigned to fish species which is relative to the previous price, the previous cough percentage, and the current caught percentage.

$$\begin{aligned}\text{Market price} = &\ \text{Initial market price}\\ &+ \text{Previous market price}\\ &\times (\text{Previous cough percentage}\\ &- \text{Current cough percentage})\end{aligned} \tag{4.1}$$

In other words, rare species are more expensive. So, male fishers go hunting them to earn more money (4.6). This situation does not threaten the income of fishers; though, we can see that after an extinction of some species, their income would not grow as much as before (4.7).

Scenario II-c

In this experiment, both male and female engage in on-boat fishing. As a result, we can see that the environment would be sustainable for a long time and all species will survive (4.8). The interesting part of this experiment is that both men and women can make profit for a long time (4.9). And the amount of money that they can make are almost the same and growing rate of their profit is more than Scenario 2-II. It means that sustainable

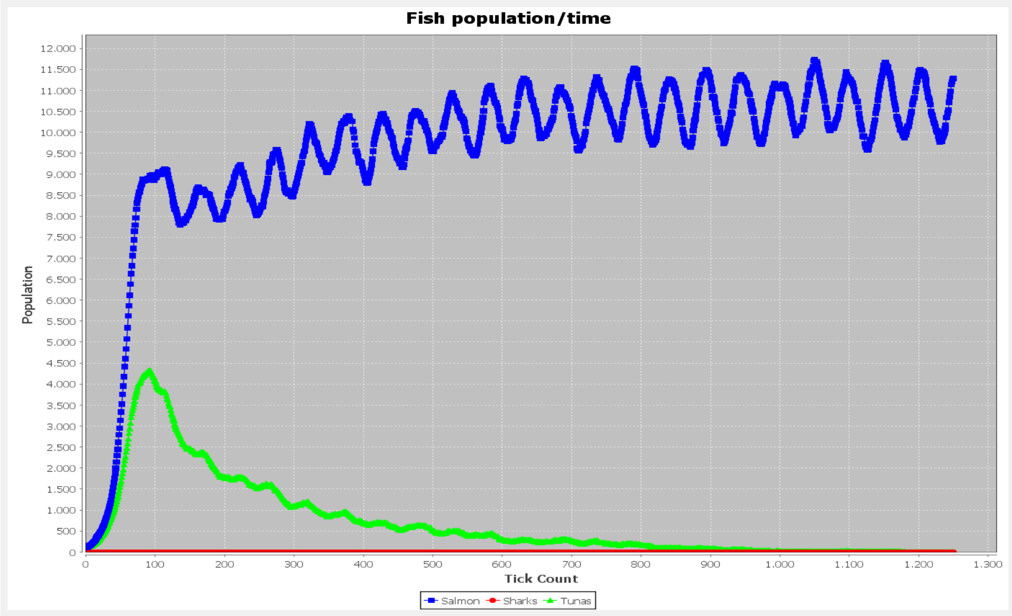

Figure 4.3: no fishers and not enough food: Fish species with less offspring rate will be extince eventually.

environment and sustainable economy can be held at the same time which is an efficient case.

4.5 Conclusion

In this chapter, I addressed personal values and showed how the environment can be affected by them. I used fisheries society as a case study and modeled it using MAS. In this model, two conflicting personal values had been assigned to the human agents (fishers). Simulation experiments showed that how individual values can make change in fish population.

This model is a basic model that includes economic, ecological, and social components. This model will be enriched in the next chapters by considering the mutual impact of social, ecological, and economic system on each other in an infinite feedback loop. Also, considering all the other possible values and more actions will add more dynamic to the system which helps studying dynamic behaviours, the influential factors that change them, and the factors that keep them stable. In the next chapter, I will provide an ABM to study the infinite feedback loop between social, ecological, and economic systems. In the given model, I will consider more complex values for the agents and more actions.

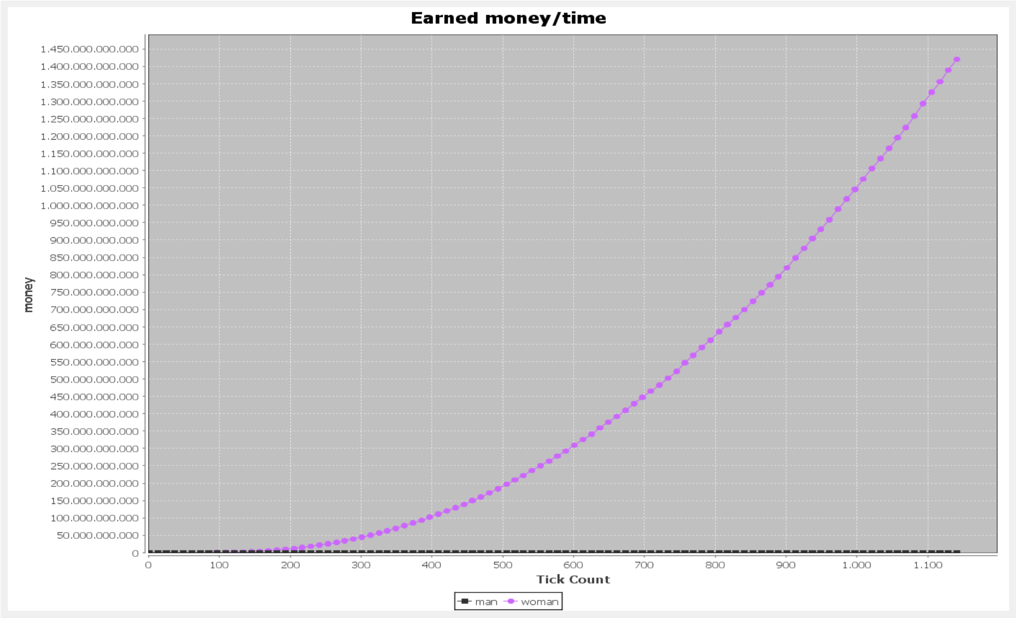

Figure 4.4: Only women do on-boat fishing: All fish species will survive over time and none of the species will not be in danger of extinction.

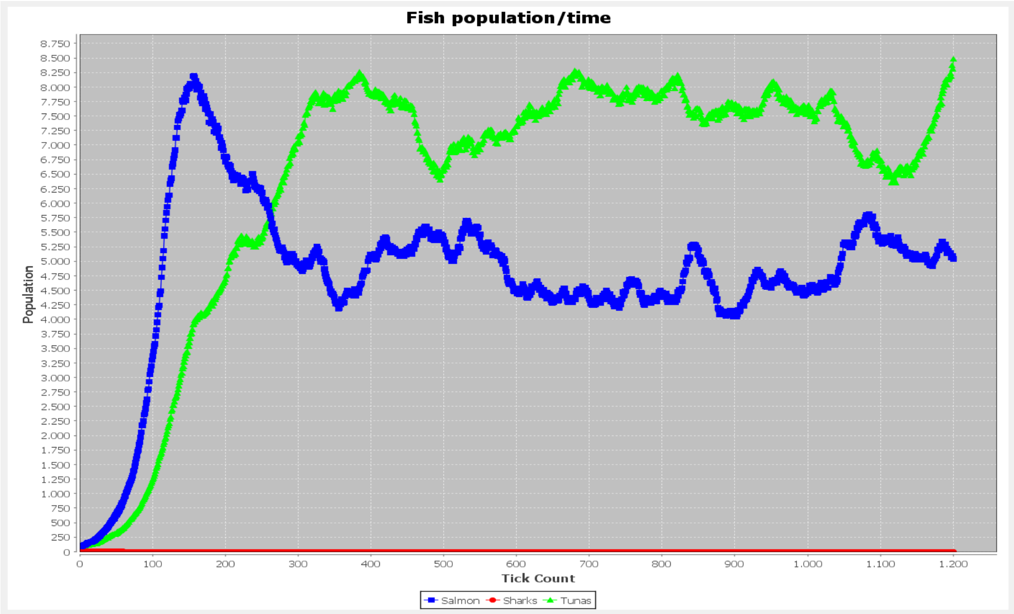

Figure 4.5: Only women do on-boat fishing: Still, they are able to make enough money out of fishing.

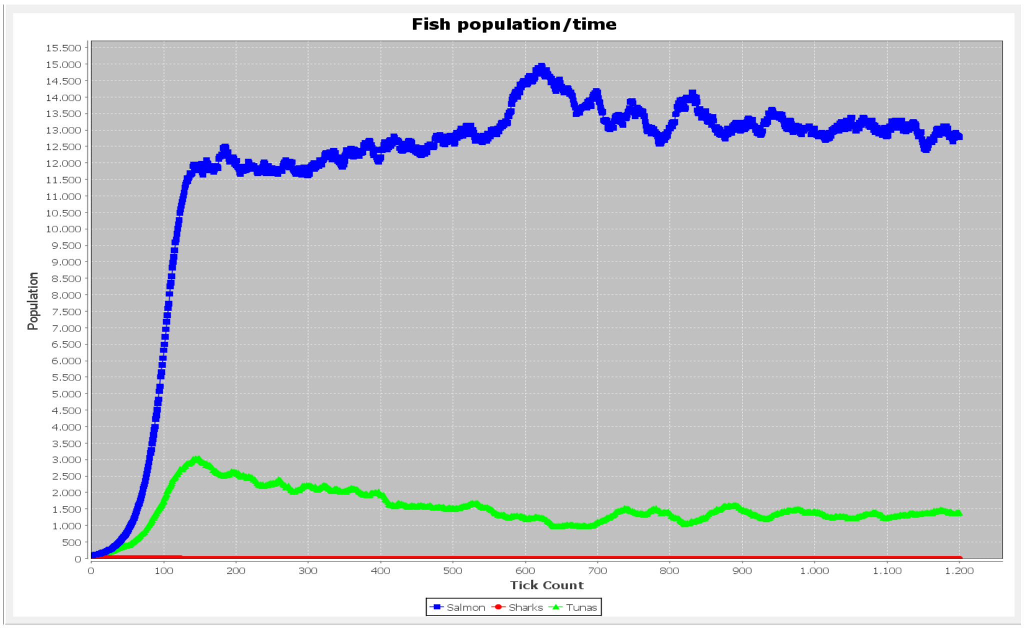

Figure 4.6: Only men do on-boat fishing: Some species will disappear from the environment.

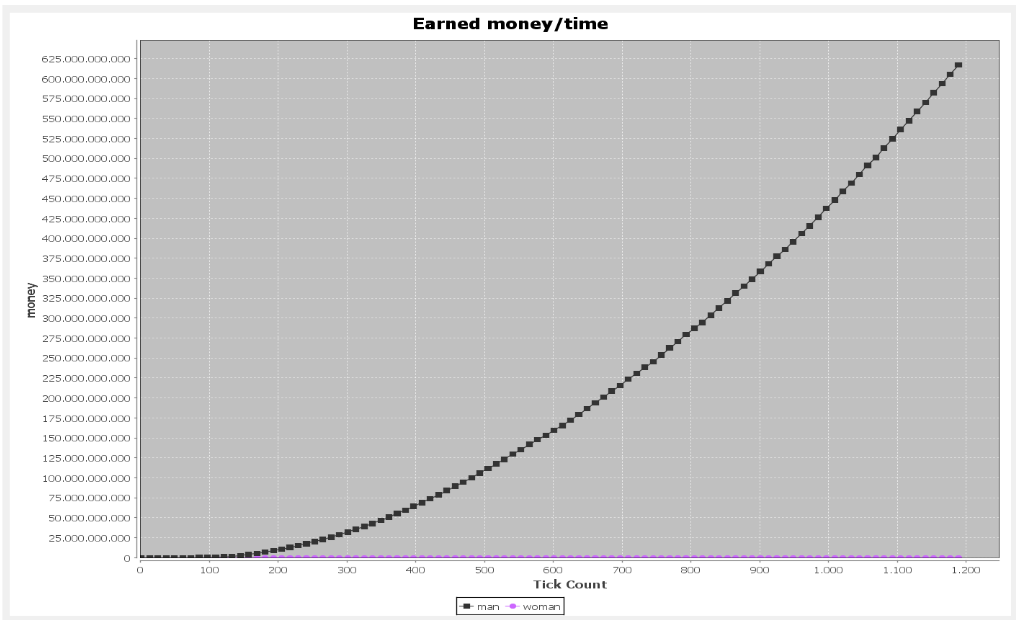

Figure 4.7: Only men do on-boat fishing: the growth rate of earned money is less than previous scenario (Figure 4.4).

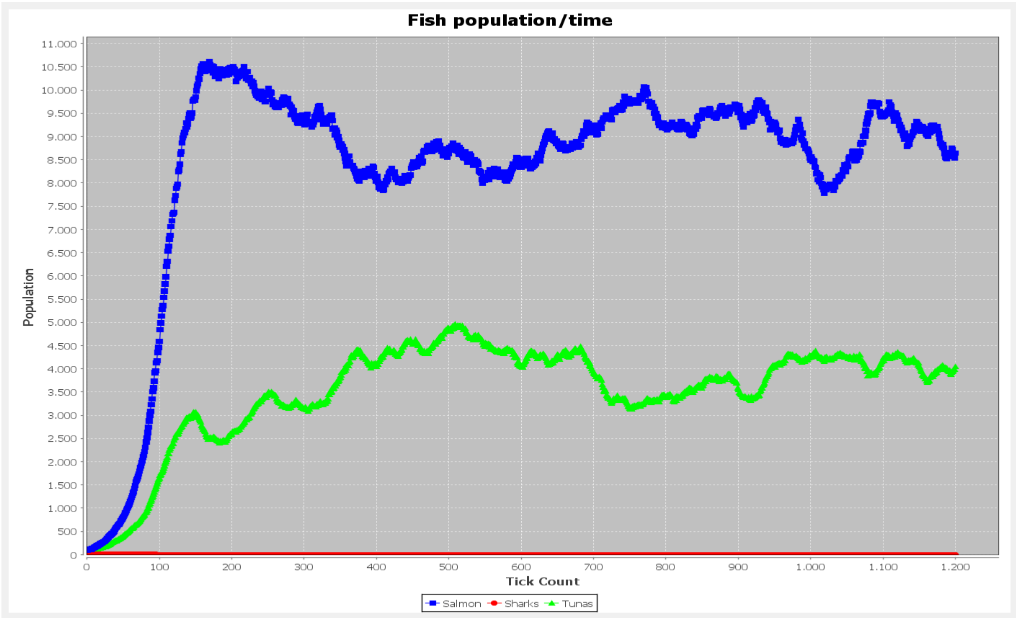

Figure 4.8: Men and women contribute to on-boat fishing: all fish will survive.

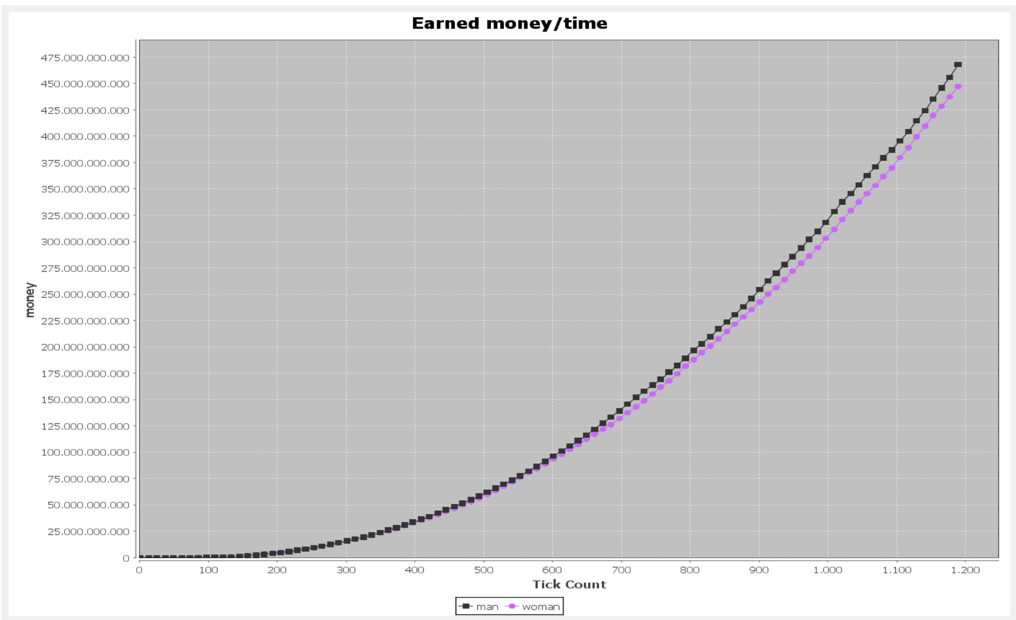

Figure 4.9: Men and women contribute to on-boat fishing: sustainable profit

5

Value based Agents for Social Simulation of Fishery Management

Although there have been many simulations of ecological systems that include social aspects of the persons involved, very little have considered the social aspects of the communities themselves as a separate system. In this chapter, we will integrate social, economic and ecological models in order to simulate a more realistic fishery community. We need this type of integrated model when we want to explore the effects of new fishing policies on these communities. We argue that a value based approach for the agents is essential and show how this can be used to integrate the different systems.

5.1 Introduction

There is quite some research about the complexity of ecological, economical, and social systems (82, 83, 84). In complex systems there are feedback loops which cause the cause and effects of actions to be interdependent and thus small changes can lead to big effects that are difficult to predict. Such feedback loops have been regarded in combination of models, such as social-ecological systems, social-economical systems, and ecological-economic systems (66, 85, 86, 87, 88, 89). However, the feedback loop is usually on one of the ecological or economical systems and social factors are only taken into account to study ecological or economical decisions. In other words, despite the fact that these systems are called socio-ecological, they are ecological models with some social factors added to them.

In order to really account for both social and ecological phenomena we should take both systems as being full fledged complex systems with their own feedback loops, plus the connections between them. In this chapter, we argue that models of fishing communities

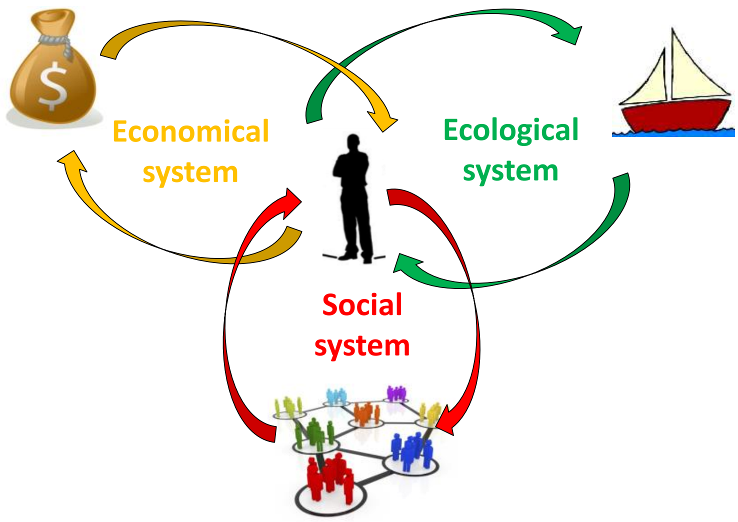

Figure 5.1: Feedback loop in a social, ecological, and economic system

need to have three subsystems: social, ecological and economical. The ecological model represents the interaction of the humans with the physical environment that influences their life most. The social model is needed to model the relations and interactions between the people in the community. The economical model is needed to represent the relation of the community with the outside world (if communities would have a closed economical system this could be incorporated in the social model). The dynamics of such a complex system is driven by feedback loops between these subsystems and within them. The combinations of these subsystems are modeled in many research efforts, whereas only a few of them considered the dynamic interactions and feedback loops between the subsystems.

In this study, we consider the full combination of feedback loops, feedback within each subsystem (social, ecological, and economical system) and feedback between each two of them (social and ecological, social and economic, and ecological and economic systems). In what follows we demonstrate the feedback loops within the social system, ecological system, and economical systems by giving some examples.

People have interactions, they influence each other's behavior, decision, and way of thinking. Waste sorting is a good example. Many people voluntarily contribute to waste sorting by separating their household garbage and help to recycle. It means that they do not get paid for their efforts. One intuitive reason of such a behavior is the desire of being accepted in the community where recycling is an accepted environmentally friendly action (90). Thus, one recycles mainly because it is the norm and everyone does it. In a fishing community, a fisher may decide to fish at least as much as his neighbors, because he feels he has to win the competition and get a high status as a good fisher. In a similar way, a fisherman might feel he needs to invest in a new boat when all the other fishers in the community are doing so. He does not want to be seen as less modern than the rest.

In addition, people have interaction with the environment. For instance, they use the facilities provided by the environment (i.e. water and food). They affect the environment through over-using or misusing of the resources and dumping of industrial wastes in the ocean. They will react to the environmental changes. There is previous research modeling socio-ecological systems in various fields, such as fishery, land-use, and agriculture. Hunt et. al (91) present a socio-ecological framework and illustrate the connection between the fishers' actions and the environment with several examples. One of the main impacts of the fishers' actions is changing the fish population. According to (91) the management challenge is to consider fishers' desires and fish population at the same time .

Furthermore, general economic conditions and decisions affect the financial situation of all units of a society (companies, families, individuals, etc.). The financial situation is one of the important factors that plays a role in people's decisions. As an example, fishing companies that make a high profit can increase their quota by buying more from fishers. High demand for buying quotas can increase the price of quota. Thus, it could be more profitable for fishers to sell their quota and move to a cheaper country to enjoy a comfortable life.

The result of the system as a whole evolves based on the feedback loops and interaction between all subsystems and people as shown in Figure 5.1. We discuss how values can be used to link the decisions of people in the different subsystems 5.2 by making them concrete in each context. Such a context needs to be appropriate to study the importance of taking into account all the subsystems and their interaction in a good balance. The basis of our simulations is fishery (92, 93).

One can see that the people are the connecting pin of the systems Figure 5.1. It is important for people to keep the overall system in a good balance. Symes and Phillipson (94) claim that many small scale fishing communities may not be viable in the long term; lack of balance between all the subsystems of their life is one of the key reasons. They suffer from lack of local facilities, such as school, hospital, housing, and limited access to public transport (94). These facilities cannot be provided for small communities due to the economies of scale. In this case, people have to leave the village, even though they have strong social connections and they experience a healthy environment. For individuals with a lot of money but no social relations the choice to leave becomes even easier. They will move based on economic reasons and build up new social relations in another community. (This might happen to fishers who sell their quota and are seen as traitors of the community). We claim that the way that people balance the different aspects of their life (the aforementioned subsystems) and make consistent decisions over all subsystems is through the use of abstract values that underlie all decisions in the end. Thus we need to model these values in the agents of our simulations if we take more than one aspect of life into account.

We will discuss the use of values in the next section. In section 3 we discuss the model that we build using value based decisions. In the section after we discuss the different types of influences that can be modeled based on our value based agent model. We show the first results of our simulation that indeed show some of these influences and how they affect the balance of the complete system. We conclude with some conclusions and directions for future research.

5.2 Values

In order to connect the social system with economic and ecological systems, we propose to use agents with values. These values are defined in line with the Schwartz' value model (28). Values are criteria to evaluate actions and events (6). In our model, we use this definition and let the agents have a different ordering of values (priorities) which are considered into their decisions.

Each value has a different concretization in different situations for each agent (30). For example, universalism in Schwartz' value model can be made more concrete when it motivates the importance of protecting human life or even more concrete supporting refugees. It can also be made more concrete into respecting the environment (95). In other words, the concrete effect of values is context dependent.

Agents have their own private priorities of values. They will decide what is the best action in each situation based on their value ordering. For example, if a fisher prefers hedonism over universalism, he might decide to fish more expensive species even if it is a threatened species.

It is worth mentioning that, the salience of a value depends on the situation, while the value ordering for each agent does not change over time. As an example, consider a situation where there is plenty of fish. The universalism value is not very salient for a fisher in that case. No matter how much he fishes the environment will not suffer. This changes drastically when there is not enough fish. In that case, the fisher has to balance between catching enough fish to survive himself and not too much in order for the fish to survive.

Value		Definition
Benevolence	:	preserving and enhancing the welfare of those with whom one is in frequent personal contact (the 'in-group')
Universalism	:	understanding, appreciation, tolerance, and protection for the welfare of all people and for nature
Tradition	:	respect, commitment, and acceptance of the customs and ideas that one's culture or religion provides
Hedonism	:	pleasure or sensuous gratification for oneself
Self-Direction	:	independent thought and action;choosing, creating, exploring
Achievement	:	personal success through demonstrating competence according to social standards
Power	:	social status and prestige, control or dominance over people and resources
Conformity	:	restraint of actions, inclinations, and impulses likely to upset or harm others and violate social expectations or norms
Security	:	safety, harmony, and stability of society, of relationships, and of self
Stimulation	:	excitement, novelty, and challenge in life

Table 5.1: A brief definition of the Schwartz' values

In accordance with Schwartz's theory of basic values (28), agents in our model have the following values: power, self-enhancement, universalism, benevolence, hedonism, tradition/conformity, and achievement which are the most relevant to the ecology and economy. Furthermore, these values can show the incompatibility of satisfying values simultaneously. The meanings of each value provided by Schwartz, which were described in chapter 3, are also listed in table 5.1.

In order to use these values in the simulation we decide upon the use of a set of more concrete values that are kept as minimal as possible while still covering all subsystems. Each adult agent that has family takes care of them (hedonism and benevolence). Having an income is important for each adult agent and promotes social status (power), but also can promote the financial support of family members (hedonism and benevolence), etc. Continue fishing against adversities, which is happening in many small fishing communities, promotes tradition and conformity. Adult agents prefer to work in a job according to their education and skills, as this promotes achievement. Taking care of the environment and engaging in public benefit activities are two other concrete values that agents have and which promote universalism and benevolence. Adult agents want to be financially independent as this promotes self-direction. The above indicates the set of values that all agents will in principle consider (when salient) in their decisions. Which decision is taken depends on the priority of the values.

For example, all the agents want to have income. But some will also prefer more income over a healthy environment. In the fishery environment, fishers try to catch fish as much as possible (based on their available facilities). In the case that there are some species which are in danger of extinction, those fishers who prefer the value of "taking care of the environment" more than "making more profit" will choose to catch fish from other species. Fishers with the value preference of the environment more than money, check the environment advocacy NGOs suggestion, advisory rules, and observe the environment before making a decision.

In the next section we will describe the role of values in our model.

5.3 Model description

We develop a multi-agent model that includes different types of agents and an environment (i.e. common resources, market, and facilities). This simulation includes human agents, fish species, a market place, a factory (that buys and preserves fish), and a university. The agents and their interactions with the common resources, market, and each other makes a socio-ecological-economical complex system. In this section we only describe the main characteristics of the model as space does not permit describing all variables.

Human agents grow up, give birth to children, work, are being retired, and die. The status of an agent in each time tick is an element of the set {*child*, *retired*, *fisher*, *factory employee*, *jobless*, *employee outside the community*}. We will discuss the actions of the agents in a separate section later on.

For the sake of simplification, we followed Bousquet approach (96) and consider three types of fish species. *Small* species eats plankton, *Big* species eats *Small* and plankton, and *Predator* species is predator and eats *Small* and *Big* species. All fish species grow up, create offspring, eat, swim, and migrate.

In order to introduce sustainable behavior we introduce an agent that plays the role of adviser. This agent observes the whole ecological environment and determines which species need to be taken care of, which species are forbidden to catch, and which species are allowed to catch. Having this agent means that we do not need every agent to calculate the consequences of catching fish, but only distinguish agents in whether they follow the advise or not.

The Market is a place to buy and sell fish species. Based on the availability of fish species in the market and in the environment, the market price of each species will change according to supply and demand.

The Factory represents all industry in the community that is fish dependent. It buys fish from fishers, processes them, and sells it to the market. The factory employs people. There are limited vacancies for higher educated people as well (10% of regular vacancies). The factory increases or decreases the number of vacancies based on the available fish (caught fish by fishers) and its profit. The factory makes money from selling fish to the market and spends money for paying its employees' salary and utility costs. The factory has to accomplish maintenance periodically. If it cannot make enough profit, it gets subsidized with the public savings. If the savings cannot cover the deficits, it starts firing its employees until it reaches the minimum required number of employees. If using the public savings and firing employees do not save the factory it declares bankruptcy.

In this model, agents have all the values mentioned in section 5.2; including power, self-enhancement, universalism, benevolence, hedonism, tradition/conformity, and achievement. However, the priority of each value is different for different agents. For example, for male agents the importance of "making money" is higher than women (in average) due to the fact that most of the time men are responsible for financial support of the family (an empirical fact in these communities, not a desired one!).

Adult agents decide about their action in each time tick. Adult agents can continue their education at the university. They decide to continue or change their job status. The job can be inside or outside of the community. The jobs inside the community include $\{fishing, \textit{factory employed}, \textit{retired}, \textit{jobless}\}$. There are two types of *factory employee*s, high ranked and regular. Without loss of generality, we consider only one type of job outside of the community with a fixed range of salary.

5.3.1 Agents' action

In each simulation time tick, each human agent acts as follows:

- Step 1. Working to earn money for agents aged between 18 (child) and 70 (retired);
- Step 2. Deciding to change or continue the current status that is only possible for agents aged between 18 (child) and 70 (retired);
- Step 3. Giving birth to a child that is only possible for agents aged between 18 (child) and 70 (retired);
- Step 4. Calculating the current time tick living cost;

- Step 5. Calculating the current time tick profit;
- Step 6. Deciding whether to invest in public benefits.

Except fishing, a fixed amount of salary is assigned to each job before starting the simulation. High ranked factory employees need to be higher educated and their salary is higher than regular employees.

Fishers need to fish and sell the fish to the factory or market in order to earn money. Fishers decide how much fish to catch, what are the target species, and which gears to use. To make such a decision, they take into account the ecological situation (advisory rules and their observations) and their personal values. Each agent has a parameter, called survival intention (SI), that shows how much is its intention to protect the environment. SI is a random number between 0 and 100 assigned to each agent when it is created. Maximum capacity of catching fish of each agent is determined according to its gear and physical power. Each fisher agent detects all the available fish according to its gear. Fishers check the market price and the advisory rules of all species at the start of each time tick.

If $SI = 0$, the agent starts catching fish from the most expensive available fish species that are not forbidden to catch. It continues catching fish until it has no more capacity. If $SI > 0$, the agent cares about the environment. Thus, it takes into account the advisor agent and its observations. Starting from the most expensive specie, the fisher agent hunts fish if the agent does not consider a significant decline in the population of that species and if that species is allowed to be fished. If that species is allowed to be fished, but their population decreases based on the agent experience, the fisher agent catches at most $(100 - SI)\%$ of them. In addition, if that species needs to be taken care of based on the advisory rules, the fisher catches at most $(100 - SI)\%$ of them.

In the second step, each agent checks whether it earned enough money (at least their living cost) out of the current status in the previous time tick. If the current status does not satisfy the basic living requirements, the agent decides to change the current status as described in Algorithm 1.

To change the current status, first the agent decides whether leaving the community or staying in is more preferable. This selection occurs based on the agent's personal value of intention to stay inside the community(ISI), where ISI is a real number between 0 and 100.

Algorithm 1 Changing status of an agent based on its personal values

```
set A ← {}
rand ← random real number between 0 and 100
if rand < ISI then
    set A ← {jobless}
    if fishing is thriving & there is a vacancy for a new fisher then
        A ← A ∪ {fishing}
    if agent is high educated & factory has a vacancy for a high educated then
        A ← A ∪ {factory employee}
    if agent is not high educated & factory has a vacancy for a regular then
        A ← A ∪ {factory employee}
else
    A ← A ∪ {employee outside community}
new status ← select an element of the set A
```

When an agent is born, the maximum number of children, in its lifetime is assigned to it. In each time tick, each adult agent with the probability of 50% gives birth to a child if its number of children does not exceed its maximum number of children.

Personal living expenses for each agent is represented by a number which is assigned based on its age and status. Each adult agent takes the responsibility of supporting its underage children, its university student children, and its jobless children. Therefore, the agent's living expenses are calculated by adding its children living expenses that are under its guardianship and its personal living expenses.

The current time tick profit of each agent is the amount of income that remains after living expenses and additions to public savings. Each agent may donate to the public savings from its profit according to a donation rat. The donation rate is a fixed real number between 0 and 100. Its value is determined before starting the simulation. The agent adds the current time tick profit to its saving. If the agent will become jobless or retired, it will use its saving money.

In Figure 5.2 one can see some of the model parameters that can be set (Parameters tab), define output data and charts (Scenario Tree tab), and control the running options (Run Options tab). The main window shows the fishermen at sea and the different types of fish. In the next section we will show some of the results of the simulations.

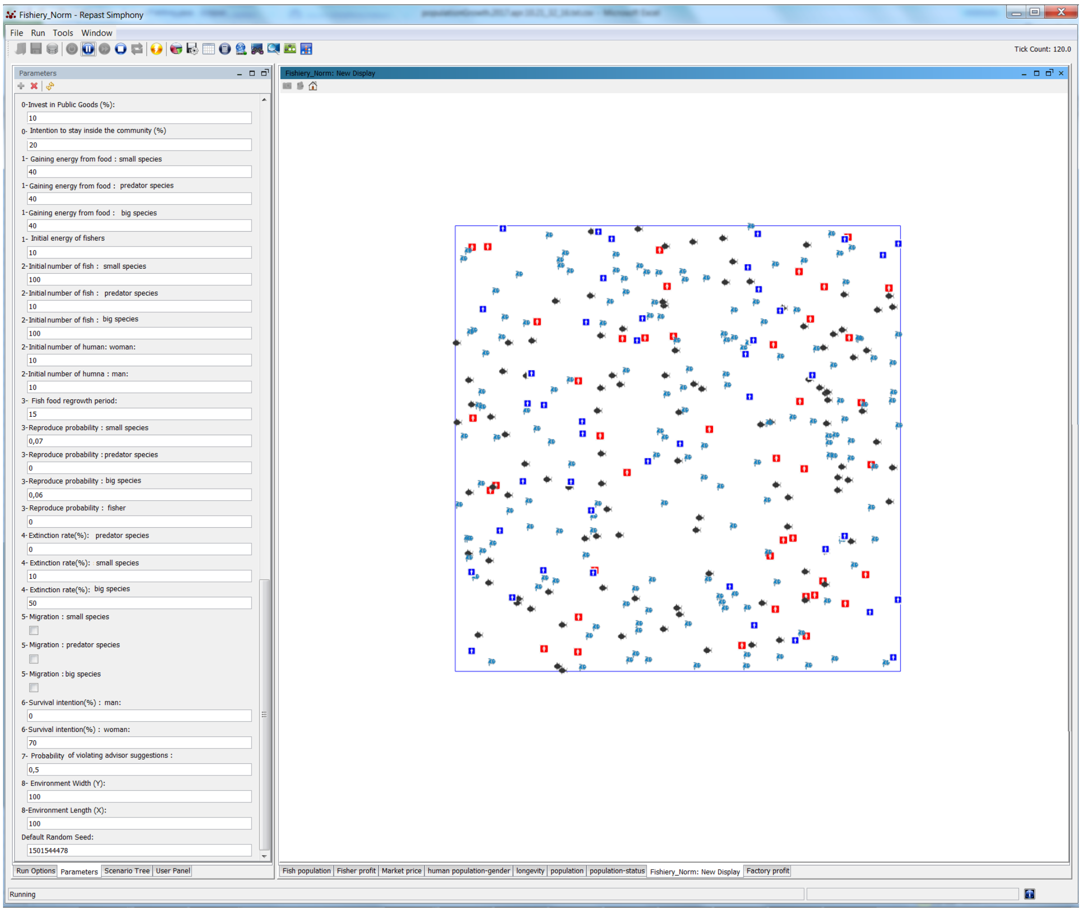

Figure 5.2: Screenshot of the fishing simulation

5.4 Simulation experiments

In this section we discuss why considering feedback loops between all of the three aforementioned subsystems (social, ecology, and economy) is important. We design several simulation experiments in order to study the dynamicity of the feedback loops within and between those subsystems.

We model the complex system, that includes all subsystems, using Repast (97). As shown in Figure 5.2, this model contains a lot of parameters that allows users to control the model. These parameters are the initial configuration of the simulations. For example, parameters for the human agents are initial female population, initial male population, probability of increasing fisher's population, survival intention for each gender, and probability of violating a rule.

We perform our simulation experiments for value based agents as mentioned before. For these agents some values have high priority. The concrete values with high priority include supporting family members, having income, and finding a job according to education. We change the other values in each simulation experiment to compare the result in order to study the impacts of those values on the whole system. We make changes in social variables (intention to stay inside the fishing community, care the environment, and donate for public benefit), ecological variables (fish species population by changing the offspring rate and available amount of food for fish), and economic variables (sensitivity of the market price of fish pieces to fish population and available amount of fish).

We start with calibrating the operation of each subsystem. In order to isolate one subsystem, the other two subsystems are considered in the extreme conditions that their changes are ignorable and have no effect. The extreme conditions contain infinite fish, infinite job vacancies, infinite money, fixed market price, and no human agent in the environment. However, it is not possible to completely isolate each subsystem from the others in this special model. For instance, the economic variable, market price, is connected to the available amount of fish in the market and estimation of fish population in the environment.

Running the simulation repeatedly and displaying the average result is a common approach of showing simulation results. We do not offer the average result since averaging the simulation results might exclude certain critical features. Instead, each simulation scenario was repeated numerous times to ensure that the overall pattern of the runs remained consistent. In this chapter, all of the figures represent the outcome of a single simulation run to provide a comprehensive description of the system's behavior.

Figures 5.3, 5.4, 5.5, 5.6, 5.7, 5.8 represent contribution of the three subsystems (social, ecology, and economy) to emerge the whole system situation over time. In these figures, we have four sub figures that depict:

- fish species population over time,
- average profit of the fishers over time,
- human agents population, separated by their job over time,
- fish species market price over time.

Each of these sub figures shows the status of each sub system (economy, ecology, social) over time. Therefore, the sub figures clarify the feedback loops occur between all the subsystems. In each of the following simulation experiments, one parameter changes and the other parameters remain fixed in order to make it possible to compare the simulation results. The parameters involve fish population (that is controlled by offspring rate, the available amount of food, and initial fish species population), tradition value (ISI), universalism value (SI), and benevolence value (donation). The market price of each fish species is a function of two elements; the amount of available fish in the market; and the estimation of the available fish in the environment. There is a sensitivity rate that defines how much the market price is sensitive to the changes in those elements. The sensitivity rate is set to a high value in all of the experiments.

Figure 5.3 illustrates the situation that there is not much fish. Additionally, most of the agents do not care about the environment and do not donate to public benefits. Staying in the community has a high priority for most of the agents. As the fish population is not high, there is less opportunity for being a fisher. All of this makes it difficult for the factory to survive because it cannot buy enough fish and there is no external source of money (i.e. subsidy from the public savings). Thus, the number of jobless agents increases. Also, fishers catch the most expensive species that causes decreasing its population. Decreasing the population of the species results increasing its market price. As universalism has a low priority for most of the agents, the number of the most expensive fish species gradually decreases over time. Fisher agents do not fish cheaper species because there is not enough of them in the environment to satisfy the cost of fishing and living. In addition, fisher agents have to take their caught fish to the market (if the factory is bankrupt). In other words, they have to spend some time off-boat in order to sell their products. During this time period, they are jobless. When there are fewer fishers, there will be less fish in the market that results in increasing market price. This situation is a reason for making the fishing marketable, even if the amount of caught fish is not high. The feedback loops continue like this ever after.

According to Figure 5.4, if a lot of agents are committed to their tradition value as well as universalism and benevolence, the system is in a balance. Agents take care of the environment while satisfying other requirements. Higher priority of universalism and tradition values mean that sustainability of the environment and the community are important for the agents. When the fish population is low, fisher agents do not fish more than they need and fish less than the amount that is harmful for the environment. Such a decision minimizes the risk of fish species population collapse. There is not a considerable change in the available fish species in the market and the environment in each two consecutive time slots. Therefore, the market price does not fluctuate a lot. Comparing Figures 5.4 and 5.7, agents earn money a bit less out of fishing in this experiment (Figure 5.4). However, fishers can fish permanently as fish keeps plenty. The factory keeps operating and gets subsidized when needed. Although most of the agents stay in the community, there is not a lot of jobless agents. The whole system is stable; the market price does

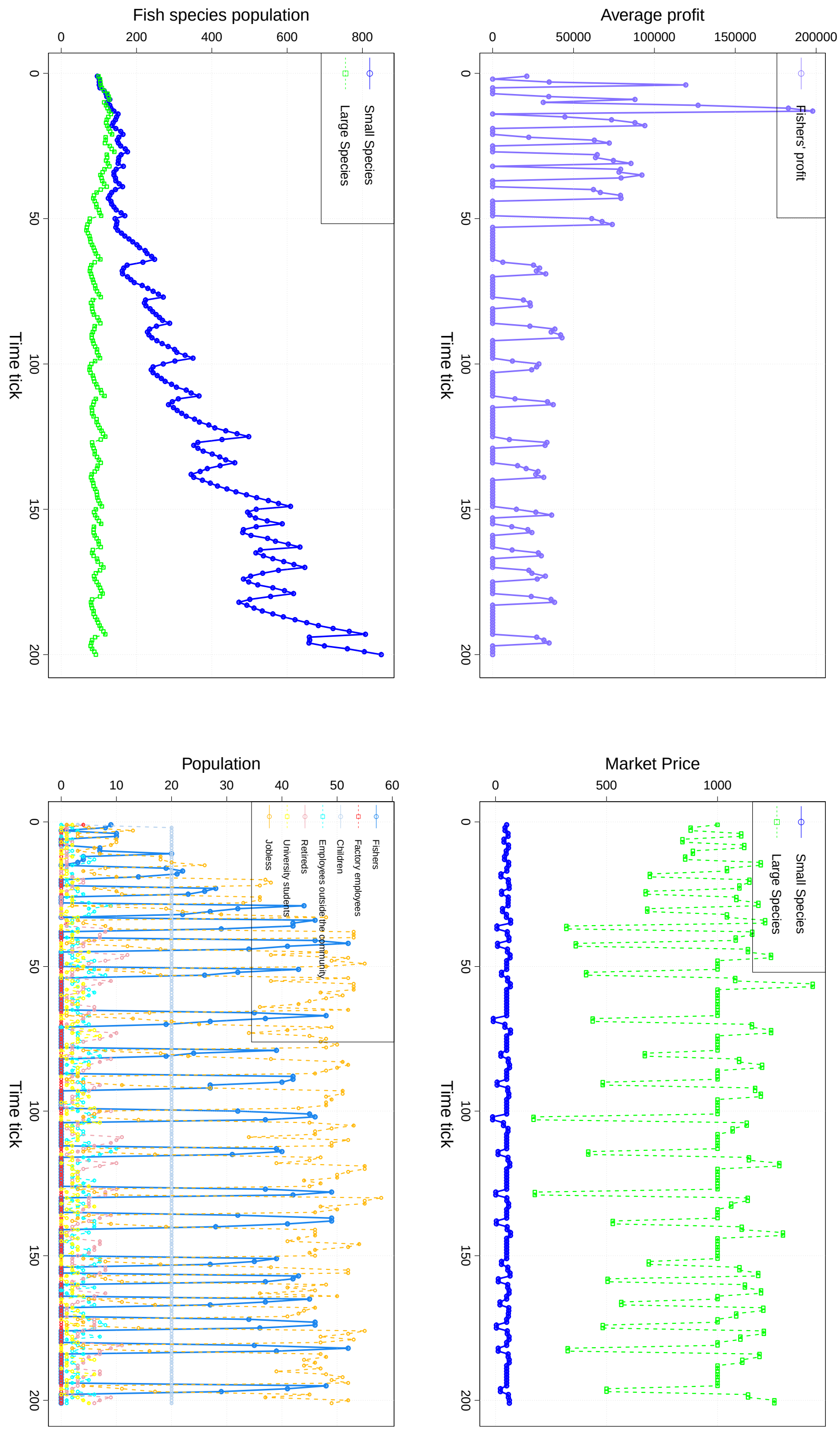

Figure 5.3: Starting conditions are: fish species population is low (initial population, available amount of food, and offspring rate); low priority of universalism and benevolence values ($SI = 0$ and no body donates); high priority of tradition ($SI = 90$). This simulation shows while agents are willing to stay in the community, their personal values do not facilitate sustainable fishing. As a result, the number of unemployed is high, expensive species population decreases, its market price fluctuates, and the economic condition is unstable.

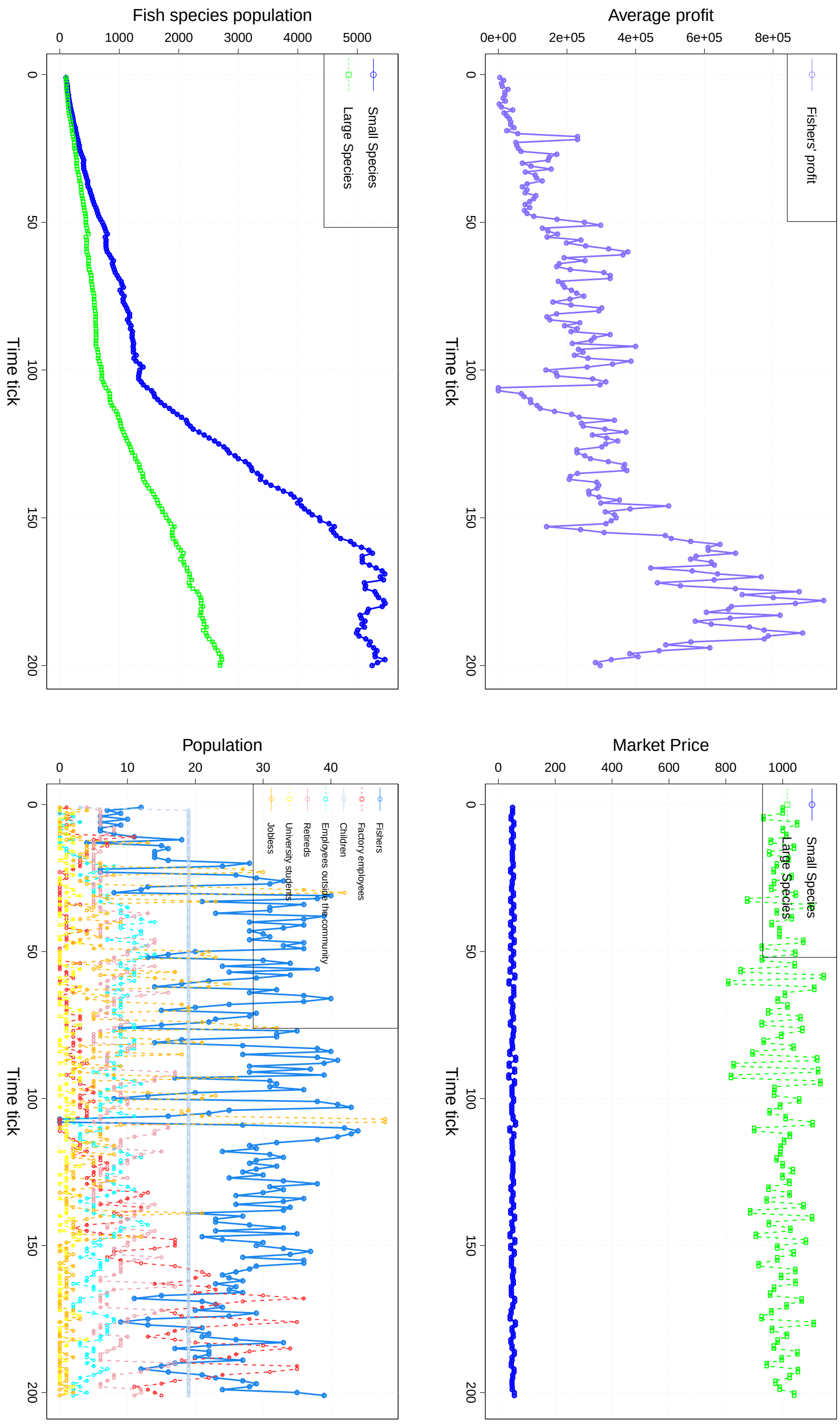

Figure 5.4: Starting conditions are: low fish species population (initial population, the amount of available food, and offspring rate); high priority of universalism and benevolence ($SI = 100$, every agent donates to public savings); and high priority of tradition ($ISI = 90$). These figures show while agents are willing to stay in the community, their personal values facilitate sustainable fishing. Thus, despite starting with a low fish population, fish species may reproduce, market prices are relatively steady, fishers' economic conditions improve, and the number of jobless remains relatively low.

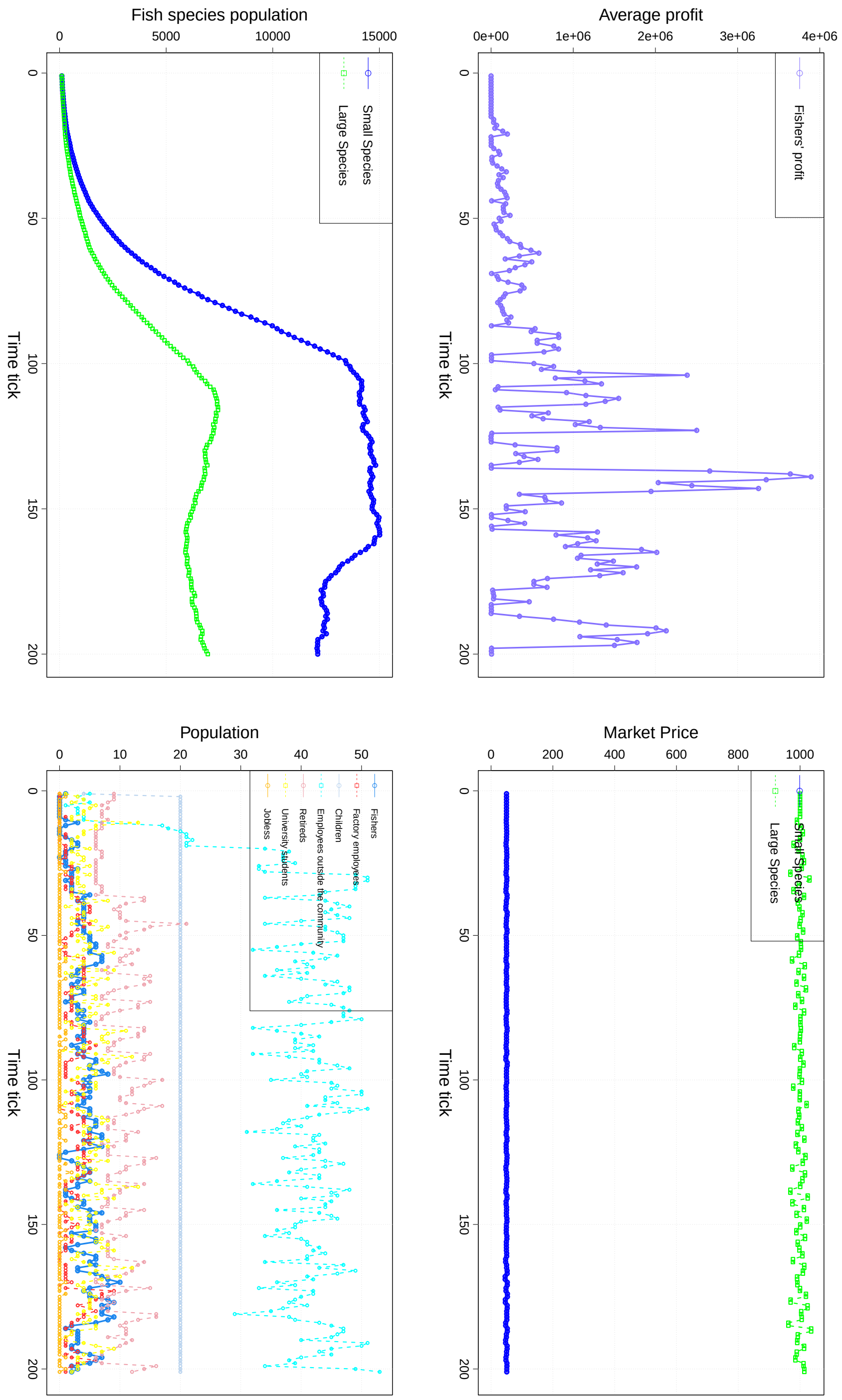

Figure 5.5: Starting conditions are: low fish species population (initial population, the amount of available food, and offspring rate); high priority of universalism and benevolence ($SI = 100$, every agent donates); low priority of tradition ($ISI = 10$). The figures show that agents do not feel obligated to stay in the community and the personal values facilitate sustainable fishing. Thus, despite starting with a low fish population, fish species may reproduce, market prices are steady, average profit improve. Also, the number of unemployed is low; since when there is no job in the community, agents would work elsewhere.

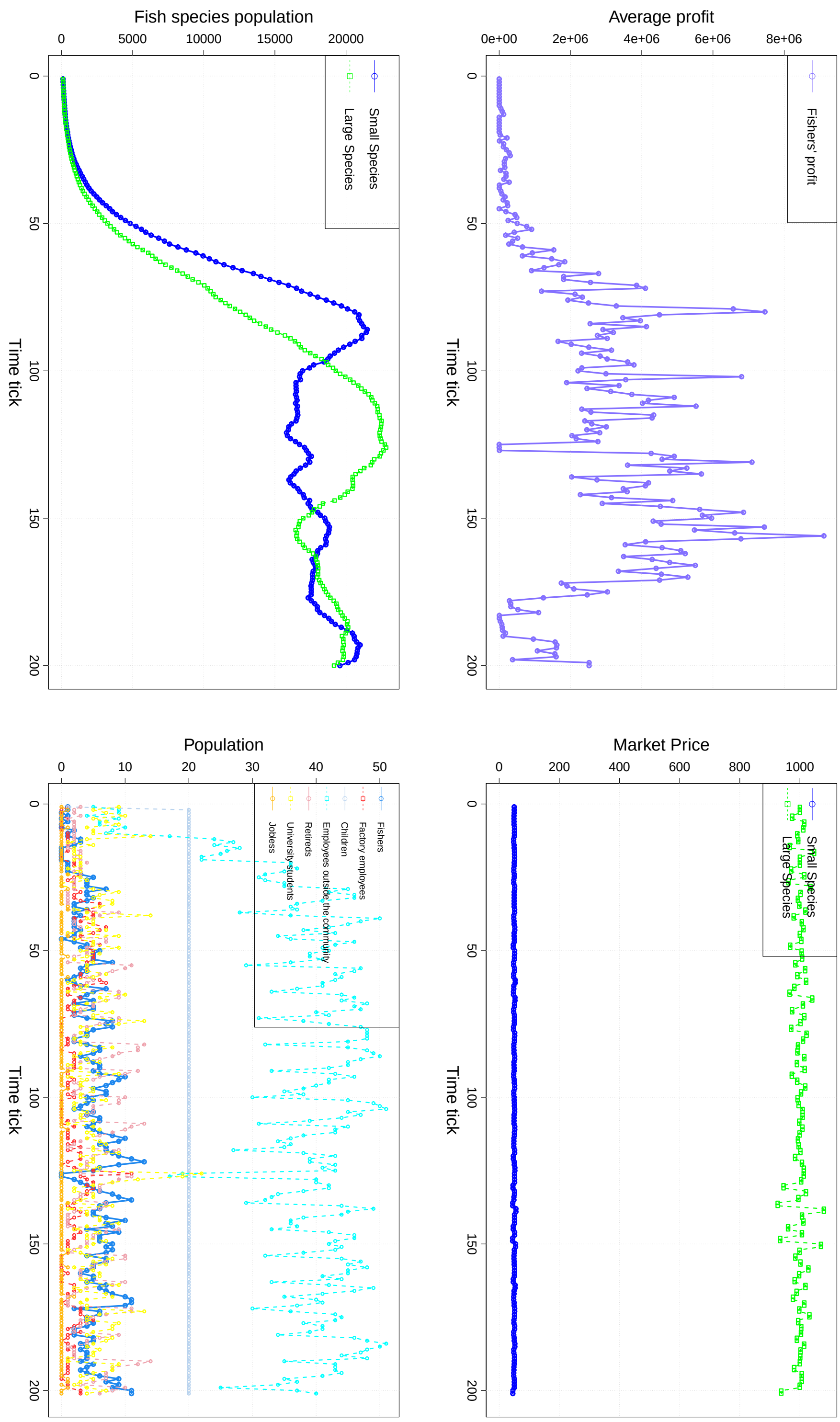

Figure 5.6: Starting conditions are: high fish species population (initial population, available food, and offspring rate); high priorities universalism and benevolence ($SI = 100$, every agent donates); low priority tradition ($SI = 10$). The figures show agents do not feel obligated to stay in the community and the personal values facilitate sustainable fishing. Thus, fish species may reproduce, market prices are steady, average profit improves. Also, unemployment rate is low as agents would find job elsewhere when there is no job in the community.

not fluctuate a lot, the factory stays active, fish species population normally grows, and people stay and work in the community upon their personal values.

Low amount of fish in the environment does not necessarily lead to destroying the fishing community (Figure 5.5). If the universalism and benevolence values have a high priority for the agents, there is a chance that the environment will be stable. Tradition value is one of the factors that influences attractiveness of fishing for the agents. When tradition value has a low priority, fishing is not an interesting job for many agents because fishing is a hard work with low income. Consequently, agents prefer leaving the community to look for a higher paid job. Fewer fishers stay in the community that are committed to the tradition value. Some of them that do fishing can make enough profit. Also, the fishing factory continues its activity with the minimum number of employees. The amount of available fish in the market and the environment does not change a lot. Therefore, the market price fluctuation is not high. During the time that fishing is slack, the factory uses the public savings to survive. In a nut shell, the community is small but remains viable in this experiment. Comparing Figures 5.6 and 5.5 demonstrates that fish population is not the only significant factor that impacts the whole system situation. The only difference between these two simulation experiments is the fish population, though the trend of the whole system is almost the same. The community, the factory, and the market are stable in both simulation experiments.

Increases in the number of fishers does not always lead to a decline in the fish species population (Figure 5.7). If universalism and benevolence have high priority for the agents, they take good care of the environment and their community. Therefore, they are aware of the fish species conditions. They catch fish as long as it does not threaten the environment. As most of the agents have a high priority for tradition value, they prefer to stay in the community. Most of them do fishing and some of them work for the factory. Similar to the experiment shown in Figure 5.4 agents keep working in the town, the number of jobless agents decreases, and the factory operates over time. The only difference is that when the fish population is higher, fishers fish more. The factory earn more profit accordingly which means it has more vacancy to hire more agents.

What will happen if a lot of agents want to stay inside the community and nobody cares about the environment (Figure 5.8). The number of fishers increases and population of the most expensive species declines. Because catching the most expensive fish species is economically justified. Increasing the number of fishers makes more fish available to the market. Therefore, the price decreases. When the price diminished, the fishing is not interesting for many people anymore. Many people leave fishing. Thereafter, the number of available fish in the market decreases which causes the market price to rise.

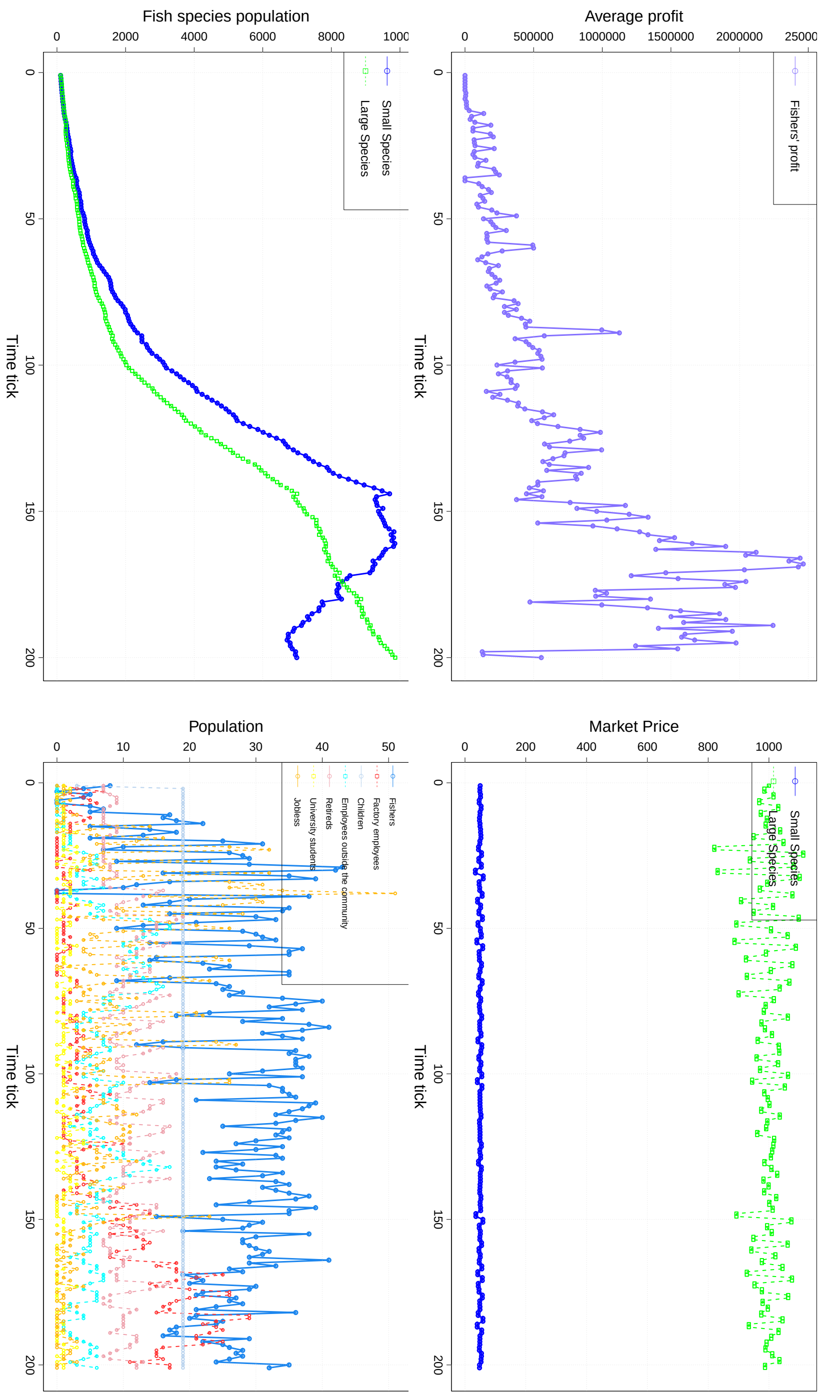

Figure 5.7: The conditions of the experiment is low fish population (initial population, available food, and offspring rate are low); universalism and benevolence have high priorities ($SI = 100$, every agent donates); tradition has a high priority. These figures show agents are willing to stay in the community and the personal values facilitate sustainable fishing. Thus, despite starting with a low fish population, fish species may reproduce, market prices are steady, fishers' economic conditions improve. Also, unemployed population is low as the community's economy can provide adequate jobs inside the village.

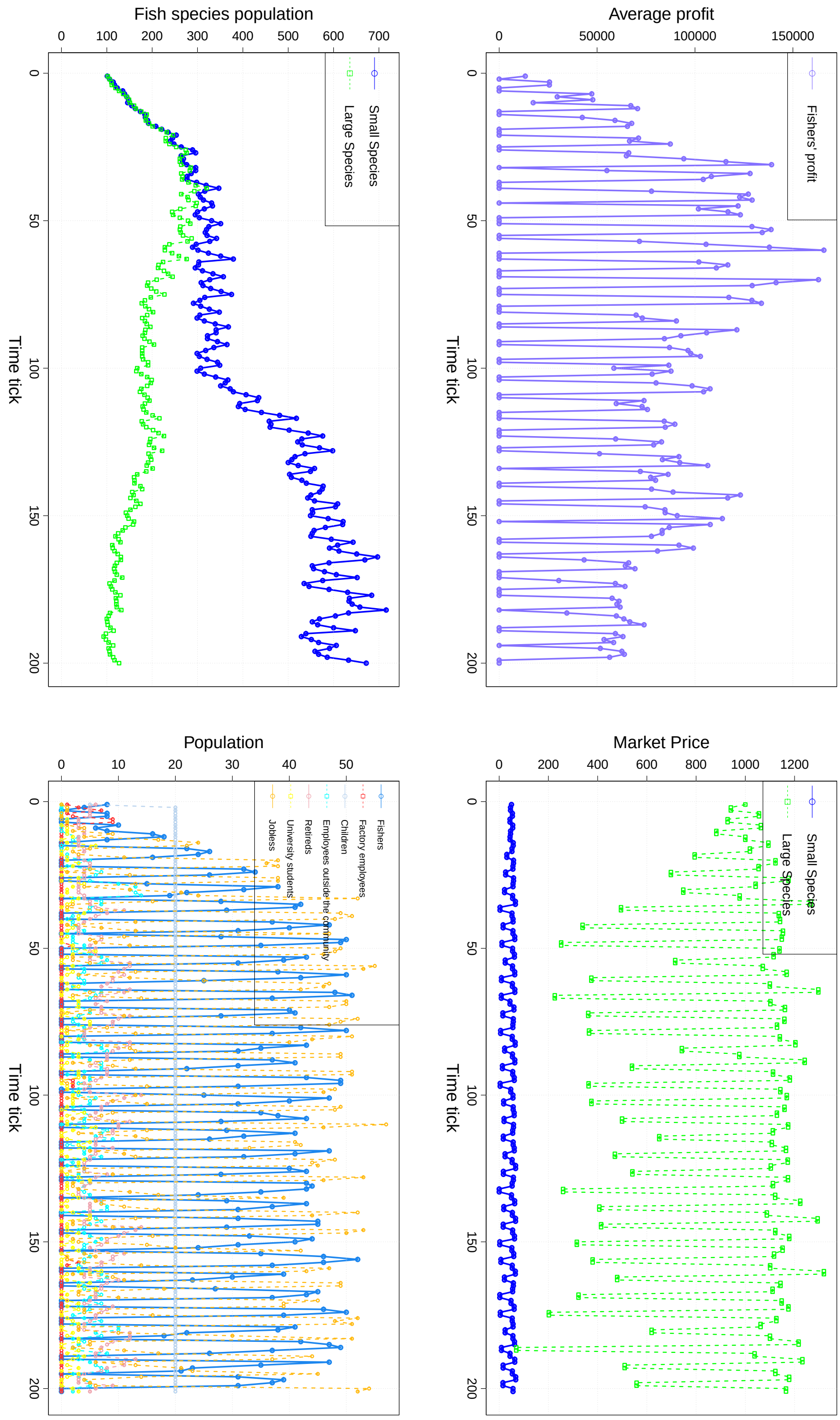

Figure 5.8: The conditions of this experiment are high fish population (initial population, available food, and offspring rate are high); universalism and benevolence have low priorities ($SI = 0$, nobody donates); tradition has a high priority. These figures show agents are willing to stay in the community and the personal values do not facilitate sustainable fishing. Thus, despite starting with high fish population, some fish species cannot be reproduced enough, market prices and economic conditions fluctuate. Also, unemployed and fishers population fluctuates.

This flipping between fishery becoming an interesting job or not causes high fluctuation in the market price. As there is not always enough fishers (and available fish for selling accordingly), the factory does not survive. Additionally, the fishers in each time slot can be different agents. So, fishing communities are not stable and will not invest in the community.

Figures 5.3, 5.4, 5.7, 5.8 depict the importance of taking care of the environment and community. When agents want to stay in the community, their commitment to the universalism and benevolence values are the main effective factors of the whole system. In such a case, the fish population only plays a role in the market price and the profit that fishers and the factory make. If the universalism value has a high priority for most of the agents, it can cause a sustainable environment, a viable community, and a stable economy. However, the community will collapse if universalism has a low priority for most of the agents. Because in that case the fish species population decreases rapidly and therefore there will be much fewer job opportunities revolving around fishing in the town.

According to the results depicted in Figures 5.6 and 5.7, the tradition value is a key factor that determines the situation of the community when the environment is in a normal condition (because of the high priority of the universalism value). Agents prefer to leave the community when the tradition value is not important for them, even if there are plenty of fish available in the environment.

5.5 Conclusion

In this chapter we argued that we need to integrate economical, ecological and social systems in order to simulate fishery communities. In order to integrate these complex systems we use value based agents. Using values the agents can make consistent decisions over the three domains and in that way create a balance between all of them.

In this chapter, we have only shown the initial simulations illustrating some of the intuitive dependencies within and between the different systems. The result of this chapter assisted us to forms a solid basis for more developed simulations which will be explain in the next chapter. This advanced simulation will be useful to explore the consequences of different priorities between values in a community and also the consequences of new policies that either forbid some behavior or give incentives for certain behavior. These policies will interact with already existing rules and norms in the social system, while also having impacts on the economic system and indirectly on the ecological system.

6

A Simulation with Values

Using values as drivers of behavior has already been done in previous research. One of the most well known universal theories of values is Schwartz's theory of abstract values. According to his theory, a universal set of abstract values can be imputed to people. As the values used in his system are very abstract, there is a need to translate the abstract values to more concrete values and assign the behavioral choices to them. A theory or methodology for this step has not been developed in a way that is widely applicable. Thus, a precise way of such a translation is necessary for practical purposes. In this chapter, we design a practical but formal framework that can be used to study the value-driven behavior of agents in social simulations. We make an agent based simulation for a fishery village that uses this framework.

6.1 Introduction

The idea that values are abstract drivers of behavior is not new. What is interesting about the use of values, at least according to Schwartz (21), is that there is a universal set of abstract values that can be attributed to people. Differences between people stem not from having different values, but from giving different priorities to the values. This makes it possible to use values as a starting point to compare behaviors. The downside of the value theory of Schwartz is that the defined values are very abstract and thus not directly related to behavior. Several steps are needed to translate abstract values into more concrete values and ultimately into behavioral choices. The way people concretize abstract values into concrete choices for action can also differ. Therefore, there is a need to describe this whole system in a precise and unambiguous way before it can be used for practical purposes. Some work of formally describing the relation between abstract values and actions, using value trees, has been done (30). Using the ideas and theories presented by Schwartz (21), Weide (30), and Dörner et al. (98), we introduce a logical framework that can be used by actual agents. Then, we show how such a quantitative framework can be used to drive behavior of agents in social simulations.

A note should be made on the applicability of values as drivers of behavior. Not all behavior is primarily value driven. In normal life values usually play an explicit role only in larger (life changing) decisions, while smaller day to day behavior is governed by goals and norms. However, in many social simulations we are exactly interested in situations where people do make life changing decisions, such as moving houses, changing jobs, change for a more sustainable life style, etc. Thus it seems that the framework is relevant for many simulations.

I start this chapter with briefly explaining the value framework introduced in Chapter 3. Then, I illustrate an implementation of the framework in an agent-based model regarding fishery management.

6.2 Reviewing the Value Framework

As explained in detail in Chapters 2 and chapter 3, we use the conceptual theory of value dentition represented by Schwartz (21). As shown in figure 6.1, Schwartz value theory describes the dynamic compatibility and conflicting relation between all the value types by positioning them in a circle. More explanation about the Schwartz circle can be found in Chapter 3.

As it has been discussed in chapter 2 in detail, values and value systems, such as Schwartz's value system, have been used in many research efforts to explore the behavior of a complex system. However, the relation between compatible and opposite values in the Schwartz value circle is not included in any of them. Our model incorporates not only translating Schwartz values into actual values, but also the relationship of values in the circle (Figure 6.1), employing values as a pre-condition (filter), and justifying an action all at the same.

Values can be used at different places in the deliberation cycle of agents to select options (goals, plans, actions, etc.). If agents use goals and norms then the values can be used to prioritize between those. Once goals are chosen and pursued, the values can be used to guide which plan is mostly in line with values. In this chapter we focus on the motivational aspect of values which implies that they are at the basis of action selection. We start with the set of all salient actions (i.e. actions that can be taken at that moment because their pre-condition is true). If there is only one action available no value decision has to be made and the action is performed. If more than one actions are available the

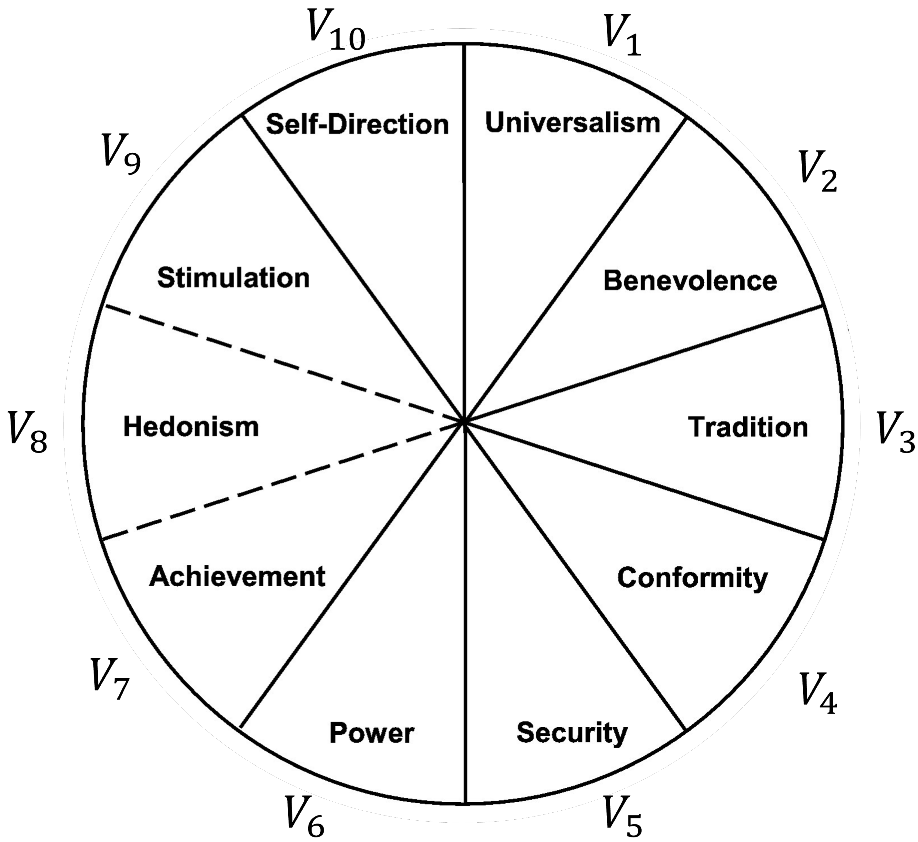

Figure 6.1: Schwartz value circle, categorization and dynamics of abstract personal values (21)

value tree and the current satisfaction of values is used to determine the highest priority of values. Then, the set of actions that are in line with the highest priority values will be chosen. From the resulting set of actions one action is selected based on the current goal, the norms and motives of the agent.

The modeling of circumplex of Schwawrtz is explain in details in chapter 3. Here, I briefly explain the equations and symbols. I defined two sets. The first set is an input set which is a collection of Schwartz abstract values;
$Values = \{V_1, V_2, V_3, V_4, V_5, V_6, V_7, V_8, V_9, V_{10}\}$,
where V_1 = *Universalism*, V_2 = *Self-direction*, V_3 = *Stimulation*, V_4 = *Hedonism*, V_5 = *Achievement*, V_6 = *Power*, V_7 = *Security*, V_8 = *Tradition*, V_9 = *Conformity*, V_{10} = *Benevolence*. The indices are important to determine the position of each value in the Schwartz circle in the framework.

The second set is the amount of importance for each $V_i \in Values$ which is defined as $Importance = [0, 100]$. Any member $V_i \in Values$ can get any value from $Importance$ to indicate how often the value V_i has to be satisfied.

Function $\tau : Values \rightarrow Importance$ that returns the importance of a given value V_i. For salient values $\tau(V_i) = 0$. When $\tau(V_i) = 100$, the agent will try to satisfy this value constantly as it has the maximum importance.

There are two conditions that have to be always true to satisfy the relation between the values. The following condition shows the importance of any member of $Values$ are more related when the values have closer indices.

$$\text{Condition 1: } \forall i, j \in 1..10 \ : \ 0 \leqslant |\tau(V_{\mathrm{i}}) - \tau(V_{\mathrm{j}})| \leqslant m_{i,j}, where :$$

$$m_{i,j} = \begin{cases} |i-j| * c & \text{if } |i-j| \leqslant 5 \\ (10 - |i-j|) * c & \text{if } |i-j| > 5 \end{cases}$$

c is a constant real number between [1..100] and is a multiplier that shows the maximum difference of assigned values to each two successive values in the Schwartz's value circle. 5 is the number of abstract values in one half of the Schwartz circle which is the maximum distance between two values.

The second condition models the the conflicting relation between values.

$$\text{Condition 2: } \begin{cases} \tau(V_i) > 50 & \text{if } \tau(V_j) = 0 \\ 100 - \frac{c}{2} \leqslant \tau(V_i) + \tau(V_j) \leqslant 100 + \frac{c}{2} & \text{if } \tau(V_j) \neq 0 \ \& \ \tau(V_i) \neq 0 \end{cases},$$

$$\text{where } j = (5 + i)\%10.$$

Many alternative value distributions are available with these two conditions. For example, it is feasible to have all values with equal importance as well. Also, it is possible to have some values that do not play a role in the system ($\tau(V_i) = 0$). In the validation of the framework, I show how this feature can be used in a simulation.

6.3 Value based selection

6.3.1 Value satisfaction

In the Schwartz theory, the set of values contains ten values that humans consider in their life. These values impose a personality on a person. What makes a different personality is a different importance of values. As an example, consider a CEO of a multi-national and an employee of a Non-Profit Organization (NGO). The NGO employee will do more activities that are in line with the *Universalism* value and the CEO will do more activities that satisfy *Power*. But, that does not mean that the NGO employee does not do any activity towards *Power*. The difference is in the frequency and types of actions of satisfying the values. But, all the values need some level of satisfaction from time to time.

In other words, values have a level of satisfaction in addition to the importance. It indicates that people must occasionally fulfill all of their values. But, the frequency of satisfaction differs due to their personal values. Function $\tau(V_i)$ shows the importance of a value which indicates how often value V_i needs to be satisfied. Therefore, there is a need to consider satisfaction level in the framework as well.

To model these dynamics, we use the water tank model represented by Döner et al. (98). We consider one tank for each $V_i \in Values$. The water tank model is visualized in Figure 6.2. Each agent has ten tanks, each with the same capacity and the same draining level. Each tank has the following base parameters: fluid level λ_i where $0 \leq \lambda_i \leq 100$ to indicate how much the value is satisfied, the value thresholds (shown with red line to indicate the importance level, $\tau(V_i)$), and the threshold deviation $\rho(V_i)$ where $0 \leq \rho(V_i) \leq 100$ to indicate when a value gets salient.

In this water tank model, the fluid drains every time step with a fixed amount of 5 to indicate that the value satisfaction is time dependent and increases when the agent does an action which is in line with the value. To be able to model the differing priorities of values of an agent we use the threshold and calculate the priority. Agents try to fill up the tanks with the highest priority first. Priority of values is determined by using the following equation:

$$\rho = -((\lambda - \tau(V_i))/\tau(V_i)) * 100$$

We use negative sign as the priority of value satisfaction has reverse relation with its filled level. Filling up the tank can be done by performing actions that satisfy the abstract value connected to the tank. The increase amount is given by $(100 - \tau(V_i)) * \sigma$. This formula makes more important values fill up slower, thus the agents have to perform more related actions to satisfy those values. It is possible to assign different values to multiplier σ for different actions. For example, buying a house usually has a larger effect on your values than buying an ice cream, and thus has a larger multiplier σ for more impact.

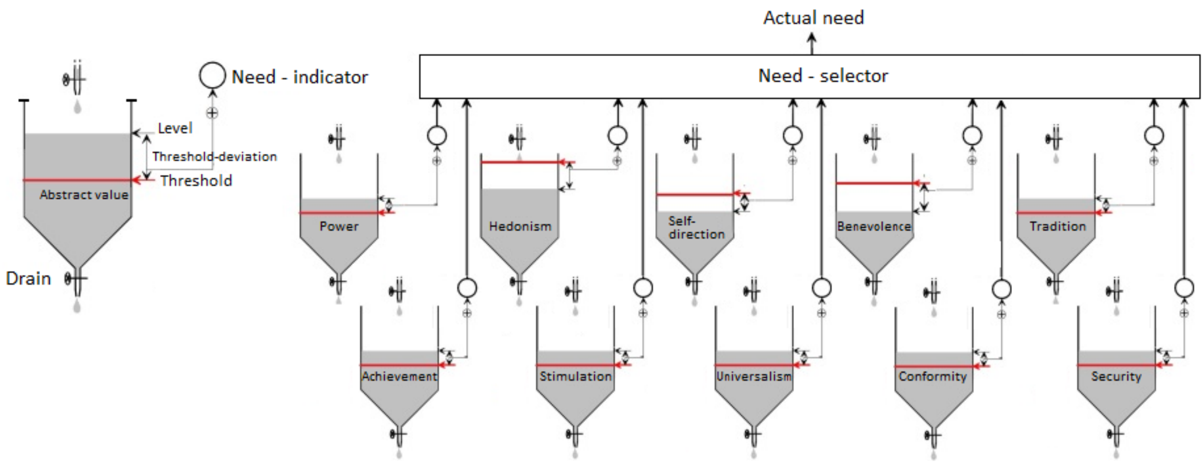

Figure 6.2: Example figure of the water tank model for an agent

6.3.2 Value tree

The water tanks are used for determining which abstract value has to be satisfied. As mentioned prior, the abstract values do not directly impact the behavior of people. But rather through a series of perspectives that link the abstract values to concretized values that are directly related to behavioral choices. To make values work, we need to define more concrete values. Concrete values are easier to implement and assess their impact on a decision.

Several steps might be taken to translate an abstract value to its concrete values. One possible solution of formally describing the relation between abstract values and concrete values is through defining value trees (99). The root node of the tree is an abstract value from Schwartz values. Nodes in the value trees that are closer to the leaves are more concrete.

To view an example, one could look at section 4 figure 6.4 in which the abstract values are *Power*, *Self-direction*, *Universalism* and *Tradition*. The abstract values are the roots of the trees. The values get more concrete the further we go down from the root. Leaves of the trees are the most concrete values that related actions are assigned to them. By looking at the parent nodes of an action we can determine which values it can satisfy and vise versa. Different path from each action to the root is deliberation that an agent uses to justify his action. For example, *donating* as an action can satisfy *Tradition* and/or *Universalism*.

People generally have different perspectives which can be modeled by giving only a subset of the total value tree to individuals. For example, to satisfy the *Universalism* value through caring for the environment, agent A might buy an electric car because the emission of an electric car in use is less than a petrol car. Agent B might think electric cars are actually worse for the environment than petrol cars because of the chemicals used to create the batteries. He will use public transport instead of his own car. This illustrates that two agents might perform different actions to satisfy the same abstract value. It can also be the case that, agents perform the same action to satisfy two different abstract values. E.g. playing a sport for one person can satisfy the *Achievement* value (trying to win) while for the other it satisfies the *Tradition* value (play a game with friends as a way to be together). In other words, it is possible to assign different subsets of value trees to agents.

Some actions (and therefore their related concrete values) can be linked to more than one abstract value. Considering definitions of types of values introduced by Bardi and Schwartz (100), we can assign actions to abstract values for our case of interest, which is studying the behavior of a fishery village. For example, people in a fishery village might go fishing because they like to connect with nature (*Universalism*), they like adventure (*Stimulation*), they want to make money/promote their social status (*Power*), or they want to comply with their family traditional profession (*Tradition, Conformity*).

Actions that are linked to compatible values might be positively interrelated. For example, actions that satisfy *Benevolence* might have a positive effect on satisfying *Universalism* as well. In contrast, if an action promotes a value, it can hardly attain the value opposite of it in the Schwartz circle.

6.3.3 Value-based filtering

Using values agents make initial selections among the available actions to perform. The highest priority value that needs to be satisfied is selected according to the following formula:

$$\arg\min_{V_i \in Values} \rho(V_i) = \{V_i | V_i \in Values, \forall V_j \in Values : \rho(V_j) > \rho(V_i)\}$$

This formula returns the most preferred value (highest priority) in the current situation that needs to be satisfied. Then the actions promoting the highest priority value are returned. Further decision processes can select an action from the returned action set. To compare the priority of each two values in order to find the highest priority, we use the following formula:

$$\forall V_i \in Values, V_j \in Values : \rho(V_i) = \rho(V_j) \ \textit{if} \ \rho(V_j) - \rho(V_i) < \delta$$

Meaning that $\rho(V_i)$ and $\rho(V_j)$ differ very little. Then all the actions that promote either V_j or V_i and are available, get chosen.

The rules and conditions provided earlier are defined for abstract values in the Schwartz value system. All the concrete values in the value trees have the same importance as their root value. Therefore, all the rules and conditions of the abstract values (roots in value trees) are applicable to their related concrete values (leaves of the value trees).

It should be noted that it is possible to have some actions that are common between different value trees. For example, an agent can satisfy *Power* or *Universalism* by choosing to be a captain, as captain is a shared action in these value trees (figure 6.3). However, the agent only satisfies one of the values by choosing action captain which depends on which deliberation he did before picking up the possible actions. For example, if the agent wants to satisfy his *Universalism* by doing related actions and picks being captain, he only satisfies his *Universalism* value (increasing the filled level of *Universalism* water tank) and not the *Power* value.

6.3.4 Making decisions

After filtering the actions by values, we have a list of actions that are value consistent. Any of these actions that get chosen by the agent comply with his value system. Among all the value complying actions the agent needs to pick an action that can be done at the moment. Therefore, other filters and decision making methods can be applied. These filters can be motivations, social norms, goals, plans, etc. The number of filters and how those filters filter down the value consistent action set is the modeler's choice.

6.4 Validating Value Framework

In this chapter, we validate and discuss the proposed value framework, how values play an important role in human decision making, and how decisions of individual people in a society change the overall behavior of the society. We use an agent-based model of a fishery village and show two scenarios with different abstract value settings. As it comes from the field of exploring personal values, the whole study and therefore proposing a framework for it is a qualitative study. Mercuur defines validating a qualitative model as the ability of the model to replicate the relations between variables (27). For instance, if the *Universalism* value gets promoted in a society ($\tau(Universalism)$ is high), the probability of hurting the environment decreases accordingly. As described in our previous study (15), one point that we want to include in our experiments is to consider the feedback

Age	There are four different age categories: children under 18, adults 18-64, elderly 65-74 and eldest 75 and older.
Status	Adults have a status that reflects their employment the set is {*unemployed, captain, fisher, factory worker, factory boss, teacher, caretaker, worker outside, mayor*}. Elderly and eldest agents cannot be employed. Eldest agents use *elderly care*. Children agents can only go to school.
Ticks	There are 4 ticks per month, which makes a total of 48 ticks per year.
Buildings	The buildings in the village are {*houses, school, council, factory, social care, elderly care, event hall*}. Outside the village there is another *school* and a company where agents with the status *worker outside* work.
Work	Every month agents (*adults*) pick a job according to the value they want to satisfy. The value watertank level is increased when they keep the same job and when they switch their job.
Event	Every tick *adults* and *elderly* can organize or attend an event. The organizing agents can choose between a free event (costs money) and a commercial event (generates money).
Donate	Every tick *adults* and *elderly* can choose if they want to donate to the council or not.
Council	The council gets money from tax and donations and distributes it among the school, social care, elderly care and factory.
Migration	Agents migrate when they are homeless and they are not happy (i.e. half of the values or more are below the threshold). A higher self-direction value then gives a higher probability of migrating.

Table 6.1: General simulation components

loop between society, environment, and economy. Therefore, we develop all parts and feedback between them in our simulation. The attributes and mechanics of the simulation are denoted in table 6.1. The simulation code is accessible via GitHub (101).

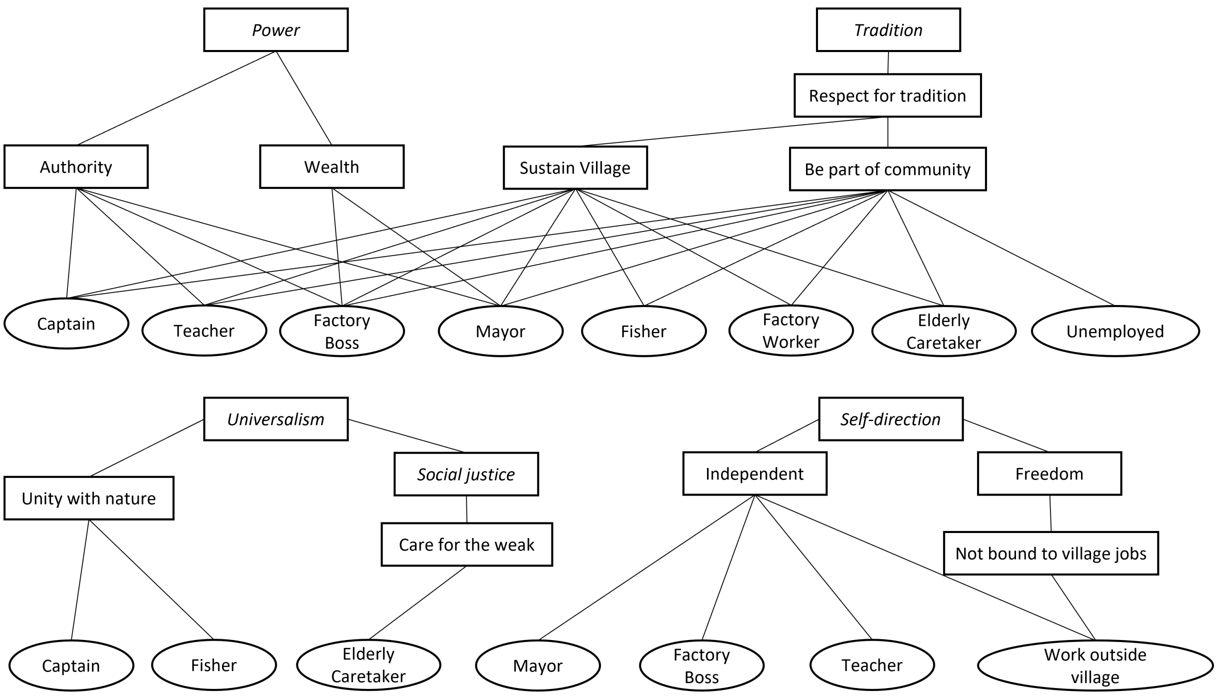

Figure 6.3: Value tree of getting a job

6.4.1 Abstract values implementation

There are three main action sets that use the value framework, these are job selection, event organizing/attending and donation/not donating. We developed value trees for those actions and for the values *Power*, *Self-direction*, *Universalism* and *Tradition*. The job selection value tree is shown in figure 6.3. Here we see that some jobs are capable of satisfying many values like a mayor (*Tradition*, *Power* and *Self-direction*) while other jobs have only one connected value e.g. unemployed or factory worker (both *Tradition*). The value increase multiplier of job picking is $\sigma = 1$.

The event trees are denoted in figure 6.5 and show four possible actions. Organizing an event has a value increase multiplier of $\sigma = 2$ as only a small number of agents can organize an event (the maximum of events is 1 per 11 residents). Attending an event has a lower value increase multiplier, it is $\sigma = 0.2$.

The donation trees are shown in figure 6.4 there are only two possible actions here. The value increase multiplier is $\sigma = 0.2$, which is also low since donations actions can be done every tick (which is more frequent than job picking at every 4 ticks).

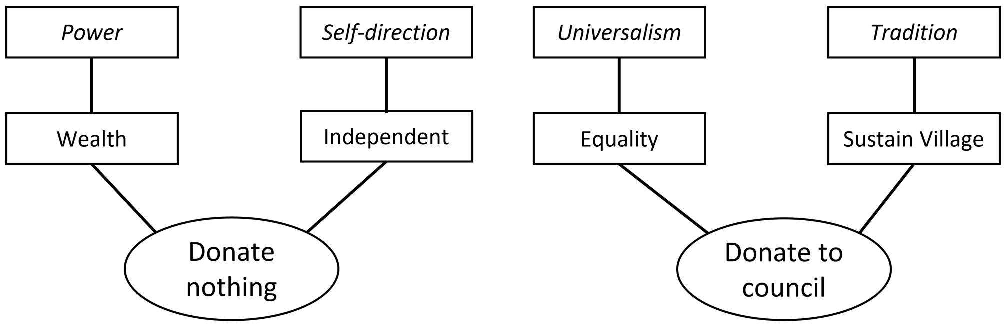

Figure 6.4: Value tree of donation

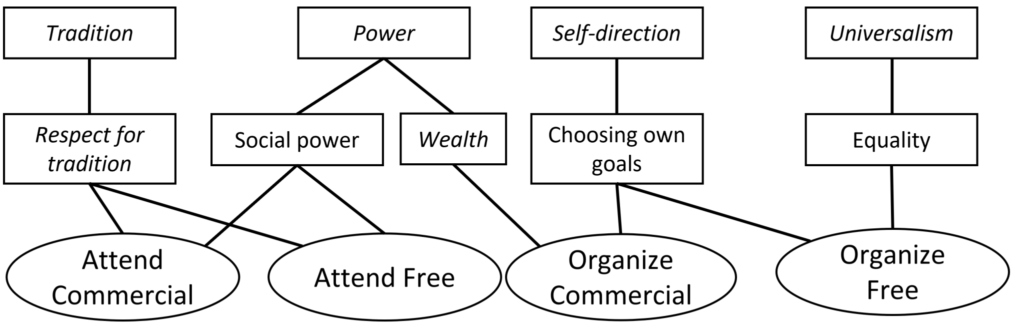

Figure 6.5: Value tree of social events

6.4.2 Results

Before explaining the simulation results, it is important to specify how these results are generated and represented. Running the simulation repeatedly and displaying the average result is a common approach of showing simulation outcomes. We do not offer the average result since averaging the simulation results might exclude certain critical features. Instead, each simulation scenario was repeated numerous times to ensure that the overall pattern of the runs remained consistent. In this chapter, all of the figures represent the outcome of a single simulation run to provide a comprehensive description of the system's behavior.

We consider four values out of ten Schwartz values: *Tradition*, *Universalism*, *Self-direction*, and *Power*. These four values have been chosen because they contain both compatible values and conflicting values. Also, we set multiplier $c = 20$ as we want each value to have a stronger influence on its neighbors in the Schwartz circle and very weak influence on the values that are far from it. Figures 6.6 to 6.13 represent the dynamic behavior of the systems in two different settings. Figures 6.6, 6.8, 6.10 and 6.12 show the system output with setting (1) when there is a high priority of *Power* ($\tau(Power) = 80$, $\tau(Self\text{-}direction) = 50$, $\tau(Universalism) = 30$ and $\tau(Tradition) = 50$). Figures 6.7, 6.9, 6.11

and 6.13 show the behavior of the system when *Universalism* is promoted ($\tau(Power) = 20$, $\tau(Self\text{-}direction) = 50$, $\tau(Universalism) = 70$ and $\tau(Tradition) = 50$). Having high priority for *Universalism*, means that agents need to do actions that satisfy *Universalism* more.

Figures 6.6 and 6.7 show the age distribution in the village. These two figures show the distribution in the simulation with setting (1) (having more *Power*-oriented agents) is the same as the simulation with setting (2) (having more *Universalism*-oriented agents). Therefore, we can compare the outcome of these two simulations together with eliminating the agent distribution variable.

Figures 6.8 and 6.9 show the value satisfaction through actions. *Universalism* and *Tradition* will be satisfied by donation and *Power* and *Self-direction* will be satisfied by saving more money instead of donating to public goods. Using the setting (2), there is almost always a maximum amount of fishers and captain, since these jobs also satisfy *Universalism* (6.13). As agents have low priority for *Power* (they do not need to satisfy *Power* value very often), they organize commercial events and attend free events which are enough to keep them satisfied of *Power* value (figure 6.11).

As shown in figure 6.13, most of the agents make money as they have a job. So, a lot of them earn enough to be able to donate. Therefore, they satisfy their *Universalism* value by donating in public benefits, working as a fisher, a captain, or an elderly caretaker. The *Power* importance is low (as it is the opposite value in the Schwartz circle), the other two values (*Self-direction* and *Tradition*) need to be satisfied with the same frequency. These two values can be mostly satisfied with picking related jobs. Working in the factory inside the village and working in the company outside the village satisfy *Tradition* and *Self-direction* respectively. That is the reason we can see a fluctuation between workers outside and factory workers. There is a balance since both have free vacancies. The company outside of the village has no limited number of employees. The factory can have a high number of employees since there is a high amount of fish coming in, this happens because there are many fishers.

One interesting simulation result is that when a society is more into the *Power* value. As we can see in figure 6.12, the number of employees for the jobs factory worker, fisher and worker outside fluctuate but follow a general trend. The amount of fishers is lower since people have a decreased universalism (which is one of the values associated with being a fisher). A decreased amount of fishers leads to a lower job availability in the factory. Because of this we see that there are more workers outside than factory workers, even though people have to satisfy *self-direction* and *tradition* equally.

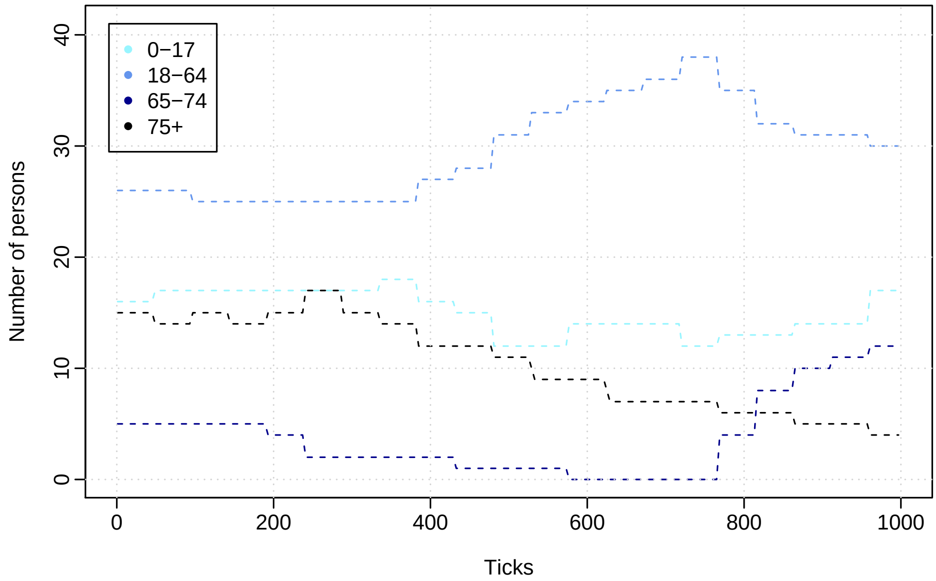

Figure 6.6: Human age distribution, setting (1) value distribution; $p = 80, s = 50, u = 30, t = 50$.

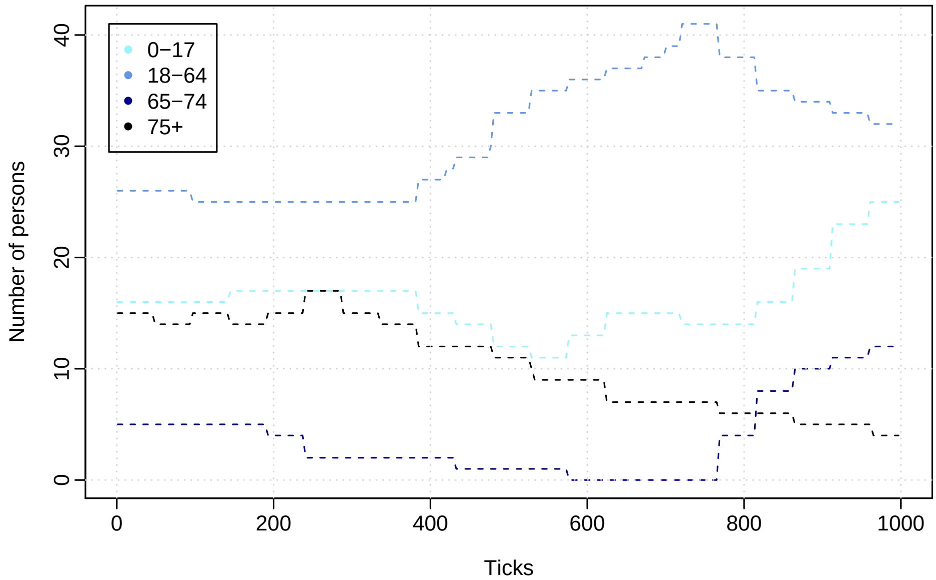

Figure 6.7: Human age distribution, setting (2) value distribution; $p = 20, s = 50, u = 70, t = 50$

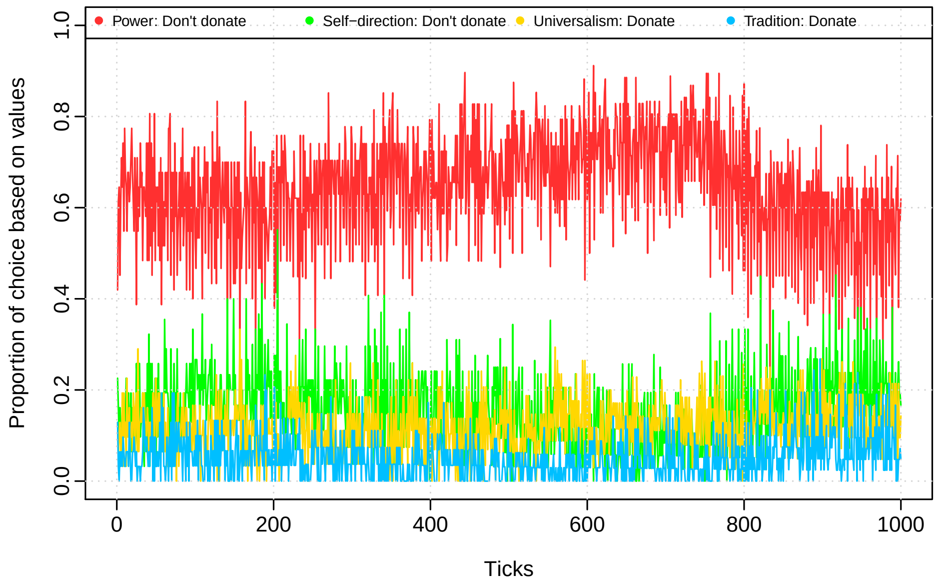

Figure 6.8: Value motivation of donation, setting (1) value distribution; $p = 80, s = 50, u = 30, t = 50$. According to this figure, most agents do not donate based on their personal value preferences.

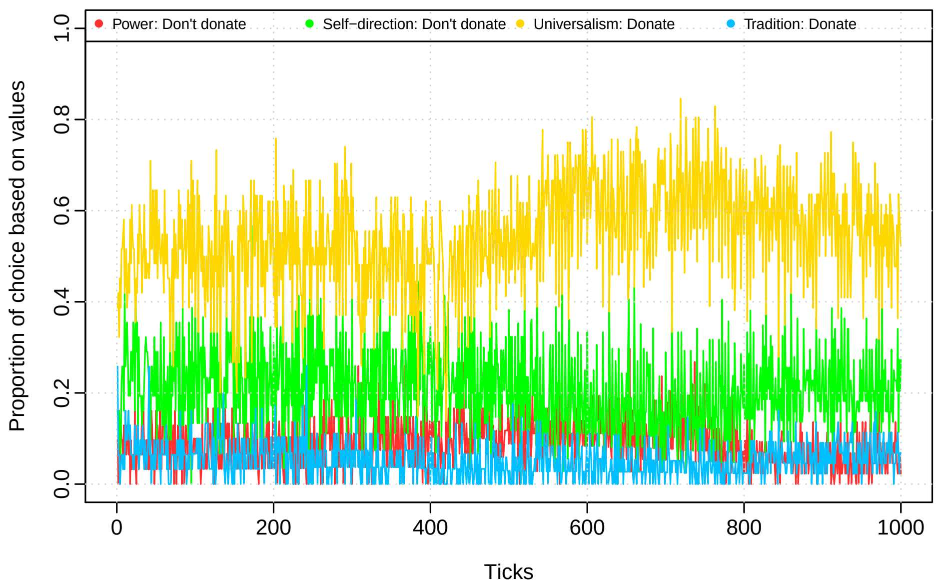

Figure 6.9: Value motivation of donation, setting (2) value distribution; $p = 20, s = 50, u = 70, t = 50$. According to this figure, most agents donate based on their personal value preferences.

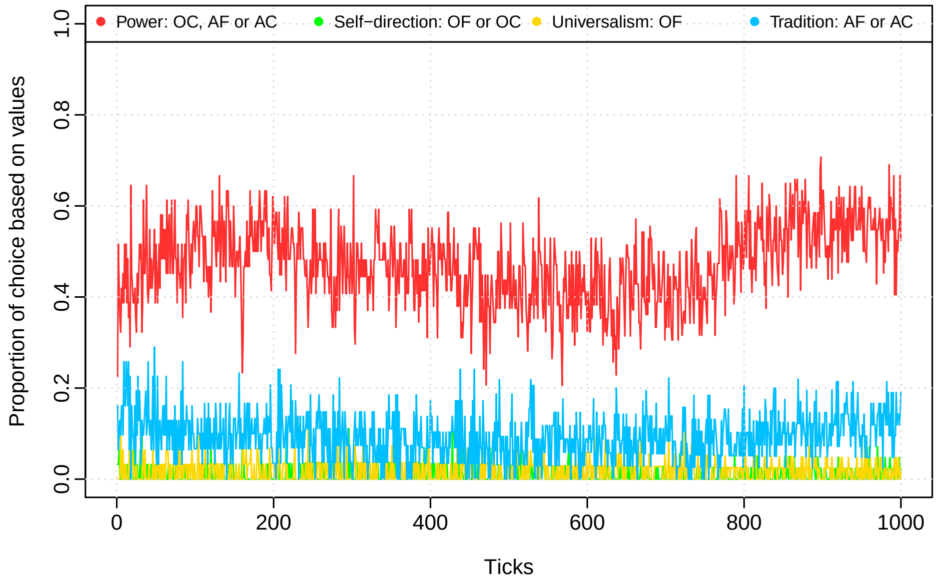

Figure 6.10: Value motivation of social event, setting (1) value distribution; $p = 80, s = 50, u = 30, t = 50$. According to this figure, most agents donate based on their personal value preferences. According to this figure, *Power* oriented agents organize and attend commercial and free social events. However, *Universalism* oriented agents rather to attend and organize only free events. Therefore, there is a visible gap in these groups.

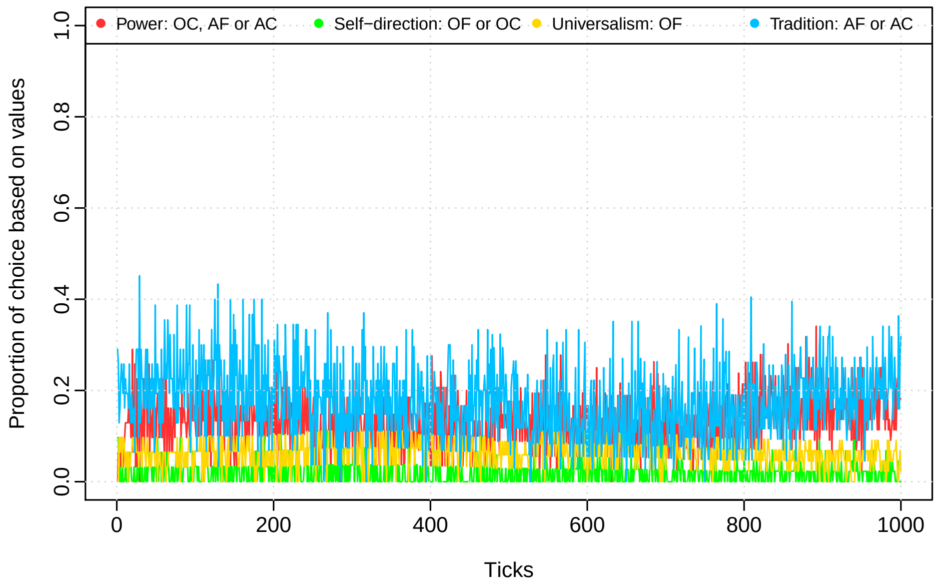

Figure 6.11: Value motivation of social event, setting (2) value distribution; $p = 20, s = 50, u = 70, t = 50$. According to this figure, the number of activities of attending and organizing social events between agents with different values are close. This is due to sustainable fishing and income for the village.

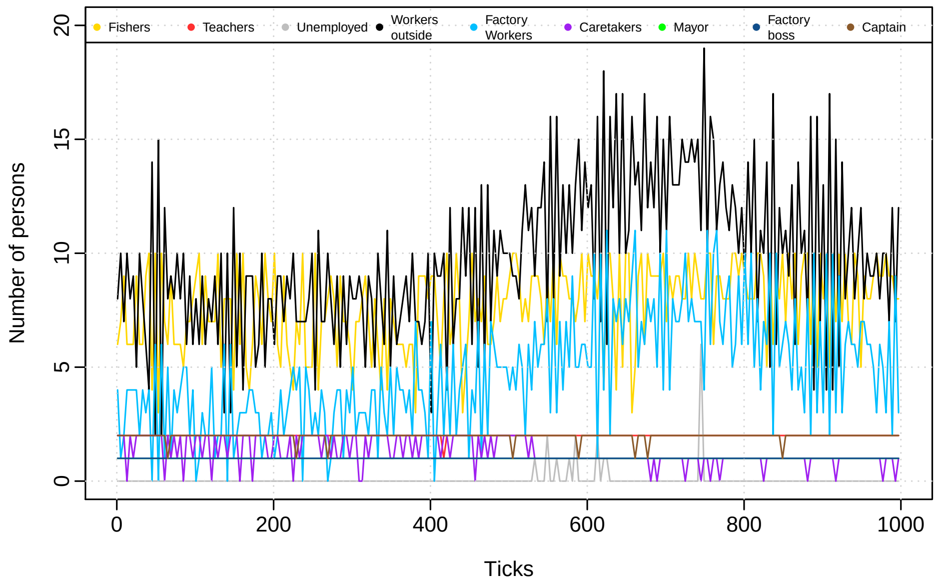

Figure 6.12: Work distribution, setting (1)value distribution; $p = 80, s = 50, u = 30, t = 50$. According to this figure, many agents have to work outside the community to make money. Number of fishers and factory workers fluctuates over time.

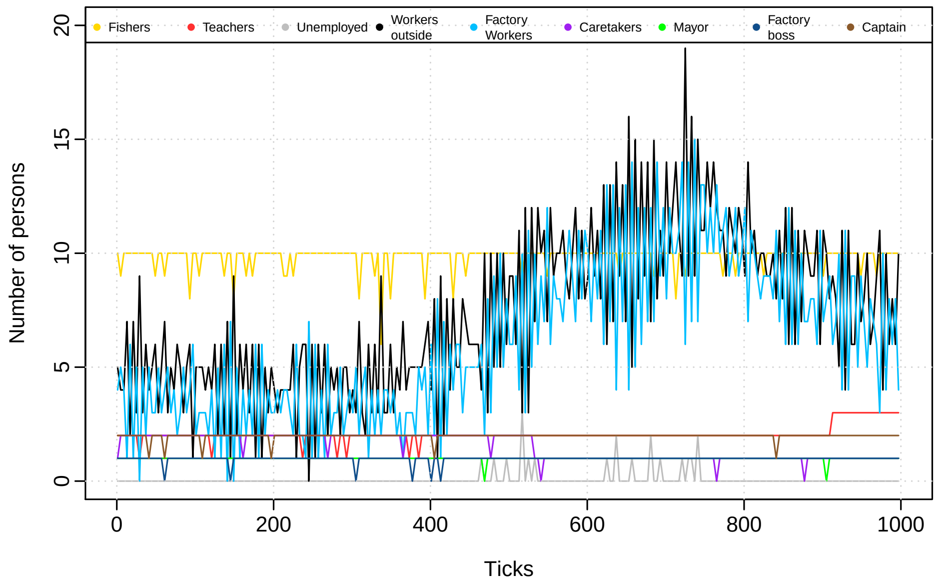

Figure 6.13: Work distribution, setting (2)value distribution; $p = 20, s = 50, u = 70, t = 50$. According to this figure, Number of fishers is rather stable and therefore the fishing factory can continue production and paying the factory workers.

People satisfy their *Power* value by organizing commercial events and having well-paid jobs. In this case the maximum possible number of commercial events happen all the time (figure 6.10). So, there are more chances to attend events for villagers to satisfy their *Tradition* value by attending the events. Besides, people tend to keep their paid job as they can make enough money to cover their living cost. The importance of *Universalism* (as the opposite value of *Power* in the Schwartz circle) is low and there is no need to put more effort than donating in public benefit to satisfy this value. Therefore, people who do not have a chance of finding a job inside the village, will look for a job outside. This justifies the higher number of people who work in the company outside.

6.5 Discussion and future work

Different factors impact human behavior such as values, social norms, and environmental and economic factors. However, introduced models to study human behavior rarely consider social, environmental, and economic factors altogether. Many factors are involved to capture human behavior including personal, social, environmental and economic factors. Values are strongly connected to behavioral choices of people among personal factors. One of the well-known theories in personal values is the theory introduced by Schwartz and it has been used by many researchers. Schwartz came up with ten general values by studying people all around the globe. Though, using Schwartz values necessitates interpreting the abstract values to concrete values related to the case study. To the best of our knowledge, there is no standard way of using Schwartz values and transform them from general to concrete values. As of yet, researchers used them and translated them according to their taste. We introduced a framework of personal values that can be used as a guideline for those who consider values to study, model, implement, and reuse previous efforts regarding values. Using the introduced framework, it is possible to model heterogeneous agents in terms of their personality and deliberation and consider various status consciously. For example, two different people can do the same action for different reasons, or they can react differently in the same (social, environmental and economic) situation. In our framework, we make a value tree for each value in Schwartz value theory. The root of the tree is a general value, and value gets more and more concrete till the leaves of the tree are the most concrete values that are directly linked to implementable actions. A possible action set is assigned to each concrete value. The result of doing one of the actions in the action set is satisfying the assigned value.

In the framework, there is a relation between Schwartz values that play an important role in decision making. Such a relation is used to capture the circular relation of Schwartz values. The framework contains making decisions according to personal values. To make a decision at each time and determine which value is more important, we use the water tank model. We assign a water tank to each value which drains in each time step and fills whenever the assigned value is satisfied. Using such a model, agents try to satisfy all the values during the simulation time. By changing the thresholds of values and therefore changing the satisfaction frequency of values, we can capture different personalities. We illustrate the use of the framework by using it to build a normative architecture for developing a socio-ecological complex system. The normative architecture is a modular one that proposes developing flexible socio-ecological complex models. This architecture includes social, environmental, and economic factors, as well as decision making process of agents. Therefore, it is possible to make a model both for micro and macro analysis depending on the decision of the modeler. Another aspect of this is that manipulating different factors is possible. A model may include any of the social, ecological, and economic factors. As an example of social factors, a model might contain personal values, social norms, motives, social practices, etc.

We created a formal foundation for Schwartz' value theory in this chapter, which could be used in multi-agent simulations and models. In the following chapter, we will study social norms in depth. Social norms emerge, change, and disappear. Many research considered one of the characteristics, given the fact that the emergence was barely addressed. The stability factor is an important aspect that has been ignored in research on social norms. Social norms are responsive to environmental changes, although they are not entirely reactive. In other words, despite certain changes, social norms stay steady. In the following chapter, we will emphasize that values are the stability factor. Considering personal values as a stabilizing factor, we will investigate social norm dynamics using a multi-agent simulation.

7

Agents with Dynamic Social Norms

Social norms are important as societal agreements of acceptable behavior. They can be seen as flexible, but stable constraints on individual behavior. However, social norms themselves are not completely static. Norms emerge from dynamic environments and changing agent populations. They adapt and in the end also get abrogated. Although norm emergence has received attention in the literature, its focus is mainly describing the rise of new norms based on individual preferences and punishments on violations. This explanation works for environments where personal preferences are stable and known. In this chapter, we argue that values are the stable concepts that allow for explaining norm change in situations where agents can move between social groups in a dynamic environment (as is the case in most realistic social simulations for policy support). Values thus reflect the stable concept that those are shared between the agents of a group and can direct norm emergence, adaptation, and abrogation. We present the norm framework that enables describing and modeling value and situation based norm change and demonstrate its potential application using a simple example.

7.1 Introduction

Social phenomena are part of our thinking (18). Therefore, it is mandatory to consider social aspects to study decision making and system behavior. Especially, if the purpose of the study is to explore the mutual effects of micro-level decisions and macro-level behavior of a system. Among different social aspects, we are interested in studying social norms, as norms play an important role in guiding all human societies (19). Social norms are important to be considered in societal studies specially in the absence of a central monitor/control (20).

Considerable research effort has been dedicated to developing models, architectures, and theories that concern social norms in making decisions. However, there are some points that have been omitted in the research efforts in two main issues: putting the focus on norm reactivity to environmental changes without regard for factors that drive norm stability, and favoring implicit, rather than explicit, representations of norms.

Studying the reactivity and stability of social norms cannot be effective without considering values, an element which is lacking in the previous works. In the absence of any stabilizing factors, modelled norms might quickly react to any change. However, many real norms remain rather stable over long periods of time due to their connection to fundamental values, which are, by their nature shared between groups of people and very stable over a person's lifespan. As for the issue of norm representation, researchers assume that social norms are explicitly defined in advance and use norms as constraints. Such an assumption is useful for simplifying the study of the effects of specific norms in a given scenario, but takes away the possibility of studying norm dynamics (such as norm emergence) and norm recognition (102). Social norms are distributed concepts rather than central. Each person might have his own interpretation of a social norm.

The simulation of social norms and their effects on decision making and on the behavior of the system has gained much interest in the field of social simulation. Therefore, we believe that a framework that deals with values and norm dynamics is relevant for many social simulations. We introduce a normative framework that covers key dynamics of social norms, their effect on micro-level and macro-level, and their relation with values. The social norms are dynamic in our normative framework. In other words, norms might undergo changes due to changes in the environment including change in the group members, economy, and ecology.

In this chapter, we start with related work and background information and introduce the concept of values as we use it (section 7.2 and section 7.3 respectively), and how they relate to social norms (section 7.4). We introduce the framework (section 7.4). Then, we discuss alternative representations and dynamics of norms in a normative decision model, and how our framework covers the dynamics of norms(section 7.5). We summarize this chapter in section 7.6.

7.2 Related work

In order to construct a normative framework, we need to identify the definition of social norms. Different definitions of norms were discussed in depth in chapter 2. We highlight the definitions here as the foundation for our framework. We explore how the chosen definitions can be used to characterize various aspects of social norm dynamics. Additionally, we explain why combination definitions should be addressed in order to have a good representation of norm dynamics.

Bicchieri defines norms as: "the language a society speaks, the embodiment of its values and collective desires". She specifies norms as behavioral rules that will be triggered in certain social roles or situations (32). Interesting enough she also mentions that norms are embodiments of values. This is in line with Schwartz, who also argues that specific norms for concrete situations are connected to a set of abstract values (33).Thus when we use norms we should also model the values from which they are the embodiment. Somehow this aspect is hardly ever used, but we will show its importance in this chapter. Bicchieri also mentions that sociologists have not agreed upon a common definition (19). Villatoro discusses that social norms are social cues that guide behaviour even in the absence of explicit punishment systems. From this we take that our framework should not exclusively rely on a punishment system(47). Most norm abidance comes from the wish to group conformance. Thus, indirectly the group determines the abidance of the norm. We will incorporate this element by letting agents abide by a norm dependent on the visibility of the norm. It does not mean that punishment does not play a role, but rather that it is not the main driver of norm emergence and norm compliance.

Gibbs discusses different viewpoints on social norms (37). We used his discussion, to extract the points he emphasized and we will cover them in our framework. According to his discussion: norms are agreements of group members; norms regulate behaviour; norms are group expectations in certain circumstances about what should and what should not be done; norms are based on cultural values; norms are abstract patterns of behaviour; and norms are alternative ways to achieve goals.

These points together will cause dynamics of norms in a group. As norms are agreements of the members, these agreements can change if the members change their mind. So, we want our normative framework to have the possibility of covering emerging norms, changing norms, and preserving norms.

In our framework, we define norms as social behavior that might involve punishment or not. In other words, some norms will be followed because people need to satisfy their conformity value[1] and be a good member of their group (6).

As said above, values are the main source of norms as values are "ideals worth pursuing" (6). Therefore, values can be seen as one of the main ultimate motives of deliberated

[1]Conformity is one of 10 abstract values that Schwartz presents in (21). Conformity drives obedience to rules and social expectations or norms.

actions. Norms and values are evaluation scales. However, norms are more concrete embodiments of values. Norms refer to certain behavioral choices in particular contexts; values are criteria to prioritize particular types of actions and situations (103). For example, a person who highly values *Universalism* would like to give away some money for altruistic reasons. However, there might be some social norms that determine how much to donate, when to donate, etc.

As the basis of our framework we use the value system as developed by Schwartz. Schwartz represents a universal theory on value system that is widely known and accepted by researchers (21, 22). We will explain this value system in more detail in the next section (section 7.3). Also, we will explain our previous work on representing a value framework based on Schwartz's value theory in section 7.3.

7.3 Summary of the Value Framework

Our norm framework is based on our previous work on the value framework (16), which has been explained in chapter 6. In this section, we briefly review the value framework and discuss how this framework is used as a basis for our norm framework.

Considering Schwartz's value circle, we introduce a framework for decision making based on (personal) values. Schwartz introduces 10 abstract values that are supposed to be universal. However, the importance and priorities of the values differ. The importance of a value is a degree that shows the salience of a value in a certain situation and time. Using the visualization of the Schwartz value circle, there are some relations between the priorities of these values. The closer to each other the values are in the circle, the closer is their priority (21).

Similar to the Schwartz circle, in our framework each value has a degree of importance. We defined mathematical equations that maintain the circular relation of the importance of values. To reflect the heterogeneity of agents, agents can have different value importances. In other words, they can assign different degrees of importance to their abstract values. Therefore, two agents with different importance distributions might take different decisions under the same external condition.

In our value framework (16), agents make a deliberate value-based decision. We operationalised the framework using an agent-based model (ABM). For the ABM we defined value trees to connect Schwartz abstract values to actions. The root of these trees are the Schwartz abstract values and the leaves of the trees are actions that agents can perform. Nodes that are closer to the leaves are more concrete. Figure 7.1 depicts a possible tree for donation in a simulation based on our value framework. In these trees, if an

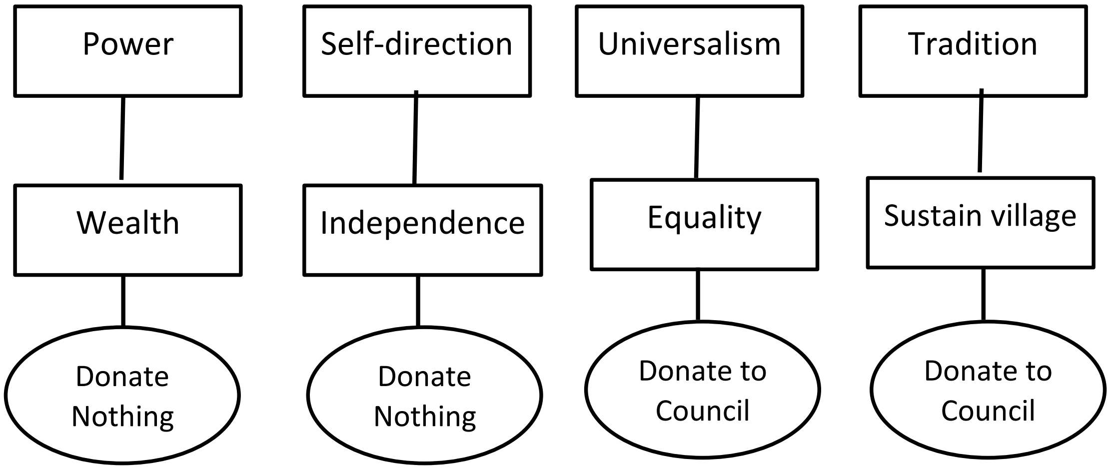

Figure 7.1: Sample value trees related to donation action (more examples in paper (16))

performs an action, he will sweep the related value tree up to the root. Then, the assigned water tank to the root will be filled.

We use water tank model to represent value satisfaction and thus salience of values. We assigned one water tank to each value tree. Each water tank has a threshold level (which is the importance of its value) and its water drains over time. Every time that an action is taken, some water will be poured into the related water tank. Each agent decides what to do based on the difference between water level and threshold of his water tanks. A positive difference means that the value is satisfied; consequently, a negative difference means that the agent did not satisfy the value enough times.

In the next section, we will extend this framework with norms. The norms are placed in between the values and the actions. Thus norms can be seen as concrete rules for deciding on actions that will promote a certain value. Thus, instead of having to reason with whole value trees we can use the norms as concrete representations of them. However, by placing the norms in the context of the value trees the agent can also reason about violating a norm in a concrete case, of adopting a norm or adapting it and even abrogating it.

7.4 Inserting Norm to the Value Framework

In this section, we explain how we can insert social norms to the value framework for building normative agent-based models and agent-based simulations. In this framework ad-on, agents deliberate based on their individual values and the social norms of the groups they are part of. Social norms are formed based on individual values. Agents participate in the dynamics of social norms by following, violating, or even by performing actions that slightly deviate from social norms, thus making social norms dynamic in this framework. In other words, norms might undergo changes due to any change in the environment including group structure, economy, and ecology. On the other hand, because they are tied to values, these changes are also opposed, constrained and directed in a controlled manner. We make use of a preliminary simulation in section 7.5 to show how these norm dynamics can have profound influences on the behavior of the agents, as well as the structure and behavior of groups.

7.4.1 Norm definition

We discussed in details various norm definitions in chapter 2. As mentioned earlier, we use the following aspects of norms as used by Gibbs (37) as a basis for the model of social norms in our framework. Since it is an important definition in this chapter, we repeat it here:

1. norms are agreements of group members,
2. norms regulate behaviour,
3. norms are group expectations in certain circumstances about what should and what should not be done,
4. norms are based on values,
5. norms are abstract patterns of behaviour, and
6. norms are alternative ways to achieve goals.

The above points do not mention sanctions explicitly. We follow Gibbs and Bicchieri who mentions that social norms may or may not be supported by sanctions (32). Thus we do not take sanctions as the main drivers of norm emergence and compliance and they are not part of our core norm model, although they can be added to it to strengthen the effect of norms in certain contexts.

Expanding on point 4 (norms are based on values), provided by Gibbs, we use Bicchieri's research on social norms to connect norms and values. She mentions that norms are embodiments of values (32). This point of view is supported by other research that illustrates that norms are connected to a set of abstract values with the aim of achieving those values (6, 33).

Bardi and Schwartz believe that values do not play a role in making behavioral choices directly and consciously for most people. However, people act mostly according to their value system, which is mostly unconscious (22). In other words, most people have a certain value system, but they do not refer to it for every single decision. Our interpretation of their work is that a person should live a normal life even without deliberating about all his actions through his values. This can be realized by assuming that social norms cover most of the actions that are needed for interactions with other people in daily life.

7.4.2 Norm type, structure and relation to values

Considering the arguments in the previous section, we explain how we formulate social norms and how we formulate norms as embodiments of values. We formulate social norms as actions that agents consider to do or not to do in certain conditions.

Therefore, we define a norm n as follows : $n =< v, c, t, a, pe, ne >$ in which n as a social norm guides the agents to satisfy value v by performing action a, under condition c. Depending on the norm type t the agent might get positive consequence pe by following n, get a punishment ne by violating n, or there is no positive social consequence nor any negative social consequence by following or violating n.

Taking the provided definition of social norms, we see that norms are not a necessary completion of values but rather norms and values are complementary. A norm is an edge in the value tree that connects two nodes of the tree whose distance is at least 2. It means that there is a path between these two nodes with length of at least 2 . If one of the nodes is an action (leaf of the value tree), the norm is a specific norm; otherwise, it is an abstract norm. Thus the norm can be seen as a shortcut for a value. Reasoning from an action upwards an agent can stop at a node where a norm is connected. Following the norm guarantees promoting the value. Thus if most actions are connected with concrete norms to the value tree above, very little (expensive) reasoning about values has to be done. However, this construction also allows the comparison of two norms by checking which values they promote and which of those values has higher priority and importance. This allows for reasoning about violation of a norm in case norms are inconsistent in specific situations or in case another value is more important than the value promoted by the norm. E.g. speeding in the highway in order to be in time for dinner.

The importance of following a norm differs depending on the importance degree of its supported values and the Norm type. Therefore, consequences of violating and following norms differ. We consider four types of norms: should follow (to represents soft social norms), have to follow (to represents strict social norms), and must follow (to represents laws).

Also, personal characteristics of people play a role on how much they might consider social norms in their decisions, especially if the social norms are in conflict with their personal values. For example, if a person values universalism a lot, he will internalize "donating to public benefits" norm as such a norm serves universalism value. Internalizing a norm raises the probability of considering it in decisions.

7.4.3 Decision Making

To recognize a normative behavior, an agent considers what most people do (32). This is what Cialdini et al. define as descriptive norms (104). However, agents consider the social standing of the person who is performing an action, $S(a)$. $S(a)$ represents the social status of agent a. If an agent has a good social standing, other agents consider his actions with a higher probability.

In our framework, each agent makes a decision about what action to perform considering their personal values and social norms. Each agent has its own value trees. These value trees are not necessarily complete from root to very concrete leaves. In other words, some of the agents might not have value trees explicitly. Either an agent has complete value trees or not, they have those shortcuts that they adopt from the society. Those shortcuts are norms. Norms can cover primary needs of people so that they do not need to reason upon their values to make a decision. Therefore, the agents that have complete value trees explicitly are the ones representing deep thinking people in the real world. In other words, these agents can deliberate about their actions explicitly.

Each agent can be a member of several groups. Therefore, each agent has a list of norms that he adopts from his groups. Such a list is dynamic for two reasons. First, social norms are not explicitly available, but rather individuals have their own understanding of norms. Second, norms are influenced by the environment. In other words, any change in the environment including changes in group members, economic situation, and ecological situation might lead to changes in the social norm. If changing the group members alters the collective values of the group, the group norm will change slightly; as the norms are connected to values. If there is any change in ecology or economy that makes following a norm not viable, a norm might abrogate slowly. For example, assume that there is a norm on donation in a community because people value equality a lot. If many new people who are self-oriented join the society, they can slightly change the norm to donate less frequently, or donate less. Or assume that economic inflation happens and people cannot earn enough money. The donation norm may change to alternative actions such as sharing food, donating cloth, etc.

We assume that each group has its own social norms. Each group might have a different norm on how to do one certain action. It should be noted that we do not consider explicit representations for norms. We do not consider a group as a central element that control and keep norms. But rather, agents perceive norms of a group by monitoring the behaviour of its members over time. To consider group membership and norms, each agent has a list $< N, g >$ in which N is a set of social norms that the agent assigns to group g.

To give an example of group norms, assume "turning trash into treasure to save the environment" as a norm that is serving the universalism value. Assume an agent is working in a company. His colleagues have the norm of "separating plastic bottle caps to donate to charity". The same agent is living in a neighborhood with a norm of "separating glass waste color-wise". Both norms serve universalism value, however they are valid in different contexts.

Each agent considers social norms in his decisions depending on how many times he observed a norm n has been followed by his group mates in group g. An agent will increase the probability of following n, if he observes n has been repeated over time regularly. Normative action of a group g for an agent a_i is a weighted average action of all other agents a_j, where $i \neq j$ and a_j is member of g:

$$n = \frac{\sum_{a_i, a_i \neq a_j}^{a_i \in g} S(a_i) * (\text{performed action by } a_i)}{\sum_{a_i, a_i \neq a_j}^{a_i \in g} S(a_i)},$$

where, $S(a_i)$ is social standing of agent a_i.

So, each agent needs to keep how many times a norm is repeated. A norm has a chance of abrogation if agents stop following it for long enough time. Therefore, we need to keep a variable showing how many time steps a norm has not been repeated. So, each agent keeps a norm repetition as a set of $< n, r, nr >$ that shows norm n has been fulfilled r times and not been used nr times.

As mentioned earlier, an agent regards several factors to make a decision including personal preference, norms, motivations, culture, etc. In this chapter, we consider norms and personal values as two factors that effectively regulate behavioral choices. An agent a_j considers both its personal preference and social norm of group g to make a decision in that group. Therefore, we formulate the normative decision according to the following equation:

$$decision = P_n(t) * n(a_j) + (1 - P_n(t)) * \text{personal preference}.$$

Where $n(a_j)$ is norm n that agent a_j considers in his decision. $P_n(t)$ is a probability function that depends on the history of norm n till time t. More explanation on $P_n(t)$ is provided in the section 7.4.4.

7.4.4 Norm life cycle

In this framework, we consider four phases for a norm, observation, adoption, internalization, and abrogation. Therefore, we define a function $P_n(t)$ (probability of following a norm n) for each agent as follows:

$$P_n(t) = \begin{cases} F_{observe}(t) & \text{if } t \in \text{observation phase} \\ F_{adopt}(t) & \text{if } t \in \text{adoption phase} \\ F_{internal}(t) & \text{if } t \in \text{internalization phase} \\ F_{abrogate}(t) & \text{if } t \in [0, nr] \end{cases}$$

Functions $F_{observe}(t)$, $F_{adopt}(t)$, $F_{internal}(t)$, and $F_{abrogate}(t)$ determine P_n when norm n is in observation, adoption, internalization, and abrogating phase respectively. The repetition times to enter to a new phase of a norm are relative and can be changed based on the particular domain. Despite the numbers assigned to norm phases, the agent increases r by 1 if he observes that most of his neighbors performed accordingly. Otherwise, he resets r and increases nr by 1. In the latter case, the agent will create a new potential norm for an action a. If a starts repeating he will update r; otherwise, he will remove the created norm. Also, when nr reaches the maximum time, the agent will remove the norm as well.

In order to make decisions on norms that might be in different phases of the life cycle we need to have the possibility of considering external and internal norms in our framework. By external norms we mean behaviors that an agent expresses/shows to public. Internal norms are the ones that are compatible with the personal values of an agent and he would like to follow whenever possible. Internal norms can be different from what other people can externally see. For example, an ungenerous person does not want to donate anything (internal norm), but will donate a small amount in order to keep up appearance of following the group norm of donating (external norm).

In the current simulation, the internal norm is represented by using a weighted sum of the values and the external norm in order to decide on a behavior. Thus an internal norm is kept implicit and not managed separately. However, in our framework, internalized norms are the norms that the agent will follow even after leaving a group. Those are the norms that has been repeated enough and are in line with the values of an agent. Therefore, internalized norms are stored as $< N, g >$, where $g = NULL$.

7.5 Simulations

This section illustrates one of the possible simulations that we developed based on the introduced norm framework. Using this simulation, we discuss some of the interesting simulation examples that explain the importance of a) value-based norms, b) norm dynamics and norm stability; and c) allowing for dynamic groups (agents can enter and leave groups). We only explain the description of the results here as we have a more concise version of this framework in the next chapter (chapter 8). The main goal is to demonstrate the fundamental behavior of a system composed of connected norms and values. Then, based on the discoveries of this chapter, a more complicated system with more dynamics may be seen in chapter 8.

We explain how our norm framework helps exploring our questions: how personal values of group members influence social norm of a group, how values make social norms more robust against small changes, how values cause the emergence of a new norm, how values guide the changes of existing norms, and how the social norm influences the individual behaviour of the members.

7.5.1 Simulation settings

We implemented a community in which we study behavior related to contributions to public good in the form of donations. The amount of donation is normative. So, there are norms going around on the normative amount of donation. Personal preference of the donation amount is connected to values, but it also serves the normative amount of the group which is served by group adherence.

Agents are heterogeneous in their values and organize into different groups. Agents considers social status of all of his group-mates are equal ($S(a_i) = 1$). Agents cannot choose some groups (family), and they can choose some groups (neighbors, colleagues, etc). An agent can also belong to more than one group at a time.

One possible setting of $P_n(t)$ that we used for our simulation, which matches the norm life-cycle design explained in Chapter 3.2, is:

$$P_n(t) = \begin{cases} \alpha_1 * t & \text{if } 0 < t < 5 \\ e^{(t-10.35708268)} - 0.00028536; & \text{if } 5 <= t < 10 \\ 1 - 1/t^{0.5} & \text{if } 10 <= t < 20 \\ 1/(1 + 0.0078 * 0.5^{(25-t')}) & \text{if } t' >= 10 \end{cases}$$

in which t' is number of times that norm n has stopped repeating and t is the number of times that norm n has been repeated. This setting is one of many potential equations that correspond to the previously described life-cycle design. This formula was employed by fitting tools in order to have a formula for each phase of the norm-life cycle considering the only variables are t and t'. According to this setting, the probability of following a norm does not increase much as the agent is still not sure about the norm. However, P_n increases exponentially during adoption phase. As mentioned prior, a norm enters the internalization phase if it has been repeated enough by other agents and if it is compatible with the personal value of an agent. Therefore, an internalized norm has a higher chance of being followed by an agents.

7.5.2 Experiment

Assume group g_1 has 4 members, agents a_1, a_2, a_3, a_4, who value power a lot (with the importance of 80%). Therefore, norm of the group emerged as n_1 =< power, "having more than enough money", should follow, donate $5\% - 10\%$, raise social status, null >. Consider agents a_5, a_6, a_7, a_8 highly value universalism (with the importance of 80%) and they used to donate about 50% on average (either because of their internalized norm or because of their other groups).

Scenario 1. robustness of norms

If agent a_5 joins g_1, it starts adopting norm n_1. It donates 10% mostly (according to external norm of the group). Agent g_5 seldom deviates from norm n_1 to keep its social image. But, it rarely donates 50% (according to its internalized norm) to satisfy its universalism value. However, its attitude does not change the norm of group g_1. After it starts adopting the norm (during adoption phase), a_6 joins the group. The same will happen to a_6; a_6 rarely donates 50% according to his norm since it does not want to deviate from the norm of group g_1, but after a while it starts adopting the norm of the group. This will be repeated for any other agents that join the group when the previous members of the group either internalized the norm or adopted the norm. In this scenario, norm is stabled over time. Even though the social norm is different from the internalized norm for $a_5..a_8$.

An exceptional case can lead to changing the group norm; when an agent a_i, that value *Universalism*, joins the group at time tick t. Assume agents $a_5..a_8$ join the group at time tick $t+1$ to $t+4$ respectively and donate 50%. Agent a_i observes that the average donation is 15%. With our simulation setting that observation time is 5 time ticks, it will start adopting norm of "donate about 15%" as the norm of g_1. If more agents similar to a_i join the group and the same story happens to them, n_1 will deviate a bit from its original amount. In other words, if many new agents joins the group while there are some members in the group that are in observation phase, the norm they observe and therefore adopt and internalize is different from the original norm.

Scenario 2. changing of norms

Assume that a large number of new members join a group at the same time. We let agents $a_5..a_8$ joins group g_1 together at time tick t. During the observation phase, agents $a_5..a_8$, that newly joined the group g_1, donate 50% according to their internalized norm (as explained before). Therefore, they observe that donation amount is around 27% on average. It is because 4 new *Universalism* agents donate 50% and 4 old members of the group, which are *Power* oriented agents, donate about 5% ($(4*50\%+4*5\%)/8 = 27.5\%$). So, they adopt "donating about 27%" as the norm of g_1. However, the other agents $a_1..a_4$ start realizing that normal donation is changing from time tick $t+1$. When they observe the new donation amount for more than 10 time ticks (which is the minimum time to abrogate a norm in our simulation setting), they abrogate their perceived norm and start observing the group behaviour again. From time $t+5$ onward, the new members mostly donate the normative of 27% (consider that the old member need to observe the norm change till at least $t+10$). From time $t+6$, the new members will see that the average amount is different from what they start adopting which is about 12% now. Therefore, they do not adopt normative amount 27%, but rather start observing whether 12% is a norm till time tick $t+10$. Continuing this run, the normative donation amount of the group converges to 27%. The convergence happens because agents ignore the random deviation from norm.

The above experiments show partly how individual values guide emergence, robustness, and changes of social norms. In these two scenarios, the same agents joined a group with different patterns. If new agents join gradually, they can hardly change values' balance of the group. As a result, the group's norm remains unchanged which means that the new members of the group will adopt the existing norm of the group. But, if new agents join altogether at the same time, they can change existing norm if it is against their values.

7.6 Conclusion

In this chapter, we introduced a primitive agent-based framework with dynamic social norms. Such a framework considers social norms as non-static social elements. In this framework, norm dynamics arise from dynamic environments which is not completely new in the field of social simulation. However, connecting norms to personal values and consider norms as embodiments of personal values has not being done before in an agent-based simulation/model/framework. This connection makes the norms robust against small dynamics in the environment. In addition, it is more realistic as there is no need to have a central element to monitor and keep social norms. But rather, social norms are distributed between agents as their perception of social norms. We discuss how such as a simulation can express the way values guide norms (emergence, changing, abrogation, and internalization). We explained it using a preliminary simulation scenarios. In the next chapter, we introduce an agent-based framework that is designed based on the findings of this chapter.

8

Norm Framework

Social norms govern collective behaviour by guiding individual behaviour in the absence of a central enforcing authority, which makes them powerful self-regulating mechanisms for societies. This is in stark contrast to policy or legislative norms - also targeted at governing behaviour in society - which are issued by a central authority who also then needs to enforce compliance. In their case, it is not just that enforcement is expensive, but also that they might come into conflict with existing social norms, which causes further issues. It is, therefore, not surprising that much research is aimed at understanding existing norms around behaviours connected to important issues like health or adaptation to climate change: designing policy that piggybacks on existing norms to promote behaviours like healthy eating, recycling or biking rather than driving would be a faster and cheaper solution than trying to use the classic carrot-and-stick approach of most policy design.

The modelling community has invested quite a bit of effort into developing normative frameworks, models and simulations, yet very little of this effort has been directed towards the study of the norm life-cycle. For example, some groundwork was done in developing normative frameworks (44, 45, 46, 47). However, we are looking for models of social norms that can cover the whole life-cycle of a norm, without making norms completely reactive or completely stable, models that can provide the possibility of implementing norms explicitly. We propose a social norm framework that is focused on norm dynamics - their emergence, perpetuation, and eventual disappearance. We operationalize the framework by way of an agent simulation of the norm life-cycle in the context of environmental change and absence of sanctions for deviant behaviour. We show that values are the stabilizing factor that allow norms to persist through changes in the agents' environment and perpetuate and spread even in the absence of punishment. A norm will, however, change, evolve or disappear altogether if it becomes impossible to perform or if the values of the agents change.

8.1 Introduction

Social norms regulate the collective behavior of human societies (19). This regulation happens even if the norms are not verbally defined and in the absence of a central enforcing authority (36). Social norms are everywhere, in everyday life. They are the, often unspoken, rules that people follow and expect others to follow as well, often without a conscious awareness of the existence of the norm, and often even in the absence of other people observing whether the rule is being followed. We do not chew with our mouths open, we sit quietly in class, we text rather than call. Would society function without norms? This question might conjure images of chaos, being greeted by anything from a polite "hello" to a punch in the face, enduring your neighbour's terrible taste in music at all hours of the day and night, busses running on no discernible schedule. Or it might bring to mind social paralysis – what am I supposed to do in this setting? Do I greet first or do I wait to be greeted? Am I wearing the right clothes for the occasion? echoes of which are familiar to anyone who found themselves immersed in a foreign culture. Norms are integral to the successful functioning of a society.

However, most agent models that incorporate norms do not include norm dynamics. The norms in these models are static structures that constrain behaviour in predefined ways (10, 11, 12). This type of setup is suitable if the goal is to study the effect of norms over a short time or in an unchanging environment with static conditions. However, over long time-frames, or in environments that undergo significant changes, either ecological (fish stock collapse, severe widespread droughts, recurring hurricanes), economic (financial crash) or social (increased migration, new policies), norms must be able to change and evolve themselves for the model to be useful. Take the model of a community where the norm is to donate a percentage of income towards helping those less fortunate. If the community is hit by an economic downturn, the people may not have income to spare to fulfil the norm. Does this mean the norm ceases to exist? Without norm dynamics, this would appear to be the case. However, in reality, people would likely transform the norm from donating money to helping in some other way, maybe volunteering their time, or donating old clothes and items. A more informative model would account for the way norms evolve in a changing environment and produce new behaviour in a way that models which assume norms either exist or do not cannot.

In this chapter, we will investigate the dynamics of social norms over time in dynamic environments. We are interested in studying social norms as behavior influencing factors under changing environments, both in the micro-level (individual behaviour) and the macro-level (system-wide behaviour). We are also interested in the interplay between the micro- and macro-level regarding norm emergence, and we investigate the subsequent processes of norm transformation and abrogation. We focus on the research questions mentioned in chapter 1, which, despite the considerable research effort dedicated to developing simulations, models, architectures and theories concerning social norms in decision making, are still lacking an answer:

How does a social norm emerge in a society?

Among sociologists, the topic of how norms emerge is still an open research question (7). Because social norms are powerful mechanisms for controlling behavior without the need for a centralized enforcer, solutions would be immensely valuable to policymakers, among others. By substituting policy enforcement with promoting a social norm, policymakers can reduce the cost of enforcement, monitoring, and decrease infractions because individuals propagate and enforce the norm themselves. For instance, a social norm against smoking can reduce smoking much more efficiently than smoking bans, raised tobacco taxes and heavy fines. Lighwood et. al reported the success of "The California Tobacco Control Program" - a programm that worked on building sustainable social norms against tobacco use rather than increasing tobacco tax (8). The importance of social norms to policymakers is such that numerous so-called nudge units have been created within governmental organizations across many countries.

There are numerous simulations and models that investigate norm emergence (see, for example, (9)). However, in most cases, their norms are explicit, pre-defined rules that serve as constraints on the agents' behavior.In other words, these rules are introduced to the system in advance and are activated or deactivated based on the circumstances to serve as behavior filters. Because all behavior has been pre-envisioned by the modeler, this approach to modeling norms cannot investigate norm emergence. These agents cannot produce behaviour that was not previously envisioned by the modeler, thus no norm can truly emerge because "The emergence of norms implies their immergence in the agents' minds" (55). Agent models must extend beyond employing established norms to examine their effects in order to research norm emergence. agents must be able to recognize and generate new norms that haven't been incorporated into the system in advance (102). For example, pre-defined rules can be found in traffic simulations such as (11). In this example, social norm is in the context of two drivers arrive at an intersection simultaneously from neighboring streets. The drivers need to normatively decide who has the priority. They define norm as one of these policies: yield to the car on the left or yield to the car on the right. They consider norm emergence happens if all the agents make the corresponding choice.

What factors keep norms stable in the face of environmental changes? Tax evasion is an issue fiscal authorities tend to have difficulties with in some countries. Since modern tax codes are extremely complex and are developed in a patchwork manner over time, they contain many loopholes which get exploited by people inclined towards using the letter of the law to reduce their tax burden as much as possible. Finding and closing all loopholes without sprouting new, unexpected ones, is so difficult as to be impossible. Monitoring every tax paying citizen is so costly as to be impossible. The reason some countries have good taxpayers and some don't comes down to social norms. If the prevailing norm is to pay your fair share in taxes, then you will mostly do your best to pay what you owe. If the norm is that paying fair taxes makes you a chump, the state can close loophole after loophole, build better and better monitoring systems and still new loopholes will be found. The norm of paying - or not paying - taxes remains stable through tax law changes.

It is not possible to discover a solution using agent models that express norms as fixed restrictions since their norms are stable by default. More flexibility is afforded by models which have norms triggered by environmental conditions, a mechanism which does create more dynamics in the system. In chapter 3, we explored some of these models in greater detail. In short, there are two main types of model for norms: 1) models with default norms that cannot be used to explore norm stability in the face of changing environmental conditions since the default norms are stable; 2) models with fully reactive norms that, because they are completely reactive, cannot aid in researching norm stability, evolution, and adoption.

textbf What prevents norm violations in the absence of sanctions for violators? Smoking is not socially acceptable in many Asian countries, especially for women. There is no law forbidding women from smoking, and thus no legal punishment for women who do choose to smoke, and yet not many women do. Sociological research shows that norms can and do exist in the absence of reinforcing rewards or sanctions, and yet most agent models that include norms also include some form of utility-based decision making for following/violating the norms. Thus, these models cannot account for the existence of norms that are not violated despite the absence of sanctions or followed despite the absence of rewards.

We claim that rather than having some utility-based system values play an important role in decisions of violation of norms. For example, if a person values caring for the health of other people (a person who is more likely to value "universalism" [1]), she/he is more likely to follow a norm/rule that is related to health care. For example, Dechesne et al.

[1] Universalsim is one of the abstract values introduced by Schwartz (21)

present research on introducing anti-smoking legislation to different societies considering two values (universalism and hedonism) and their effect on embracing anti-smoking rule (6). This research seems to confirm that in reality values are intricately linked to norms and should be modeled together with the norms to produce realistic normative behavior.

How does a norm disappear?

Disappearance is part of norm dynamics. Just as sometimes it is useful to spur the creation of a norm, sometimes it is desirable for a norm to disappear, maybe to be replaced by another, more suitable, norm. Suitable, in this context, refers to the purpose of the entity attempting to extinguish a norm so that another one can take hold instead. For instance, new-borns and toddlers used to be dressed in the clothes their older siblings outgrew. This norm was replaced by the now ubiquitous blue for boys, pink for girls clothes colours, meaning parents would need to spend more money on dressing their new-borns if they were of different sex from their older siblings. This greatly benefits companies that manufacture and sell baby clothes, toys, and other modern trappings of infanthood. It is not entirely clear how the old norm disappeared. Was it gradually substituted by the new norm? Did the old norm disappear first, leaving a space the new norm could easily fill? This has not yet been investigated.

There is no fixed timeline for these phases of a social norm, so the best we can say is that a social norm will disappear if it is no longer "useful". In most previous norm simulations, "useful" is predefined by the simulation designer, meaning norms will disappear if certain conditions are met in the system. This setup is not ideally suited to the study of the transformation and disappearance process of social norms because the process itself is not represented, nor are the factors involved.

Although parts of the above questions have been covered in literature (which we discussed in chapter 2), the provided solutions are either highly simplified or give only partial answers. The purpose of the present chapter is to describe a framework that allows us to address all the questions properly.

Emergence: This framework models norms not as immutable pre-set rules, but as interpretations of observed behaviour each agent builds for itself. Thus, the social norm is distributed over all the agents and influences their behaviour in the absence of a central enforcing authority. Since agents can have varying interpretations of observed behaviour and may make mistakes when they attempt to copy what they perceive to be norms, the framework allows us to study norm emergence.

Stability: Our framework provides norm stability within certain margins. This stability occurs because the norms are connected to values as underlying normative principle

(19, 54). Because of this connection, the agents follow social norms because they contribute to their personal values. Since values are mostly stable over an adult's lifetime (28), their connected norms will also be stable, displaying decreased reactivity to environmental conditions, without becoming completely rigid.

Sanctions: Since our agents act based on their values and perceived norms, it is possible for them to make mistakes, either by failing to recognize a norm, or by incorrectly identifying non-normative behaviour as normative. They can also choose to not follow a norm if it conflicts with their values, or if they *perceive* it as conflicting with their values. The tethering of norms to values means the role of sanctions is reduced, and norms can emerge, propagate or die out even in the presence of external sanctions or rewards.

Disappearance: We consider a norm to be going extinct if it is followed and observed less and less. Thus, agents can react differently to the norms they observe, not only because of their differing value priorities, but also because they may be observing a norm in any of its life stages. This allows us to study the full norm life-cycle in heterogeneous agent populations.

To illustrate these features, we implement an agent simulation using this framework. In contrast to many existing agent simulations involving norms, we will simulate the full norm life-cycle over a long period of time (several years) in a relatively large population of heterogeneous agents whose decision making process is influenced by their value priorities, perception and experience. We will also present simulation scenarios in which the norm life-cycle is artificially cut short, and in which norms are fixed predefined behavioural constraints, similar to the norms more commonly found in other agent simulations, and compare the results to illustrate the effects of norm dynamics on simulation outcomes.

8.2 Normative multi-agent framework

While existing research on social norms and their computational representation and application is vast and diverse, certain elements are still lacking. The norm life-cycle in particular, as we previously stated, is woefully understudied while being of major interest to some of the more compelling norm dynamics involved in problems such as policy design. Adding policy norms into a system already populated with social norms with the intent to extinguish, replace or modify one or more of them requires careful consideration. A poorly designed policy norm could clash with existing social norms requiring massive enforcement expenditure or just failing to meet its goal altogether. Ideally, one could investigate possible system trajectories for alternative policy designs, but the best tool available, agent models, falls short of meeting its potential in this regard.

In this section we present a normative multi-agent framework that fills some of the gaps in existing research by allowing the design and development of models which account for norm dynamics and the norm life-cycle by:

- representing norms in any of the phases of their life-cycle and the transitions between them
- allowing new, non-predefined norms to emerge
- maintaining the stability of norms by anchoring them to abstract values
- weakening the role and effects of sanctions for following/breaking norms, allowing values to be the main driver of decision making in this regard

It is important to note that this framework is not data driven but rather it is intuitive and it fits with what is observed in reality and explained in literature. Therefore the outcomes of the simulations looks realistic as the results are explainable based on observations and theories. This framework gives and explanation of what can generate the outcome (norm emergence, disappearance, and transformation). We do not claim this framework is the only way of modeling norms.

In the following, we present the framework' main elements and their role in norm dynamics. Then, we explain how these elements are connected and influenced by normative processes.

8.2.1 Main elements

In this section, we discuss the main elements in our framework; agents, groups, norms and values. The inclusion of agents and norms is self-explanatory. The groups in our framework are defined by, at the least, the set of norms they are governed by. We can then observe norm dynamics by having agents be part of one or more groups and join or leave groups based on whether they choose to follow the local norms. In order to give agents preferences over norms, we connect norms to values, and have agents follow a norm only if it promotes its personal values. This also stabilizes the norms and keeps them from being fully reactive to the environment.

Agent

Agent represents a normative agent that have its own priorities of personal values, and make normative decisions. Each agent is a member of one or more groups, has value priorities (16), and norms (personal norms, internalized norms of previous groups, and norms of the current groups). The (implicit) objective of the agents is not only reaching a decision according to a value-based reasoning, but also complying with their society as much as possible.

Group

Group represents a collection of more than one agents that can be in one or more ways related to each other, e.g. being family, colleagues, friends or neighbours. The value distribution of the members of a group might differ if the members of the group change (by joining or leaving the group). As norms are not parameters of a group, but rather individual perceptions and attributions of individual behaviours, there may be various norms observed within a group.

Norm

Norm is used in two modes in our framework. There are norms that used for the observable behaviours (what most people do, god mode, group level) and the norms that the agents see in their group (perceived norm, individual level). The group level norm can be only observed as a collective behavior. It means that it is not a explicit object that affect individual behaviors. Individual level is called descriptive norms. The descriptive norms can be observed as the actual behavior of the group members (104, 105). Descriptive norm is the collective behavior of a group that each member of the group observes to be the norm. Each group might have more than one norm. Norms are not saved as a parameter of a group. But rather, each agent keeps his own perspective of the normative behavior of his group mates (descriptive norm).

Value

Values are abstract drivers of behavior. Social norms, as flexible social phenomena, can emerge, change, and disappear. In contrast, personal values are fixed and barely change in a life time (21). Therefore, values are the stabilizing factor of social norms that prevent them from being quick reactive to any change (17).

Schwartz proposes an abstract value system according to the universal needs of human (21). We introduced a framework that can be used to simulate and model a value-based decision (16). In the framework, all the agents can have all the values from Schwartz value-circle or some of them, according to modeler's choice. Also, the agents can be heterogeneous or homogeneous in the importance level of values.

8.2.2 Normative processes

To generate norm dynamics, the framework must allow for the processes that cause norms to appear, change, and disappear over time. On an individual level, this is achieved by allowing agents to decide which groups to join or leave, which normative actions to

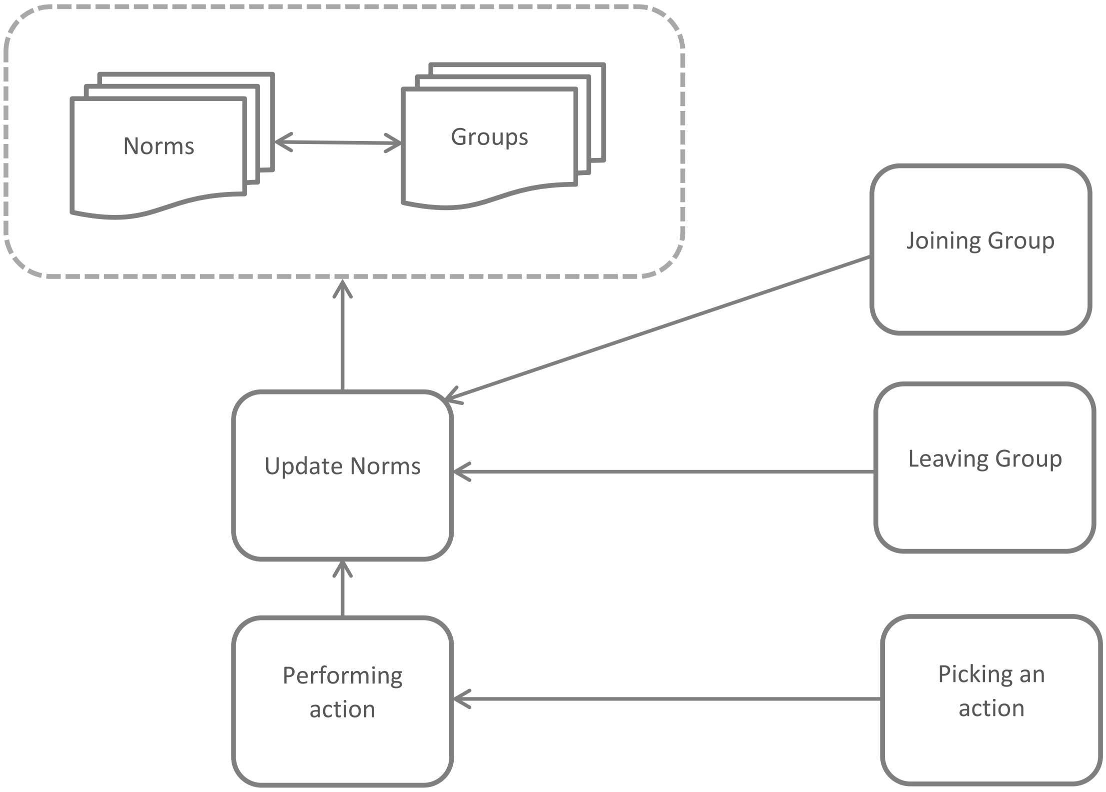

Figure 8.1: Block diagram of individual decision making process.

prioritize and perform, and whether to internalize a norm. A diagram of these processes is presented in Figure 8.1. To explain each block formally, assume n is the number of agents $(a_1, a_2, ..., a_n)$ at the current time step; $Norms_{a_i}^{g_j}$ is a list of perceived norms of group g_j belonging to agent a_i. If the norm is a personal norm, g_j can be null ($\emptyset$); $Norms_{a_i}$ is a list of norms belonging to agent a_i in all of his groups. In other words, $Norms_{a_i} = \bigcup_{j=1}^{m} Norms_{a_i}^{g_j}$; $Groups_{a_i}$ is a list of groups of agent a_i; m, for each agent, is the number of groups the agent belongs to $(g_1, g_2, ..., g_m)$. $Observation_{a_i}^{g_j}$ is a list of observed actions of group mates of agent a_i in group g_j.

Joining and leaving a group

The "Joining group" and "Leaving group" blocks in the diagram describe the algorithms for joining a group (Algorithm 2) and leaving a group (Algorithm 3), respectively. When agent a_i joins a group, it will create an empty list of norms for that group, as this agent is new and still need some time to observe and learn the norms of the group (line 4).

Algorithm 2 Joining Group

1: **if** a_i decides to join group $g_j, j > m$ **then**
2: creates group g_j
3: $Groups_{a_i} = Groups_{a_i} \cup g_j$
4: creates an empty norm list $norm_{a_i}^{g_j}$
5: $Norms_{a_i} = Norms_{a_i} \cup norm_{a_i}^{g_j}$

Algorithm 3 Leaving Group

1: **if** a_i decides to leave group $g_k, k <= m$ **then**
2: $Groups_{a_i} = Groups_{a_i} - g_k$
3: *The norms of g_k will not be removed from his list.

Agents can decide to join or leave a group based on a variety of factors, such as some physical attributes of the group, value preference, financial preference or any combinations of such, depending on the scenarios being modelled. A group must contain at least two agents, and is revoked when all agents leave the group.

Updating norms

Each agent keeps track of the norms in the groups it is a member of by observing/communicating the behavior of the other group members. Each agent keeps a record of the actions it observes other agents performing. If the action is repeated, it can be flagged as a possible norm. If enough repetitions are observed, the agents may classify the action as a norm and proceed to adopt it. Once adopted, if the agent itself repeats the action enough times, then the norm becomes internalized. If, however, the agents observes the normative action being performed less and less by its fellow agents, it will start to forget it as a norm. The overall process for norm adoption is shown in following Algorithm 4.

According to this algorithm, when an agent joins a new group and becomes aware of new norms, it will add the group to its group list and the norm to the corresponding norm list. Once the norm is internalized, the connection between the norm and its originating group is severed, making the norm group-independent. Group-independent norms are considered in the decision making process regardless of the group the agent is operating in at the moment of the decision.

On leaving a group, the agent does not remove the associated norms from memory. Rather, norms fade away with disuse.

Picking a normative action

The main decisions agents make in this framework regards the actions they will perform with the aim of maximizing their value satisfaction. In this, they consider the norms

Algorithm 4 Updating Norms for agent a_i in time tick t

for $g \in Groups_{a_i}$ **do**
  updates $Observation^g_{a_i}$ according to observations at time $t-1$.
  updates $Norms^g_{a_i}$.
  for $norm \in Norms^g_{a_i}$ **do**
    if $norm$ has been internalized **then**
      $Norms^g_{a_i} = Norms^g_{a_i} - norm$
      $Norms_{a_i} = Norms_{a_i} \cup norm$

of all the groups they are part of and the ones they remember from groups they were previously members of (17), as well as their personal value system (16). Since the norms of all groups are constantly progressing through their life-cycle as dictated by the actions of the agents, this adds a social uncertainty factor to the decision making process.

The default "Picking an action" block in the diagram follows the following formula:

$$\begin{aligned} Final\ decision = {} & X * (decision\ based\ on\ the\ norm\ of\ the\ current\ group) \\ & + Y * (value\ based\ decision\ ) \\ & + Z * (decision\ based\ on\ norms\ of\ other\ groups, \\ & \ \ and\ previous\ groups), \end{aligned} \tag{8.1}$$

where

$$X + Y + Z = 1.$$

+ sign in this formula has different interpretations depending on the decision type. If the decision is quantitative (e.g. donation amount), the + is addition as an arithmetic operation. If the decision is qualitative (e.g. greet someone by name, by title or not at all), the operand stands for OR, as choosing among the options. In this case, X, Y, Z are the probability of choosing one of the possible alternative decisions.

It is worth mentioning that an agent will automatically follow an internalized norm without going through with the value reasoning ($Y = 0$). This is inline with the interpretation of norms as abstract patterns of behaviour that save us from having to evaluate every single decision against our abstract values.

The decision process need not be restricted only to values and norms. Any other factor may be added if it is considered to be relevant to the model, as long as it follows the established pattern and rules: the sum of all coefficients must be 1, and the + must be additive for quantitative decisions and an OR operand for qualitative ones.

8.3 Operationalizing the norm framework

In this section we use our framework to create an agent simulation in order to illustrate the workings of the framework and how it contributes to answering the questions raised in the introduction of this chapter. To this end, we begin with the following assumptions:

8.3.1 Hypothesis

1. **Norms are followed without sanctions**:
   Considering that a norm is an action that is compatible with the common values of the members of a group, agents will follow the norm as long as the norm is in line with their personal value system. Conversely, agents will not follow norms that do not agree with their values. Thus, the success of a norm depends less on sanctions and more on the shared values of the group.

2. **Norm emergence/disappearance/transformation/stability**:
   Since the decision making process is largely driven by values, the more an action agrees with an agent's internal values, the more that agent will choose that action, thus strengthening the associated norm. Since values are stable over the lifetime of an agent, this means that for new norms to emerge, or old ones to die out, the composition of a group must change. Two relevant factors here are group size and rate of change. In a small group, any individual agent's action have a stronger influence than in a larger one where it can easily be lost to noise or pass unnoticed in the face of a uniform majority. A slow rate of change means any new group members can be well on the way to being assimilated by the time another agent might join, whereas a fast rate can bring in enough agents at once that they can assert their influence and either change the existing norms or split the group altogether.

   Thus, we hypothesize that group size and the rate of member change have a strong influence on the emergence, disappearance, and stability of norms.

8.3.2 Simulation Design

We designed a simple simulation based on the presented conceptual framework. This simulation shows how our framework covers different aspects of studying social norms, including emergence, stability, and reactivity. We implemented this simulation using Repast Symphony 2.6 (80). The code is available on GitHub (106). We start to explain some details about the implementation. After that, we show the results of some designed simulation scenarios to evaluate different aspects of social norms.

Norm life-cycle

As explained in section Norm life-cycle, we consider four phases in a social norm life cycle: 1-observation 2- adoption 3- internalization 4-disappearing. When an agent joins a group, he observes the norms in that group. After recognizing the norms, it will adopt the norm and consider it in his decision. After adoption, if the norm has been repeated enough, the agent will start internalizing the norm. Internalizing a norm means that the agent uses the norm without deliberation (considering value intentions behind it). In any phase of a norm life cycle, if the agent observes that the other members of the group are not following what he assumed as a norm, he will enter the disappearing phase (however it take some time to forget a norm completely).

Considering the above explanation of the social norm life cycle, timing is important in studying norms. However, depending on the context that the framework used to implement a simulation. Time steps can be considered as any time unit(day, week, month, year, etc). In the simulation, each agent assigns two parameters to a norm; *repetition* and *notRepetition*. The former represents how many sequential steps the agents observed the norm has been followed and the later represents how many sequential steps the agents observed that the norm has been violated.

Of course we also have to design when an agent is in the observation phase and how it determines that it transitions to a next phase. This mainly depends on how often he observes the norm to be used relative to other actions, how stable a norm is after it has been internalized and whether a norm is still frequently used after some time or (almost) never. These parameters will thus determine how quick norms are changing phases. In appendix A we discuss the influence of these parameters on the norm phases and argue for the choices that we made for our simulation. In our simulation, we assume that the observations phase takes 5 ticks, the adoption phase takes 5 ticks and internalization takes 50 ticks. These timings are input parameters and may change according to the simulator preferences depending on the context.

Agents

In our simulation, we design agents that have values, earn money and spend money for different purposes according to their values.

Values of agents are in accordance with the value framework that we represent in (16). With no loss of the point of the simulation, for the sake of simplicity, we use only two values for the agents; universalism and power. These two values are opposite to each other in the Schwartz value system (21). As mentioned before, we want to study the effect of collective values of a group on its norms. Therefore, having two norms which are apposite to each other would be enough for this purpose. Agents can be heterogeneous from their value system viewpoint.

Agents can earn money. The salary distribution of agents is an input for the simulation. It can follow any distribution including, uniform, normal, etc. Agents can decide about the proportion of their saving that they want to donate to the public good.

Group

We define two groups of different sizes. In this simulation, groups are considered as neighborhoods that have different capacity of houses. Joining an agent to a group means that he moves to that neighborhood. Therefore, each agent can only be a member of one group. Forming or joining a neighborhood will affect the normative decision of agents. Also, different groups can have different norms as we do not expect norms to be the same across agents. Groups represent different aspects that partition agents. For example, groups may be created based on financial status which will cause having a poor or rich neighborhood. As another example, groups may be created based on welfare activities such as charity work, elderly care, environment activists, etc. An agent can be a member of several groups and leave a group upon his will. Such dynamics in groups will cause mutual affection of norms of the groups by transferring norms from one group to another.

Decision making

In this simulation, we open only decision for the agent. Each agent can decide about the percentage of his savings that he wants to donate. This decision depends on the amount of money he has, the value system of the agent and the norm of the group. If the norm is internalized, with higher probability, the agent will follow the norm anyway even without being a group member. We use the following steps to calculate the donation percentage:

$$\begin{aligned} \textit{Donation percentage} &= X * \textit{(normative donation percentage)} \\ &\quad + (1 - X) * \textit{(value based percentage)}, \end{aligned}$$

where X is calculated according to the function depicted in Figure 9.1, "normative donation percentage" is what the agent perceive as a norm, and "value based percentage" is equal to the importance level of Universalism (or equally 100 minus importance level of power).

8.4 The Simulations

We designed some scenarios to show norm emergence, norm changing, norm stability, and unpredictability of complex parameter settings. We design the simulation scenarios in a way that helps us check our hypotheses. In the following, we explain the simulation setting, the hypothesis and how the result of the simulations support it.

There are some simulation parameters that we can control to design the simulation scenarios. Table 8.1 illustrates the these parameters. We will use this table to explain the simulation scenarios. Therefore, we need to explain each parameter.

- $Initial\_norm$
  Shows the default norm assigned to each group of agents.

- $Initial\_repeat$
  Shows the initial repetition of a norm (which determines the phase of the norm) for each agent who is a member of any group when the simulation starts.

- $Initial\_population_{big}(u, p)$
  It is an ordered pair that shows the initial population of universalist and power-oriented of the big group. For example, $Initial\_population_{big}(90, 5)$ means that the big group starts with having 95 agents, 90 universalists and 5 power-oriented agents.

- $Initial\_population_{small}(u, p)$
  It is an ordered pair that shows the initial population of universalist and power-oriented of the small group. For example, $Initial\_population_{small}$ $(90, 5)$ means that the small group starts with having 95 agents, 90 universalists and 5 power-oriented agents.

- $Population\_change\_time = \{(time_1, change_1)\ ..(time_n, change_n)\}$
  It is a list of ordered pairs. Each ordered pair $(time, change)$ identifies what is the time for change and what is the change. For example, $\{(10, +1universalist)$, $(20, -20\%power - oriented)$, $(50, +30\%power - oriented)\}$ means that one universalist agent at tick 10 joins each group, a number of power-oriented agents, equal to 20% of the population of each group, will leave the group at tick 20, and a number of new power-oriented agents, equal to 30% of the population of each group, with different value than the groups value will join the groups.

Parameter	Possible values
$Initial\_norm$	$\lvert donation \rvert = x$ where $0 \leq x \leq 100$
$Initial\_repeat$	x (where $x \in \mathbb{N}$)
$Initial\_population_{big}(u,p)$	(x,y) where $0 \leq x,y \leq 100$ and $x,y \in \mathbb{N}$
$Initial\_population_{small}(u,p)$	(x,y) where $0 \leq x,y \leq 10$ and $x,y \in \mathbb{N}$
$Population\_change\_time = \{(time_1, change_1) ..(time_n, change_n)\}$	$(time, change)$ where $time \geq 0$ and $change$ matches this regular expression : $(-\mid+)(\mathbb{N})(\%)?(v)^{*}$

Table 8.1: Parameter of the simulation

* It means that it has to start with a sign, a natural number, and might include percentage sign. This shows either joining or leaving the determined number of (or population percentage of a group) agent(s). Then, the regular expression has to include one value v from Schwartz' value system to show the change has to happen with agents that highly value v.

Norm emergence

According to the hypothesis, if we do not change the value distribution of a group, a norm will emerge in the group. Considering the simulation parameters mentioned in table 8.1, we can assign different values to the parameters to show how a norm will emerge in a group. To show the effect of the value distribution on emerging norms, we do not make any change in the other parameters of the simulation, except the initial value distribution of the groups that will not change during the simulation.

- There is not any change in the population over time. Therefore: $Population\_change\_time_{big} = \{\}$ and $Population\_change\_time_{small} = \{\}$.
- As there is not any default norm ($Initial\_norm$ is $null$), the default norm repetition (which determines the norm phase) is $Initial\_repeat = 0$.
- The default value distribution of a group can be either of the cases:

  - universalist, which means that the members are universalists.
    In the simulation scenarios, we use the following setting :
    $Initial\_population_{small} = (10, 0)$, $Initial\_population_{big} = (100, 0)$.
  - power-oriented, which means that the agents are power-oriented.
    In the simulation scenarios, we use the following setting :
    $Initial\_population_{small} = (0, 10)$, $Initial\_population_{big} = (0, 60)$.
  - combination of universalists and power-oriented agents.
    In the simulation scenarios, we use the following setting :
    $Initial\_population_{small} = (5, 5)$, $Initial\_population_{big} = (50, 50)$.

- We have two groups. The big group has the maximum size of having 100 members, and the maximum size of the small group is 10 agents.

In this scenario, we run the simulation in the case of pure universalist and pure power-oriented groups. According to our hypothesis, the agents will follow their value-based preferences as much as they can. In other words, there is not any change in the simulation environment (social and economic aspects of the simulation). For example, we set the simulation setting in a way that all the agents always have some money to donation and the value distribution of their group does not change. It is expected that if everyone want to donation some amount according to his personal value, and all the group mates wants to donate the same amount, the norm will be their shared value based amount. Therefore, their decision after a while will be the norm. As the results are exactly as predicted, we do not show the simulation results here.

Another possible simulation is the case that the groups have combination of universalist and power-oriented agents; 50% universalist and 50% power-oriented agents. We run the simulation 200 times. The tick that the system converge to a donation amount as a norm (agents will not change their donation amount and internalize the same norm) is different in various runs of the simulation. This is due to random order of donation of agents in each steps. Using this setting, the minimum convergence time is at tick 190 and the maximum is at tick 1100. Despite this time range, the most important point is the occurrence of convergence. One of the possible results is shown in Figures 8.2, 8.3. According to this figure, the average value based preferred amount is 50% in both groups (the lines are on top of each other). The starting point and the convergence tick vary in different runs.

Norm transformation, disappearance, stability and adaptability

According to our hypothesis norm transformation and disappearance depend on the value

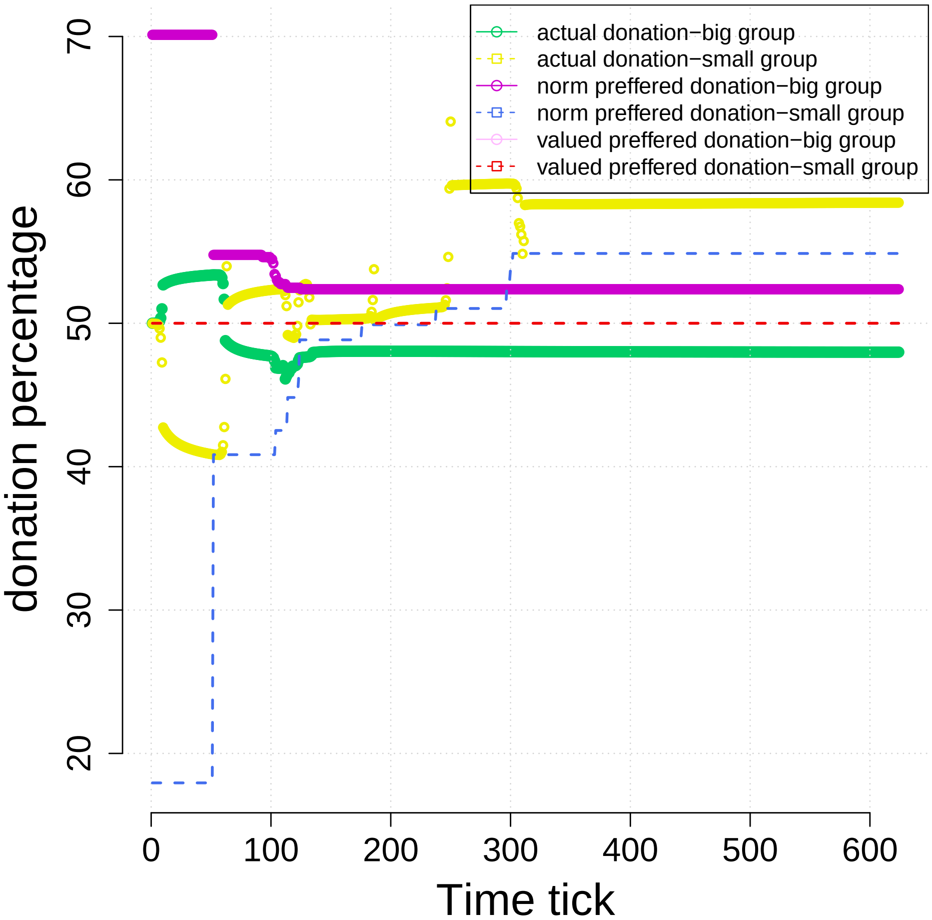

Figure 8.2: Donation amount in big group and small group when 50% of the members are universalist and 50% are power-oriented. There is no change in the value distribution of the groups over time and without any default norm. Also, the value distribution of groups are compatible with the initial norms.

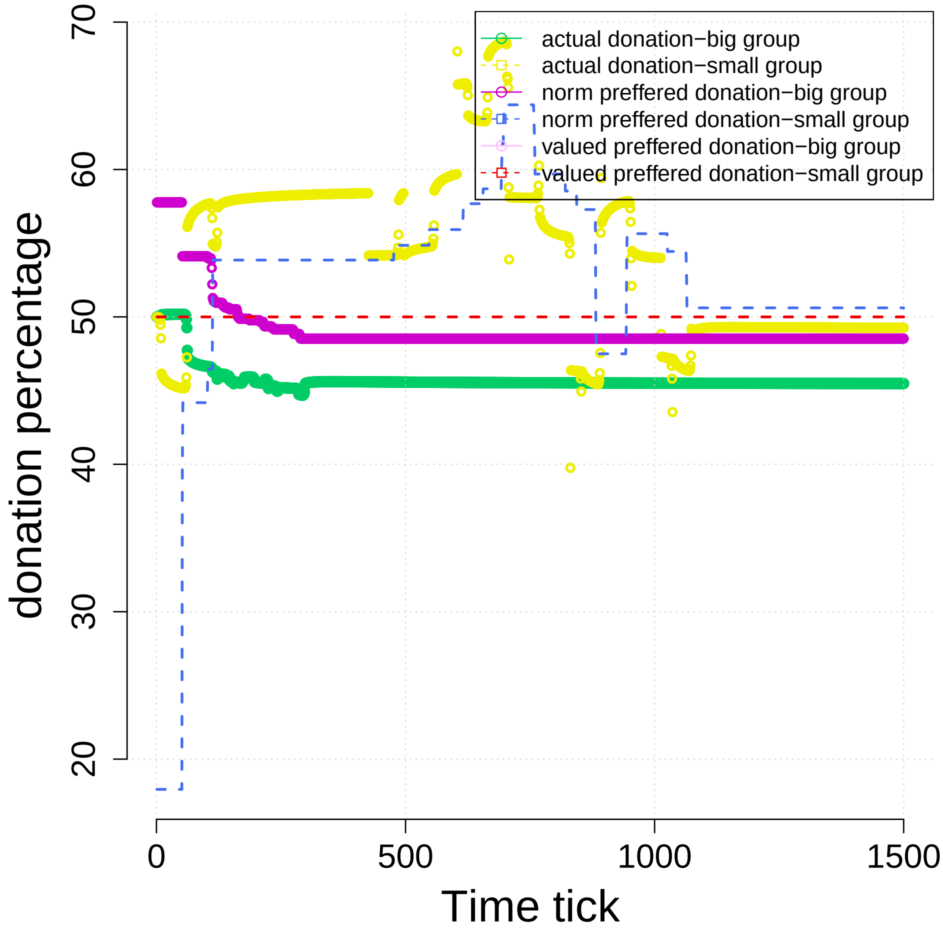

Figure 8.3: Donation amount in big group and small group when 50% of the members are universalist and 50% are power-oriented. There is no change in the value distribution of the groups over time and without any default norm. Also, the value distribution of groups are not compatible with the initial norms.

distribution of a group, group size, joining/leaving rate of members, and the number of repetitions of the norm. We combine norm transformation with norm disappearance as norm transformation includes disappearance and emerging a new norm. We take advantage of scenarios designed to check norm transformation to show the stability and adaptability of norms. In that case, we will mention the hypothesis number in the text.

As we want to check norm transformation, there should already be a norm in the system. Therefore, several settings can be configure to the simulation scenarios: the phase of the norm (what is the phase of the perceived norm of the most members of a group), the consistency of the norm with the common value of the group, and the consistency between the norm and the new common value of the group if the group change with some rate. A norm can be in observation, adoption, internalization, or disappearance phase. A norm can be compatible or incompatible with the common value of the group. The value distribution of a group might change from very slow (longer than 50 ticks to let all the agents internalize a norm) to very fast (less than 5 ticks to confuse agents about their observation). Therefore, we can make different simulation settings to try many possible combinations of these factors. However, we only consider the combinations of parameters that help us to test our hypothesis and we show the most fruitful results.

Considering table 8.1, we can assign different values to make all the possible combinations of the input parameters.

- Rate of joining/leaving to a group can be either of the following:
  - it can be fast. For example (joining/removing agents at the same time).
    In our scenarios, we set a fast joining rate as:
    $Population\_change\_time_{big} = \{(50, +50power)\}$ and
    $Population\_change\_time_{small} = \{(50, +5power)\}$.
  - it can be slow (joining/removing agents after 50 ticks that the norm is stabilized).
    The parameter setting will be mentioned in the scenarios.
- The default norm of a group can be either of the following cases:
  - it can be inline with the value distribution of groups. For example, if all the group members have an importance level of 95% for universalism, the group is universalist. If the norm is $|donation| = 95\% \pm 5\%$, the norm is inline with the group value.

  - it can be against the value distribution of groups. For example, if all the group members have an importance level of 95% for power, the group is power-oriented; their value-based preference is to donate $5\% \pm 5\%$. If the norm is $|donation| = 95\% \pm 5\%$, the norm is against the group value.

- The default norm repetition (which determines the norm phase) can be in the observation phase ($Initial\_repeat = 5$), in the adoption phase ($Initial\_repeat = 10$), in the internalization phase ($10 < Initial\_repeat \leq 50$), or internalized ($Initial\_repeat \geq 50$).

- The default value distribution of a group can be either of the cases:

  - universalist, which means that most of the agents are universalists.
    In the simulation scenarios, we use the following setting :
    $Initial\_population_{small} = (4, 0)$, $Initial\_population_{big} = (50, 0)$.

  - power-oriented, which means that most of the agents are power-oriented.

- The size of a group (number of members) can be big or small.

  - We set the maximum size of the big group to 100, and the maximum size of the small group to 10.

The results of our simulations show when there is an initial norm that is not internalized, the norm is not stable. In other words, making any change in the environment might lead to a different norm (Hypothesis 1). Because agents will give up the norm easier as it is not internalized. Therefore, we will not show the results of the simulation when the default norm is in the observation, adoption, or internalization phase as the results are precisely predictable. We will only show the results when the norm has been internalized. Just for the clarification, we will show the results for the setting in which the default norm is in adoption phase. This will illustrate that the agents will give up the norm easier.

Also, for all the cases that the default norm is compatible with the value distribution of the group, and the change is joining/leaving agents with the same value (no change in the value distribution), the will not lead to any change in the norm that proves the stability of the norm because of its connection to personal values. As this results are predictable, we will not show the results for this setting here.

Considering this explanation, we design three simulation scenarios to explore norm transformation.

Scenario 1

In this scenario we consider that there is a default internalized norm which is compatible with value distribution of the groups. We make change in the value distribution both rates (high and low joining rate). We want to see what is the influence of the changing rate on norm transformation. Also, we show the results in the big and small group. Therefore, at the same time we can see the effect of the group size as well. We consider $Initial\_norm$ as $|donation| = 95\% \pm 5\%$, Also, we set the joining rates as:

$$\begin{aligned}
Population_change_time_{big} = \\
&\{(50,\ +5\ power),\ (120,\ +5\ power),\\
&(200,\ +5\ power),\ (280,\ +5\ power),\\
&(350,\ +5\ power),\ (410,\ +5\ power),\\
&(480,\ +5\ power),\ (550,\ +5\ power),\\
&(620,\ +5\ power),\ (690,\ +5\ power)\}
\end{aligned}$$

and

$$\begin{aligned}
Population_change_time_{small} = \\
&\{(50,\ +1\ power),\ (120,\ +1\ power),\\
&(200,\ +1\ power),\ (280,\ +1\ power),\\
&(350,\ +1\ power)\}
\end{aligned}$$

, and the fast joining rate as :

$$Population\_change\_time_{big} = \{(50,\ +50\%\ power)$$

and

$$Population\_change\_time_{small} = \{(50,\ +50\%\ power)$$

.

According to this parameter setting, the value distribution of both groups change by joining new agents with different values to both groups. The result shown in Figure 8.4 and 8.5 are compatible with our hypothesis about the effect of changing rate on transforming norms (Hypothesis 2); When a large change occurs in the environment rapidly, norms might transform or disappear more easily, but norms are resistant to moderate changes in the environment. These figures depict the average donation (actual donation, value-based preference, and norm-based preference) in both groups. As mentioned before, norms are not kept as an explicit object in our framework (and therefore in the simulation). Norms are what agents perceived as normative actions based on their observation. Therefore, the average norm-based preference is the average amount of donation that agents perceived as a normative amount. However, the average actual donation is the overall observable behavior of the group, which shows the descriptive norm.

According to Figure 8.4, the normative donation amount in the big group does not change over time when the joining rate is slow. Although, there are some picks in the actual donation around the ticks that new agents join the group. Also, this figure shows that the normative donation amount in the small group changes around the ticks that new agents join the group. This change happens because joining one agent to the small group with 4 members increases the population 25%; however in the big group, joining 5 agents in a group with 66 members increases the population around 7.5%. This figure shows that the big group is less sensitive to small changes that happen slowly; even if all the small changes together changes completely the value distribution of the group.

Figure 8.5 shows that changing the normative donation amount in the big group is fast when 50 agents join the group at once. According to this figure, it takes 50 ticks until the agents forget their norms and they move on to a new norm. But, they reach a consensus about the normative act very fast (around tick 150). However, it takes much longer for the small group to get to a steady state. Even though, when we change the population in both groups, 50% of members of both groups are universalist and 50% are power-oriented.

Showing only the average donation amounts eliminates some important details; such as how the newly joined agents behave, how the perceived norm of the newly joined agents changes over time, how they contribute to change the norm, etc. Also, showing the behavior of each agent separately has redundant information. Therefore, clustering the behavior (in our simulation is donation percentage) of agents will be helpful. As we changed the distribution of values in the groups, the illustration of the values of each cluster is informative as well. Following the behavior of the system over time, by studying how agents with different values behave, will help to understand how they change the norm of their group. To be able to show all this information, the results are shown in some bar charts that illustrate the number of agents (separated by values) which are clustered according to their actual donation amount at different ticks. We got the results for about 60 ticks before making any change and 60 ticks after making the changes every 20 tick.

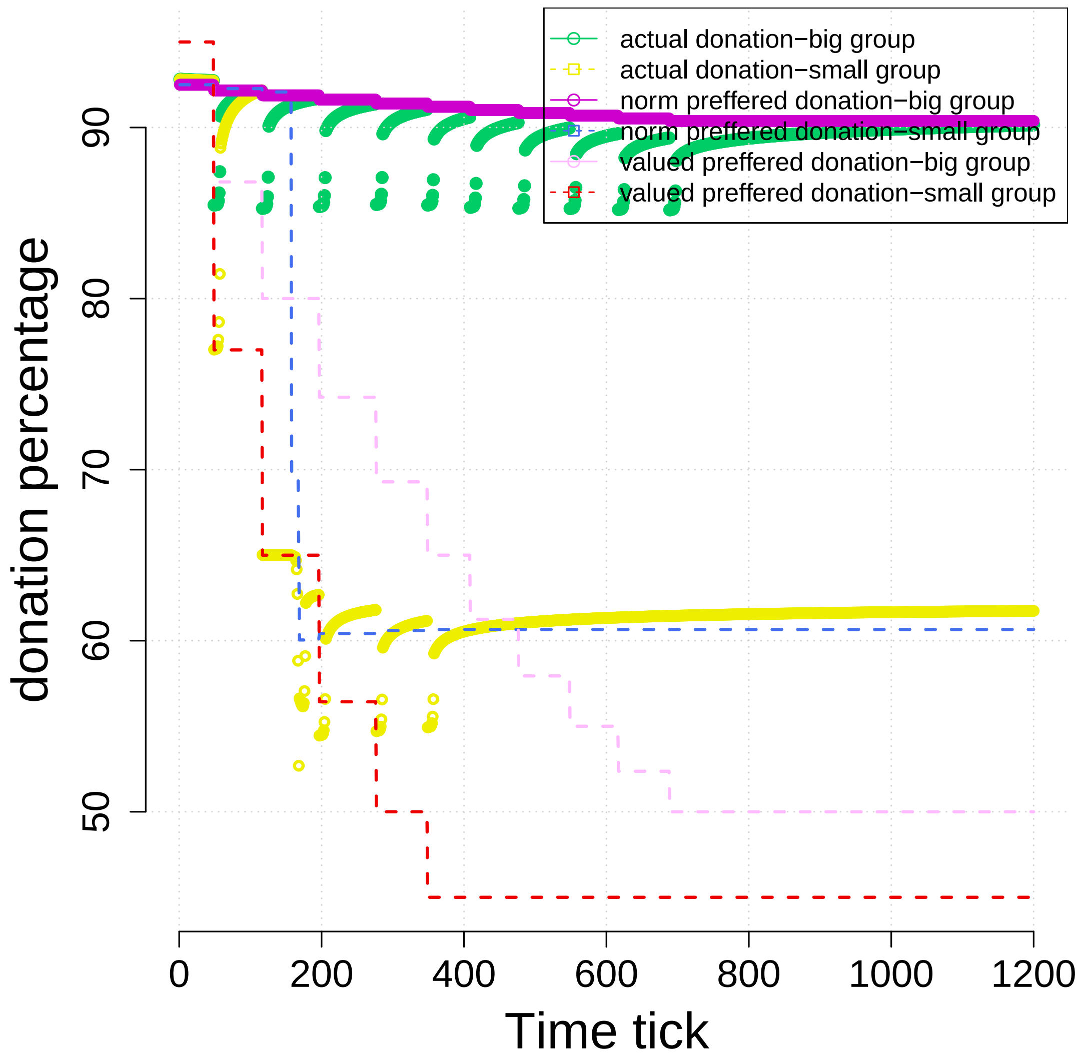

Figure 8.4: Donation amount in the big group and the small group when we change the value distribution of the groups. In these scenarios, the value distribution of groups is compatible with the initial norms. Also, the change in value distribution of groups happens gradually (slow rate). This figure shows when new agents join a group gradually, they will adopt the group norm even though their value preference is against it. For example, the average preferred donation amount based on personal values in the big group (yellow line) is 60%, but the actual donation (green line) is close to the norm (pink line).

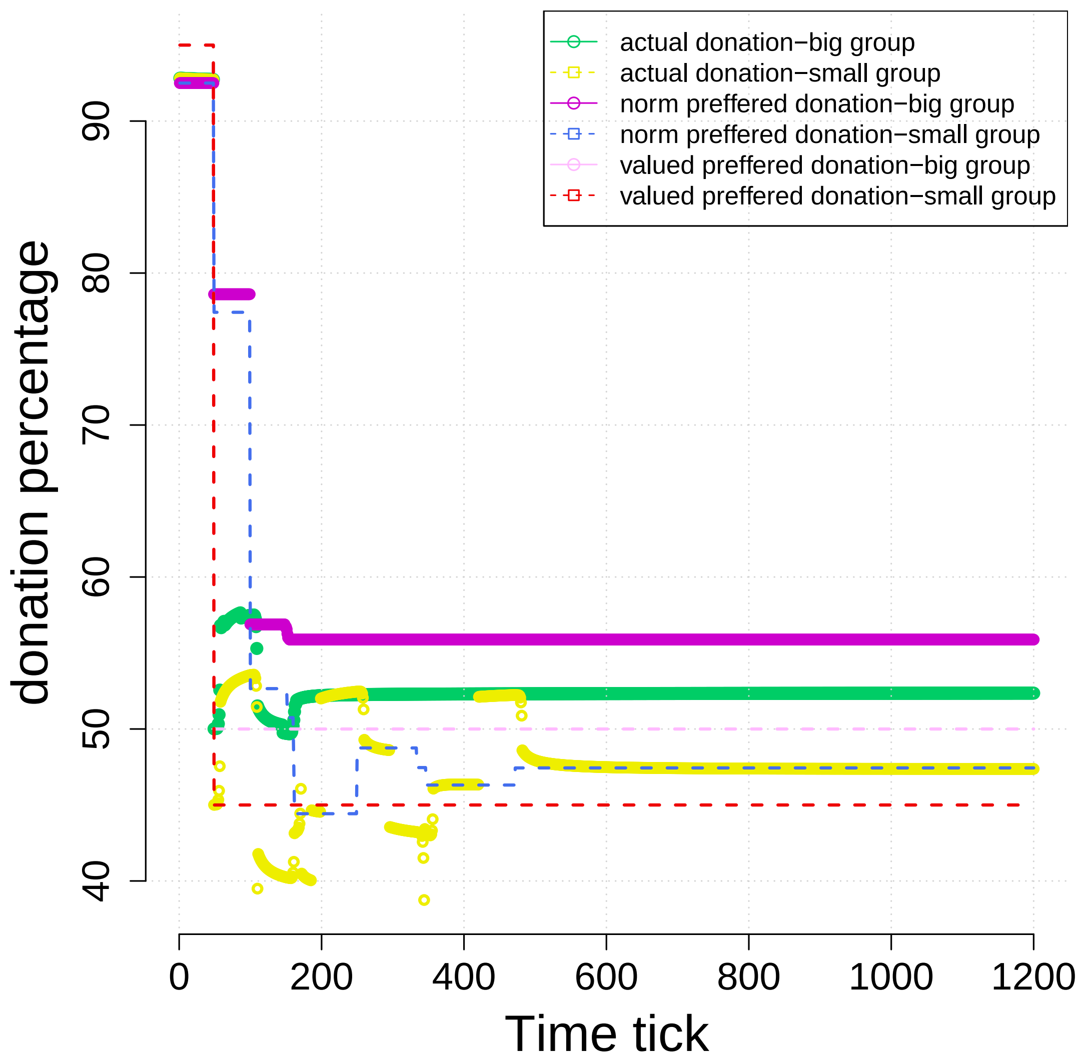

Figure 8.5: Donation amount in the big group and the small group when we change the value distribution of the groups. In these scenarios, the value distribution of groups is compatible with the initial norms. Also, the change in value distribution of groups happens in one tick (fast rate). This figure shows when new agents join a group at once and many of them are the in observation phase, they can change the norm of the group. For example, the average preferred donation amount based on personal values in the big group (dotted pink line), the actual donation (green line), and the norm (pink line) are close to each other. In other words, the new members changed the norm to be closer to their personal values.

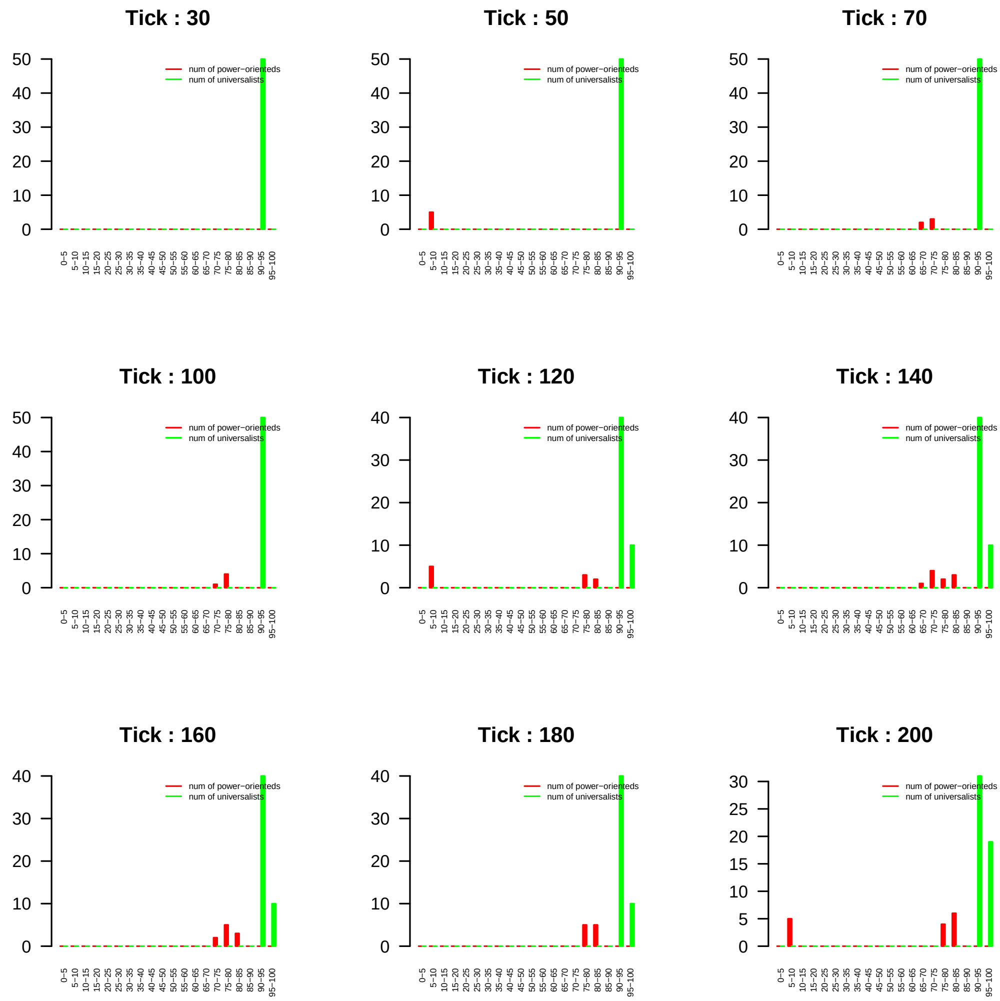

Figure 8.6: Clusters of agents based on their donation in the big group at different ticks (30 to 200), when the change in value distribution of groups happens gradually (slow rate). In these scenarios, the initial value distribution is compatible with initial norms that are internalized. This figure shows when the change in value distribution of a group is slow, the new members will adopt the norm of the group and there is not any cluster of norms (most agents donates over 70%.

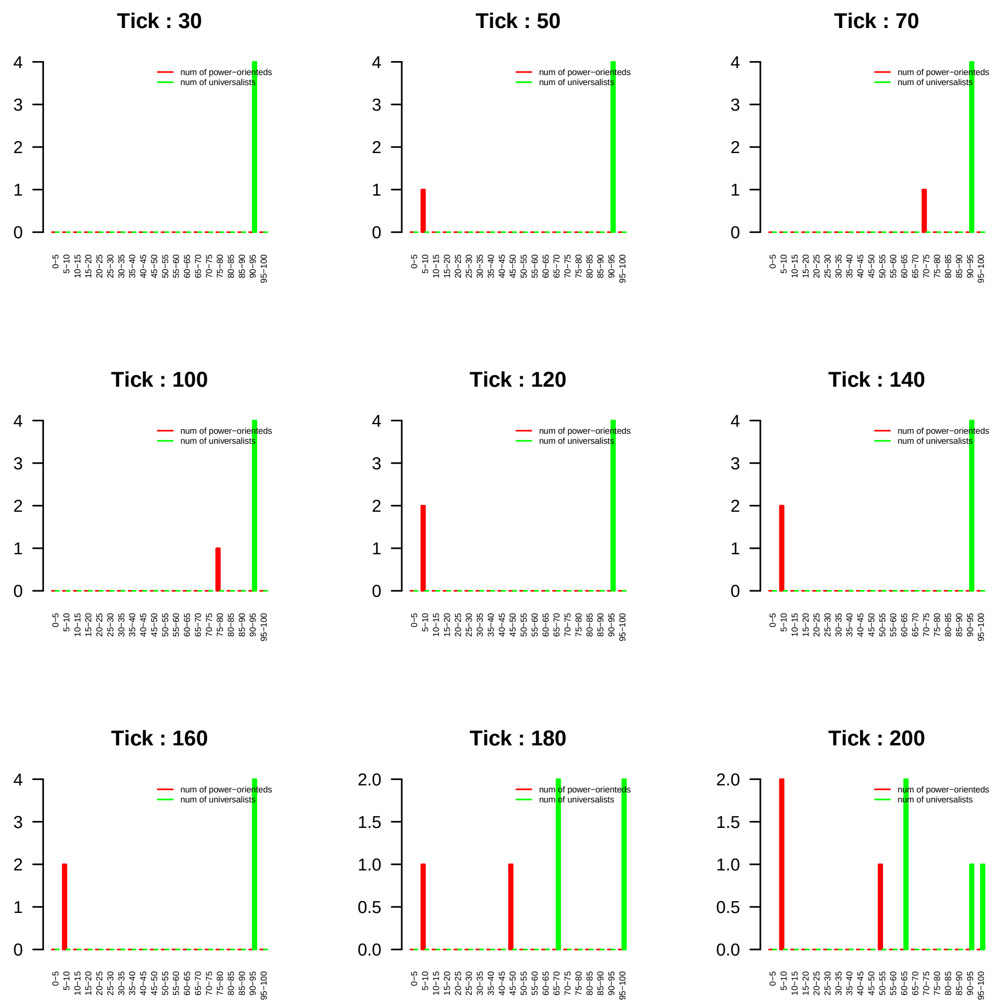

Figure 8.7: Clusters of agents based on their donation in the small group at different ticks (30 to 200), when the change in value distribution of groups happens gradually (slow rate). In these scenarios, the initial value distribution is compatible with initial norms that are internalized. This figure shows when the change in value distribution of a group is high, the new members will not have enough time to adopt the norm of the group and there are clear clusters of norms.

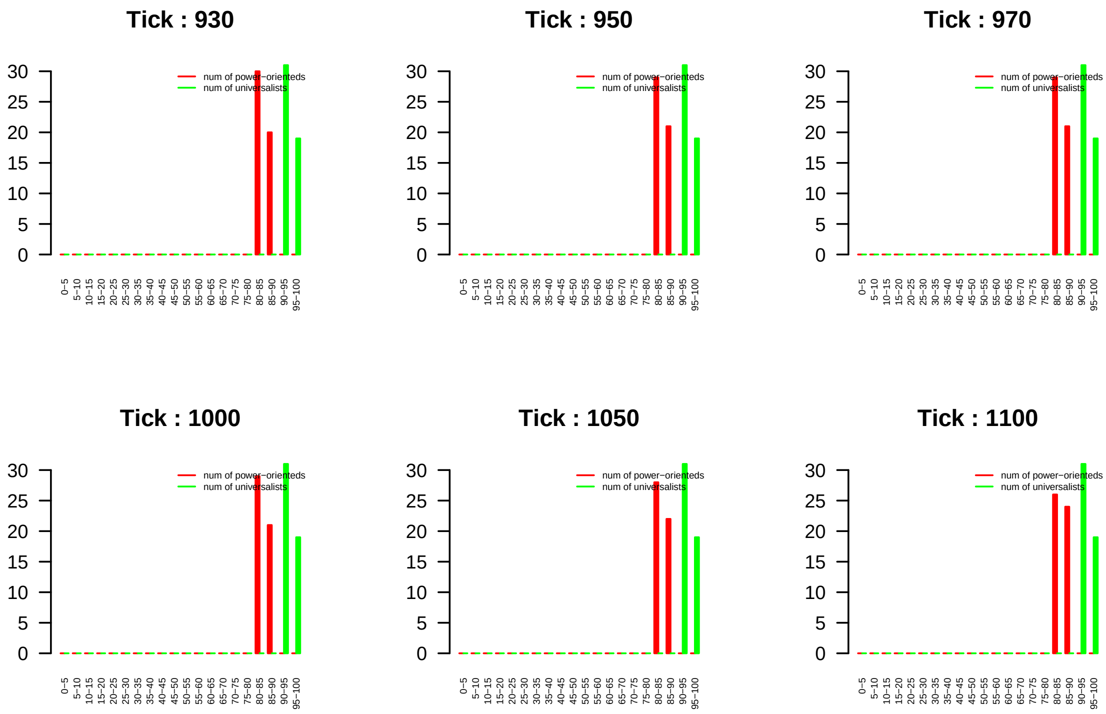

Figure 8.8: Clusters of agents based on their donation in the big group, when the change in value distribution of groups happens gradually (slow rate), at different ticks (930 to 1100). In these scenarios, the initial value distribution is compatible with initial norms that are internalized. This figure shows when the change in value distribution of a group is slow, the new members will adopt the norm of the group and there is not any cluster of norms (most agents donates over 70%.

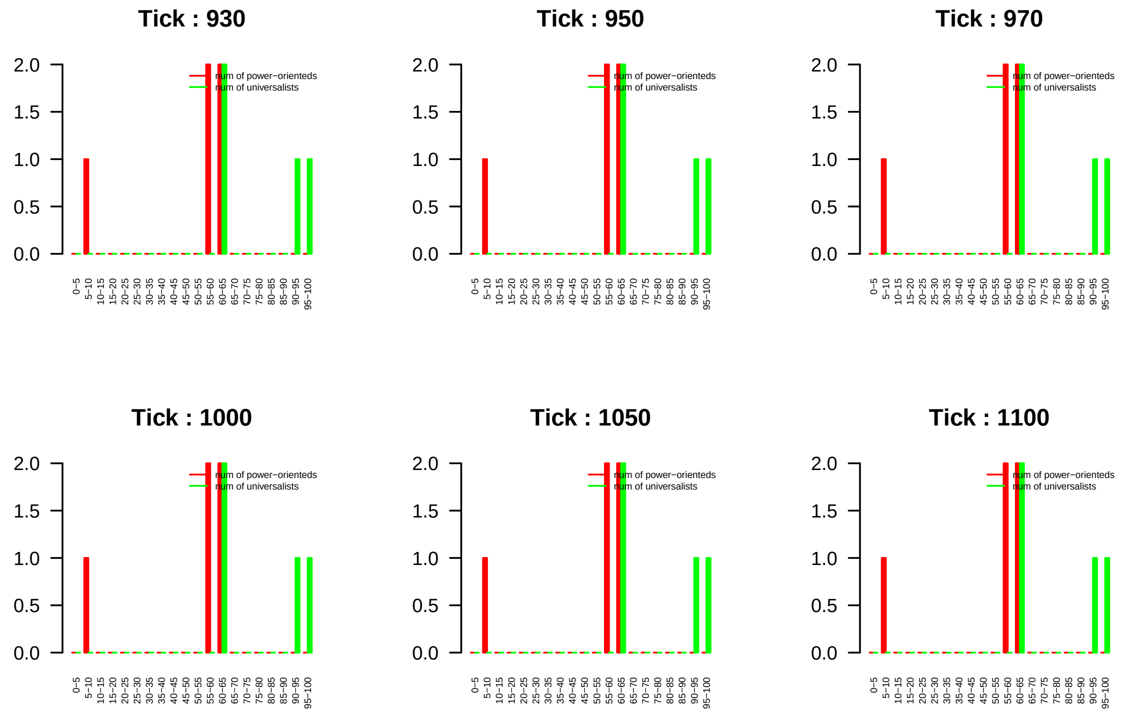

Figure 8.9: Clusters of agents based on their donation in the small group, when the change in value distribution of groups happens gradually (slow rate), at different ticks (930 to 1100). In these scenarios, the initial value distribution is compatible with initial norms that are internalized. This figure shows when the change in value distribution of a group is rapid, the new members will not have enough time to adopt the norm of the group and there are clear clusters of norms.

However, as it makes a lot of figures, we will show the ones that exhibited the general behavior of the system after any change.

As shown in Figure 8.6, the new power-oriented agents (depicted with red color) join the group at ticks 50, 120 and 200. The new agents slowly get along with the existing norm of the group (which is $|donation| = 95\% \pm 5\%$). As shown in Figure 8.8, at the end when the system reaches its steady state, the big group keeps its original norm without any change; even though, the value distribution has completely changed at the end. Even the power-oriented agents in the big group keep their behavior as close as possible to the norm. However, the small group slowly changes its norm (Figure 8.7). After the overall behavior of groups do not change (Figure 8.9), we can see that some small inner groups have been created in the small group and there is not a unique norm in the small group. It seems that in the small group, agents act more individualist; however, agents in the big group act more like a community.

Also, Figures 8.10 and 8.12 show that joining 50 agents at tick 50 to the big group will change the norm to $|donation| = 56\%$. The new norm is almost the average amount that all the agents (old members and new members) want to donation (value-based amount). Figures 9.6 and 8.13 shows that the small group will reach a norm as well. However, it takes a bit longer for the small group to get to a normative action. The reason is the impact of each member on the general outcome of the group. Considering the fact the we eliminate other social factors in the simplified simulation (such as social level), all the members have equal impact on the output. Therefore, in the small group with maximum 10 members the impact of each member is 10%; in the big group with maximum 100 members, the impact of each member is 1%. In other words, if a member in the big group violates a norm, it has only 1% impact on the descriptive behavior of the group.

It seems that the existing norm should disappear in 50 ticks and a new norm starts emerging immediately after that. However by checking the individual status of all agents, we observe that it takes longer than 65 ticks (including disappearing of the old norm, emerging a new norm, adopting it by the agents, and start internalizing it by the agents). The reason is the scheduling of Repast. When agents want to donate, they consider the behavior of their group mates. They observe the previous donation amount of their group mates. However, going trough all the agents happens in a loop in each tick. Therefore, the first agent in the loop observes the behavior of the other agents in the previous tick. He makes his decision and donates, considering the previous behavior of the other agents. The next agent observes the behavior of the first agent in the current tick, and the behavior of the other agents in the previous ticks. It is worth mentioning that the order of behaving agents is random and scheduled by Repast.

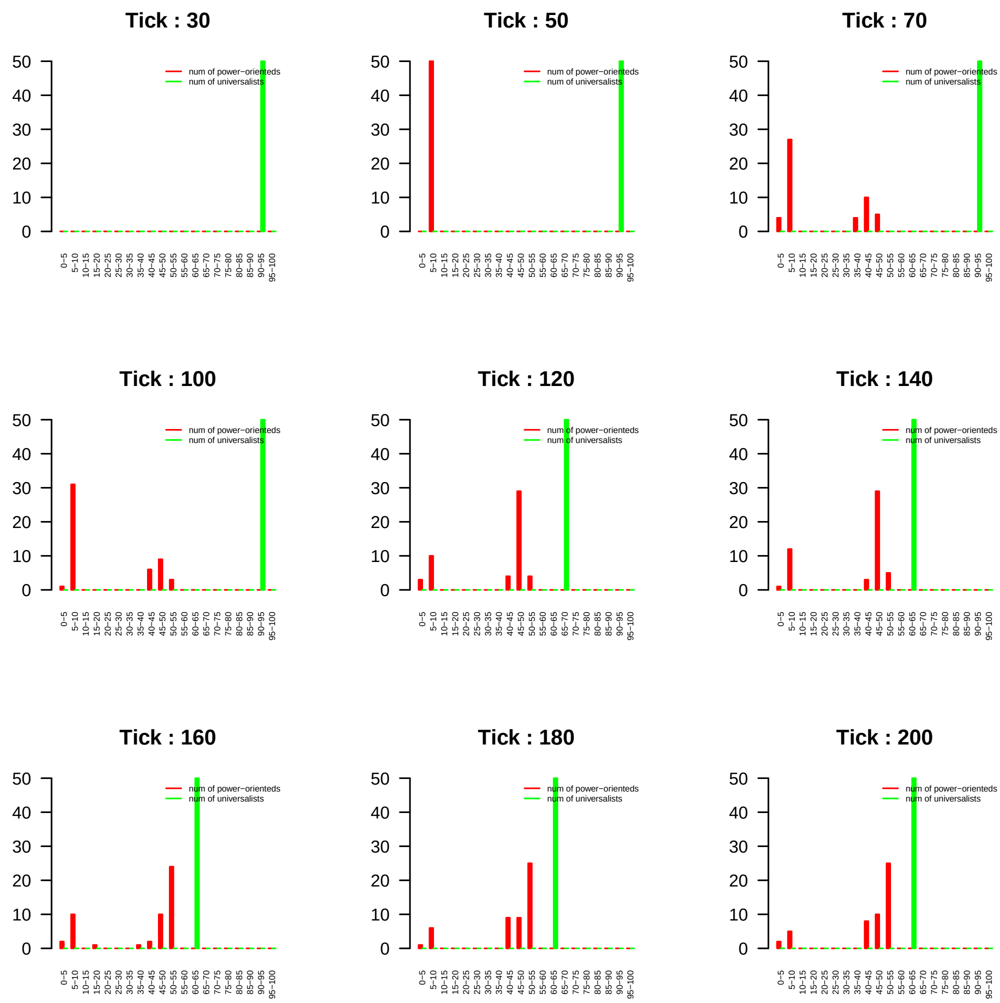

Figure 8.10: Clusters of agents based on their donation in the big group, when the change in value distribution of groups happens at one tick (fast rate), at different ticks (30 to 200). In this scenarios, the initial value distribution is not compatible with initial norms which is internalized.

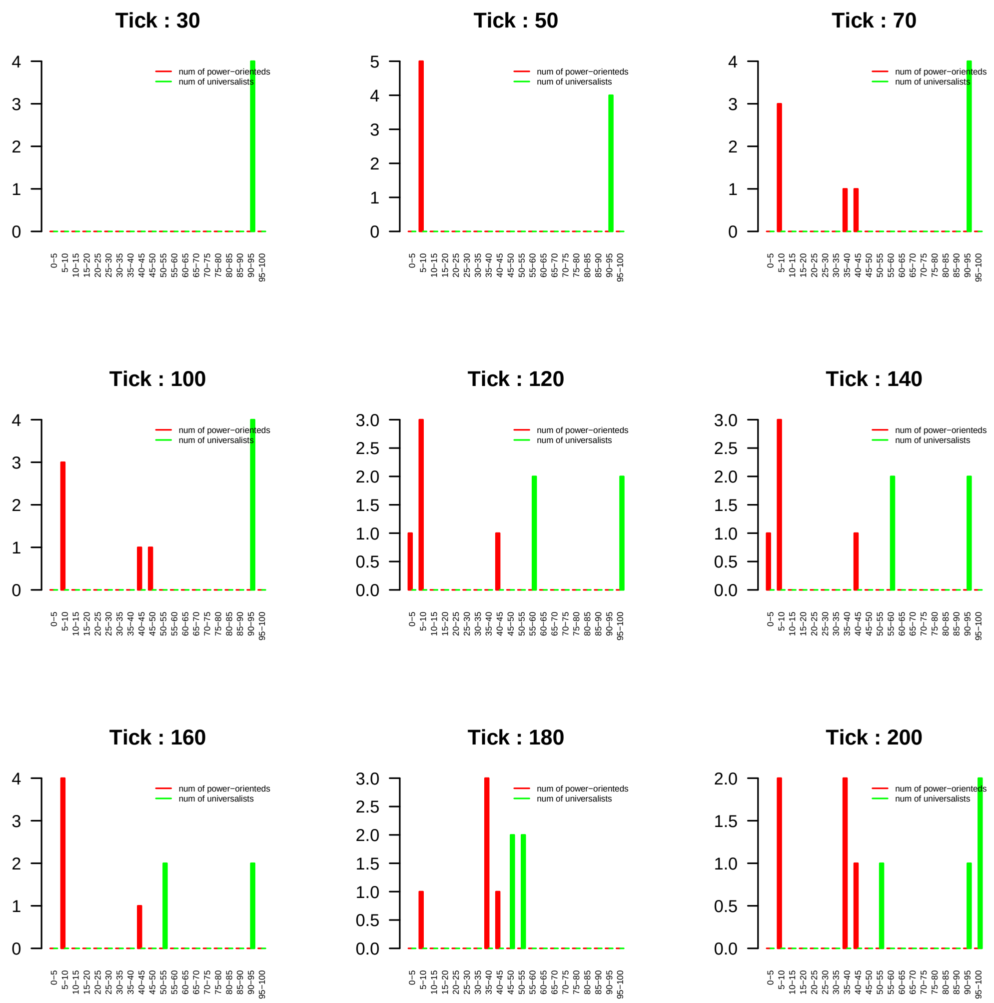

Figure 8.11: Clusters of agents based on their donation in the small group, when the change in value distribution of groups happens at one tick (fast rate), at different ticks (30 to 200). In this scenarios, the initial value distribution is not compatible with initial norms which is internalized.

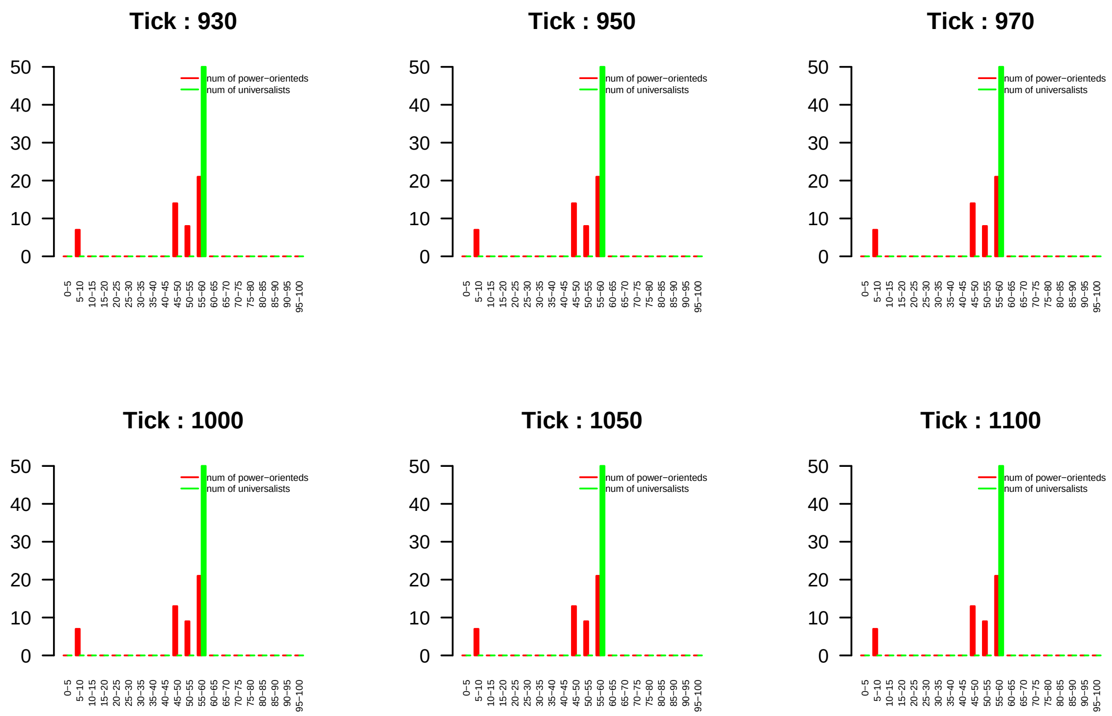

Figure 8.12: Clusters of agents based on their donation in the big group, when the change in value distribution of groups happens at one tick (fast rate), at different ticks (930 to 1100). In this scenarios, the initial value distribution is not compatible with initial norms which is internalized.

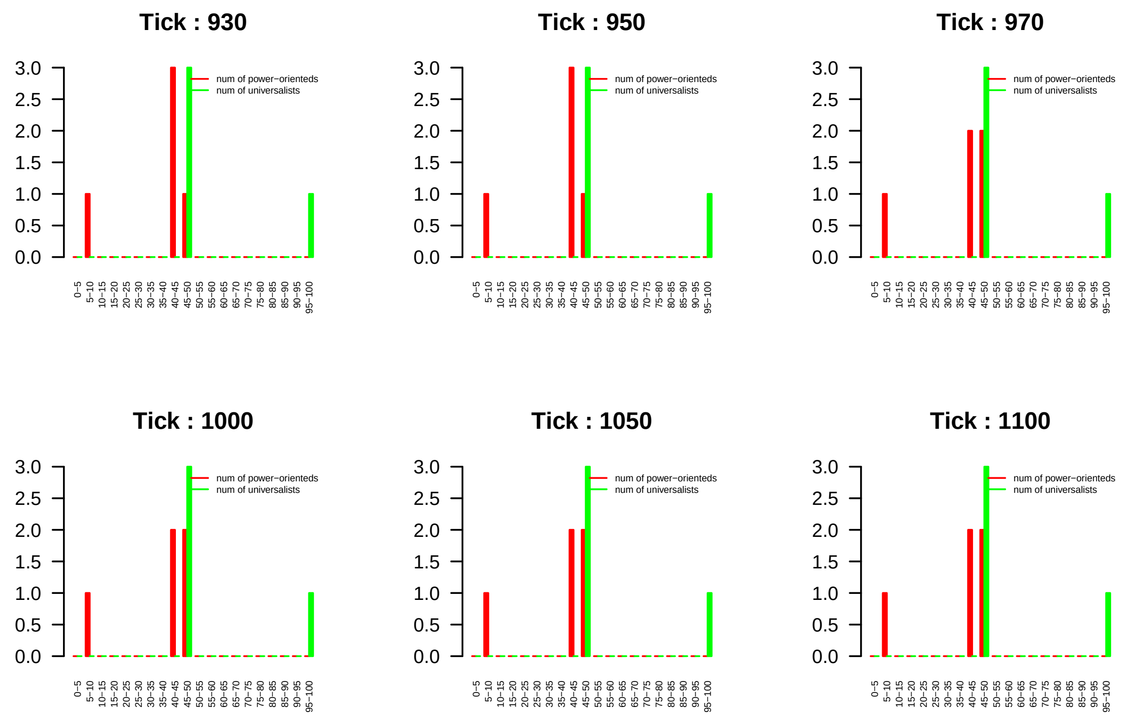

Figure 8.13: Clusters of agents based on their donation in the small group, when the change in value distribution of groups happens at one tick (fast rate), at different ticks (930 to 1100). In this scenarios, the initial value distribution is not compatible with initial norms which is internalized.

Scenario 2

Considering the **scenario 1**, we want to study what is the effect of changing the population when the initial norm, which is internalized by the members, is not compatible with the value distribution of the agents. We make change in the value distribution both slowly and fast (joining rate high and low). We want to see what is the influence of the changing rate on norm transformation in both groups. We consider $Initial\_norm$ as $|donation| = 25\% \pm 5\%$ and $Initial\_repeat = 60$. Also, we set the slow joining rates (the same as **scenario 1**) as:

$$\begin{aligned} Population\_change\_time_{big} = \{&(50, +5\ power),\ (120, +5\ power),\\ &(200, +5\ power),\ (280, +5\ power),\\ &(350, +5\ power),\ (410, +5\ power),\\ &(480, +5\ power),\ (550, +5\ power),\\ &(620, +5\ power),\ (690, +5 power)\} \end{aligned}$$

and

$$\begin{aligned} Population\_change\_time_{small} = \{&\\ &(50, +1\ power),\ (120, +1\ power),\\ &(200, +1\ power),\ (280, +1\ power),\\ &(350, +1\ power)\} \end{aligned}$$

and the fast joining rage as :

$$Population\_change\_time_{big} = \{(50, +50\% power)\}$$

$$Population\_change\_time_{small} = \{(50, +50\% power)\}$$

As shown in Figure 8.14, even though the initial norm is not compatible with the values of the original members of groups, slow changes in the value distribution of the groups will not affect the norm. As the behavior of the system is similar to **scenario 1**, we will not show the clusters of agents in different ticks. This results, prove that if the changes happen slow enough, the norm stays stable in the groups.

In contrast to the slow joining rate, the descriptive norm of the big group and the small group are different when the value distribution changes fast. As shown in Figure 8.15, the big group is more resistant to keep the norm compare to the small group. The reason is that there is less chance of observing all the new members act before the old members in the big group. As mentioned before, the order of actions in the agents is random. Therefore, in the big group, there is less chance that all the 50 new members act before all the old members for long enough. In other words, it has to happen that all the new members act first (donation 5%) for 50 ticks. Then, the old members will forget the default norm and start acting based on their values. However, this scenarios has to happen between 5 new members.

Scenario 3

In the **Scenario 1, 2**, we assumed the initial norm has been internalized by the agents when the simulation starts. However, the system will behave differently if the initial norm is not internalized. To check another important factor in norm transformation which is the phase of life-cycle of the initial norm, we design another scenario. In this scenario, We consider $Initial\_repeat = 10$. In other words, the simulation starts with having groups with universalist members who adopted the norm. Also, I assume the slow joining rates as:

$$Population\_change\_time_{big} = \{(2, +5\,power),\ (52, +5\,power),\ (120, +5\,power),\ (200, +5\,power),\ (360, +5\,power),\ (420, +5\,power),\ (480, +5\,power),\ (550, +5\,power),\ (620, +5\,power),\ (690, +5\,power)\}$$

and

$$Population\_change\_time_{small} = \{(2, +1\,power),\ (52, +1\,power),\ (120, +1\,power),\ (200, +1\,power),\ (360,\ +1\,power)\},$$

I assume the slow joining rates as:

$$Population\_change\_time_{big} = \{(50, +50\%power)$$

and

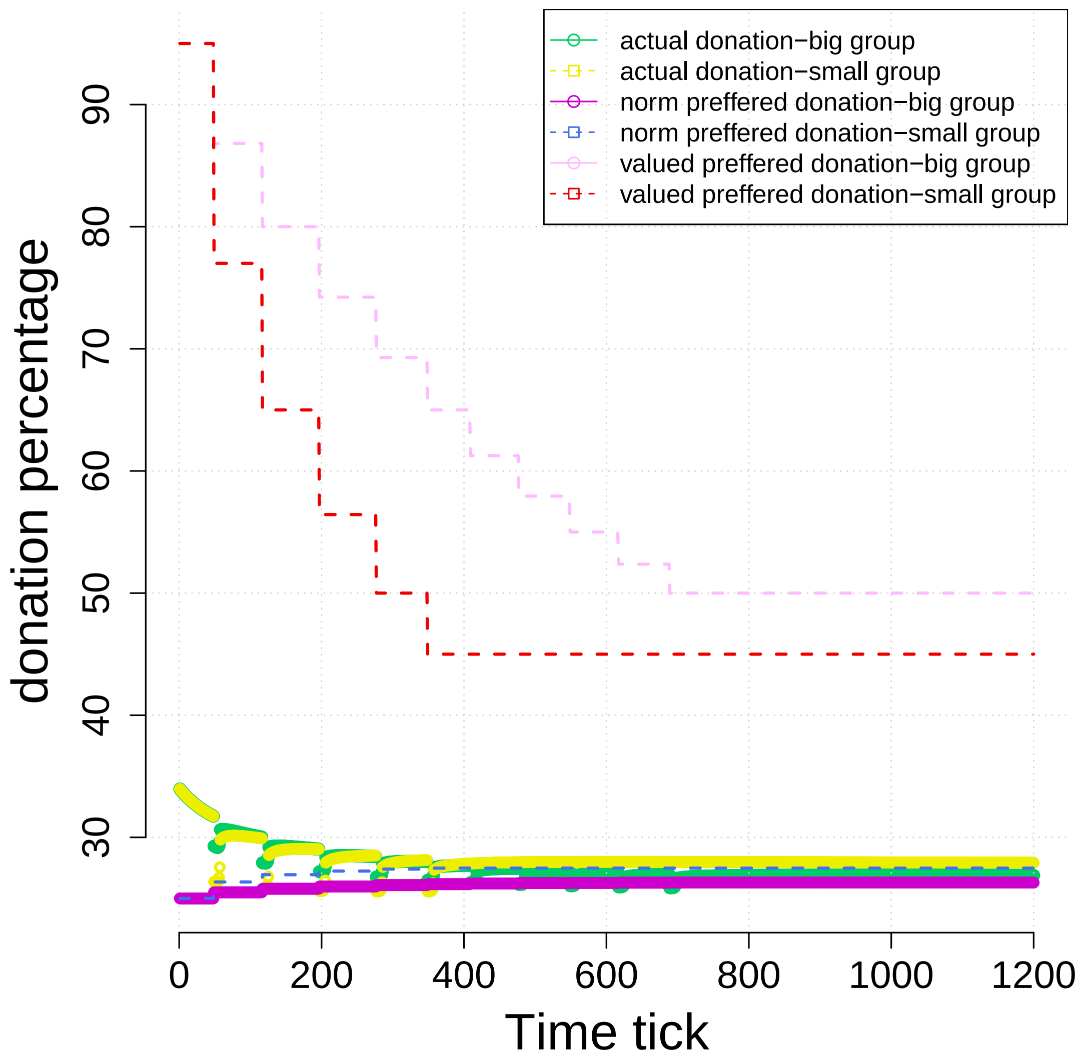

Figure 8.14: Donation amount in the big group and the small group when we change the value distribution of the groups. In these scenarios, the value distribution of groups is not compatible with the initial norm which is internalized by default. Also, the change in value distribution of groups happens gradually (slow rate).

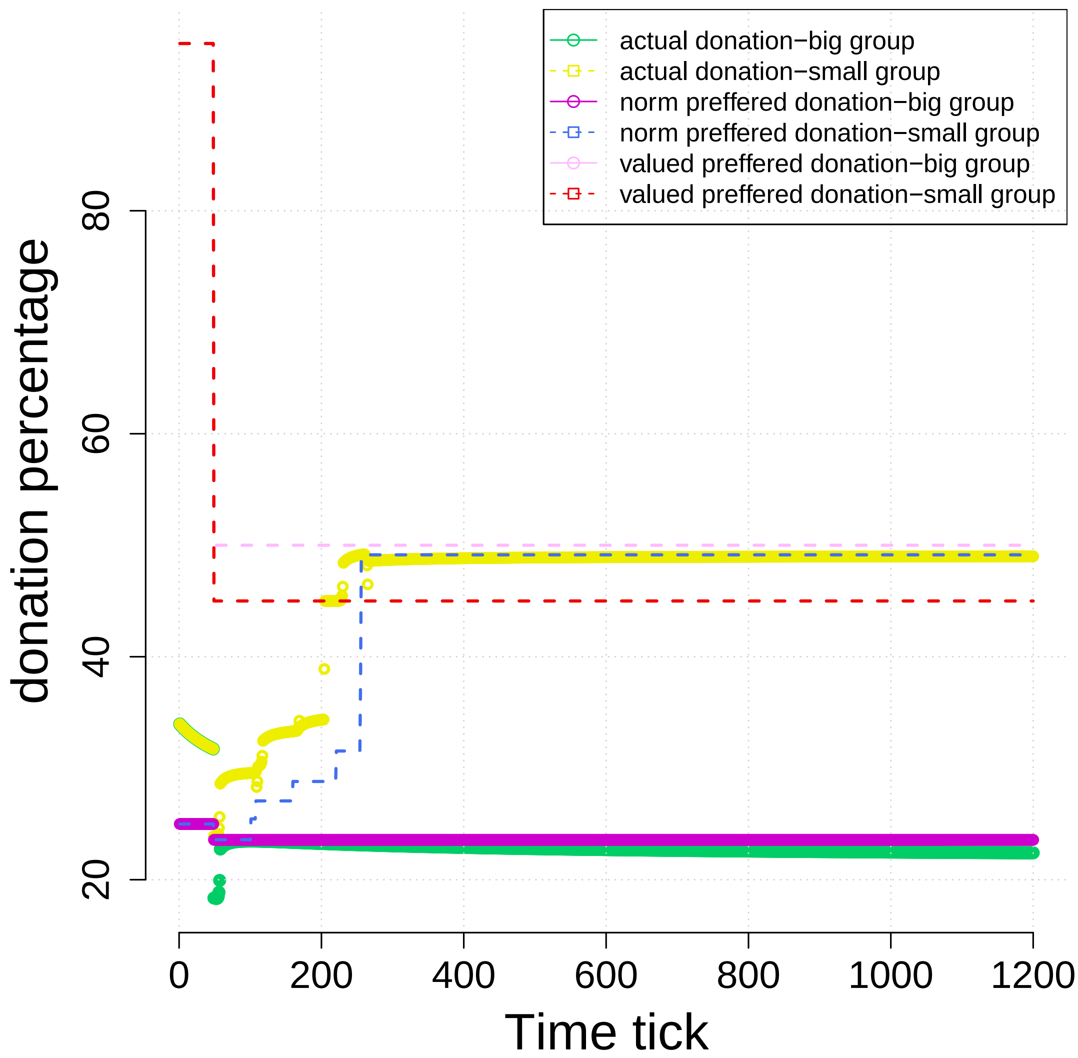

Figure 8.15: Donation amount in the big group and the small group when we change the value distribution of the groups. In these scenarios, the value distribution of groups is not compatible with the initial norm which is internalized by default. Also, the change in value distribution of groups happens at one tick (fast rate).

$Population\_change\_time_{small} = \{(50, +50\% \, power).$

The joining rates are slightly different from the joining rates in **scenarios C1** and **C2**. The reason is that we want to see the effect of joining new agents on norm transformation when the norm is not internalized.

We check the behavior of the system for two different settings; $Initial\_norm$ as $|donation| = 25\% \pm 5\%$ and $Initial\_norm$ as $|donation| = 95\% \pm 5\%$. In the first setting, the initial norm is not compatible with the initial value distribution of the groups. However, in the second setting, the default norm is compatible with the value distribution of the groups. Figures 8.16 and 8.17 depicts the results of these two scenario settings. According to these figures, changing in the population will change the norm to the average personal preference (value-based preference) of the members.

The results of these scenario settings are comparable with the previous scenarios. In the previous scenarios, we explored the behavior of the system when there is an internalized norm. Then, we checked the norm transformation in the presence of chaining the value distribution of the groups at a different pace. We can see that agents transform the norm according to their personal preference when the norm is not internalized. As a clarification, we show the behavior of the system when the initial norm is adopted (not internalized) and the value distribution of the groups will not change over time. Figure 8.18 shows the system behavior when initial norm is $|donation| = 95\% \pm 5\%$, $Initial\_repeat = 10$ (the initial norm is compatible with the value of the group); Figure 8.19 shows the system behavior when initial norm is $|donation| = 25\% \pm 5\%$, $Initial\_repeat = 10$ (the initial norm is not compatible with the value of the group). According to these figures, the norm will be internalized in the former case (Figure 8.18), and the norm will be transformed in the latter case (Figure 8.19).

8.5 Conclusions

While research into norms is considerable, both in the social sciences and in computer science, some aspects of norm dynamics are still under-explored, especially when it comes to normative agent models. We focused on these aspects, which we describe as the stages of the life-cycle of norms, explained why they are relevant and explored possible underlying mechanisms. We consider that the value-norm connection is central to explaining some aspects of normative dynamics, such as norms remaining relatively stable in the face of

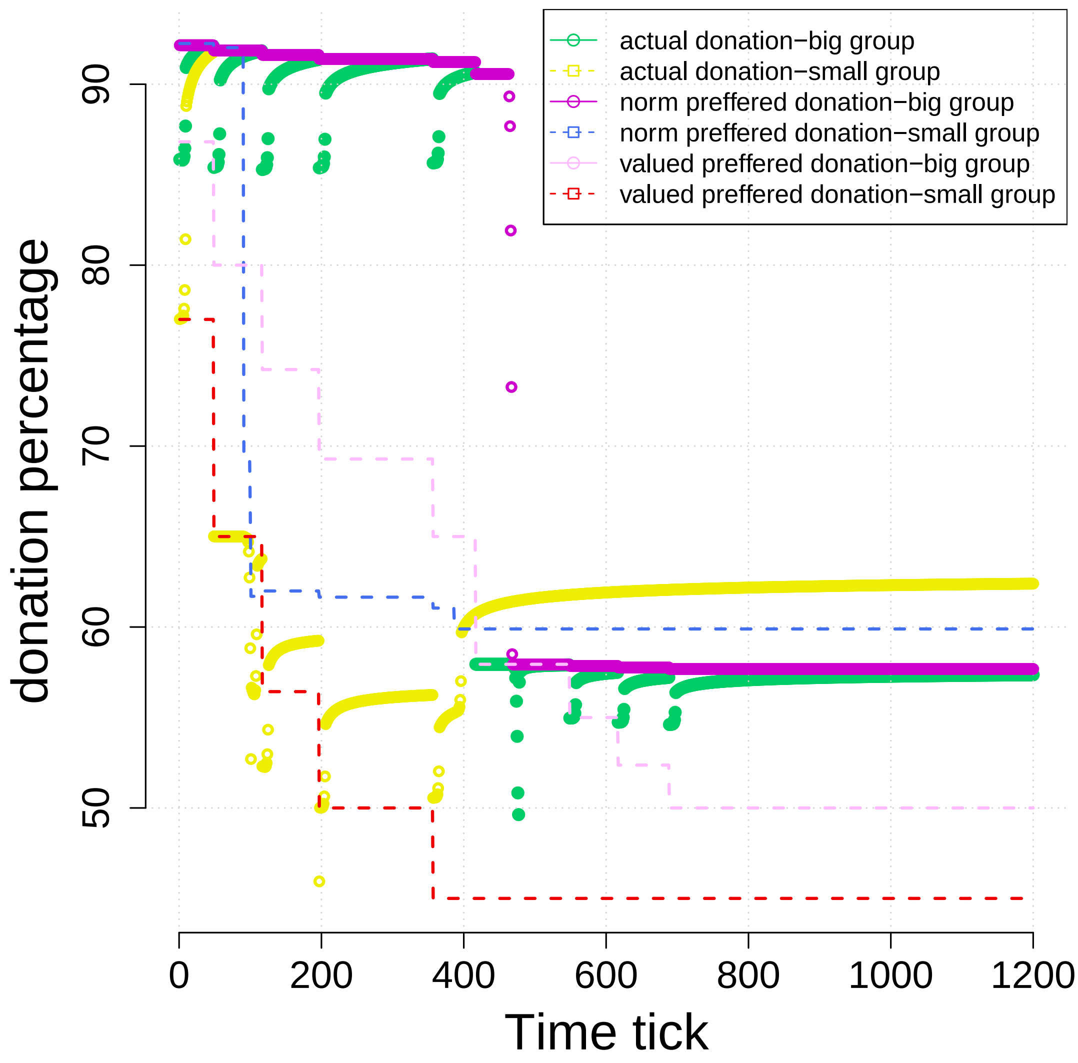

Figure 8.16: Donation amount in the big group and the small group when we change the value distribution of the groups. In these scenarios, the value distribution of groups is not compatible with the initial norms. Also, the change in value distribution of groups happens gradually (slow rate)

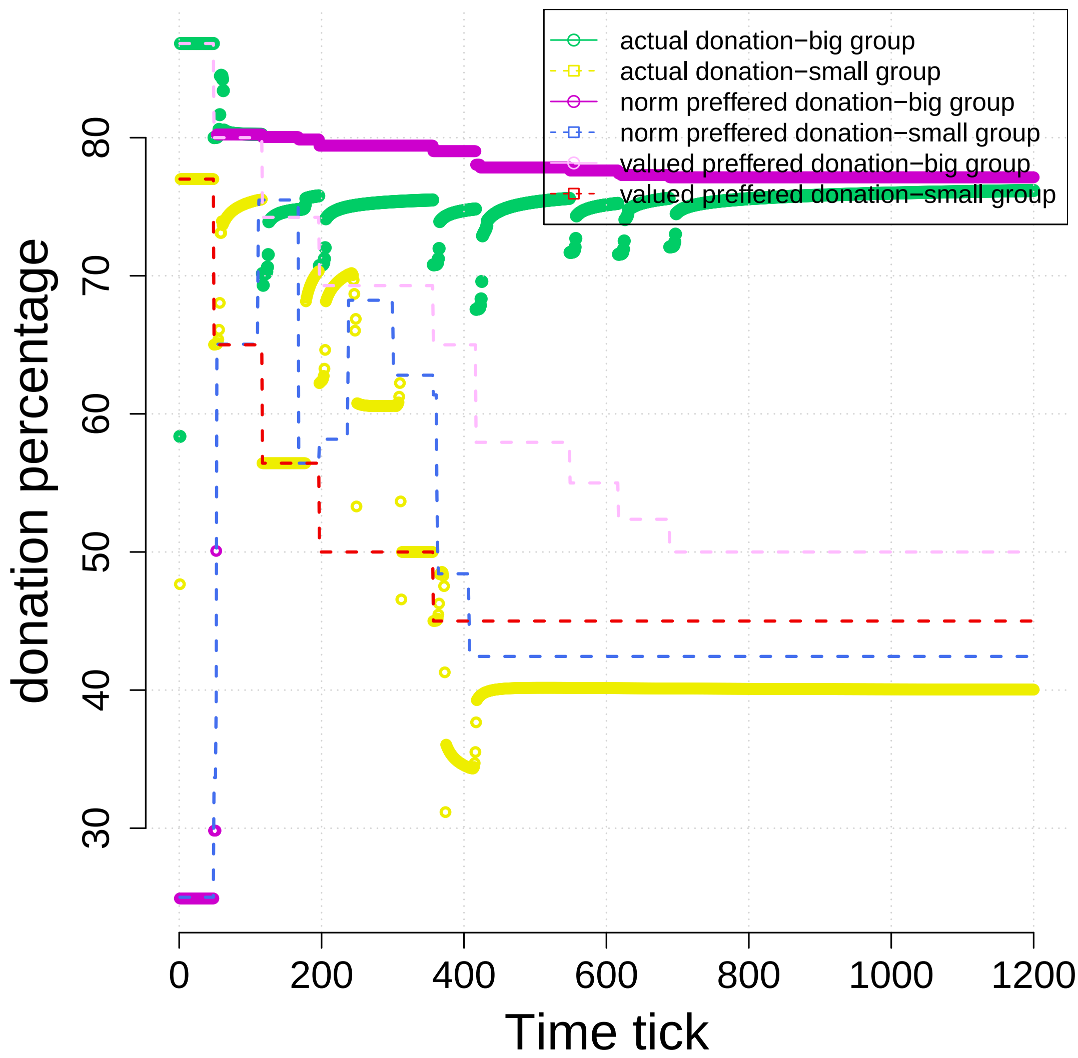

Figure 8.17: Donation amount in the big group and the small group when we change the value distribution of the groups. In these scenarios, the value distribution of groups is not compatible with the initial norms. Also, the change in value distribution of groups happens at one tick (fast rate)

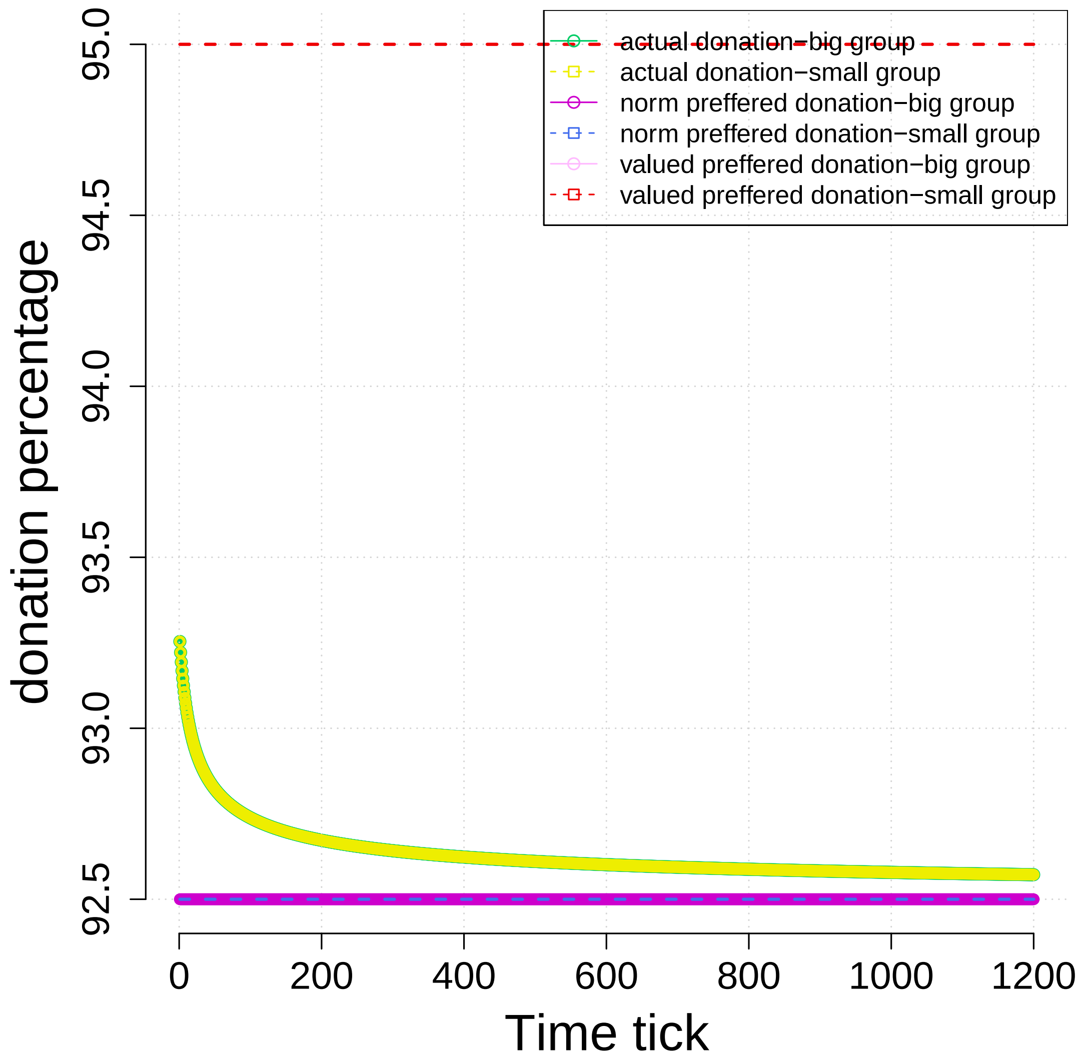

Figure 8.18: Donation amount in the big group and the small group without any change in the value distribution of the groups, when the value distribution of groups are compatible with the initial norms

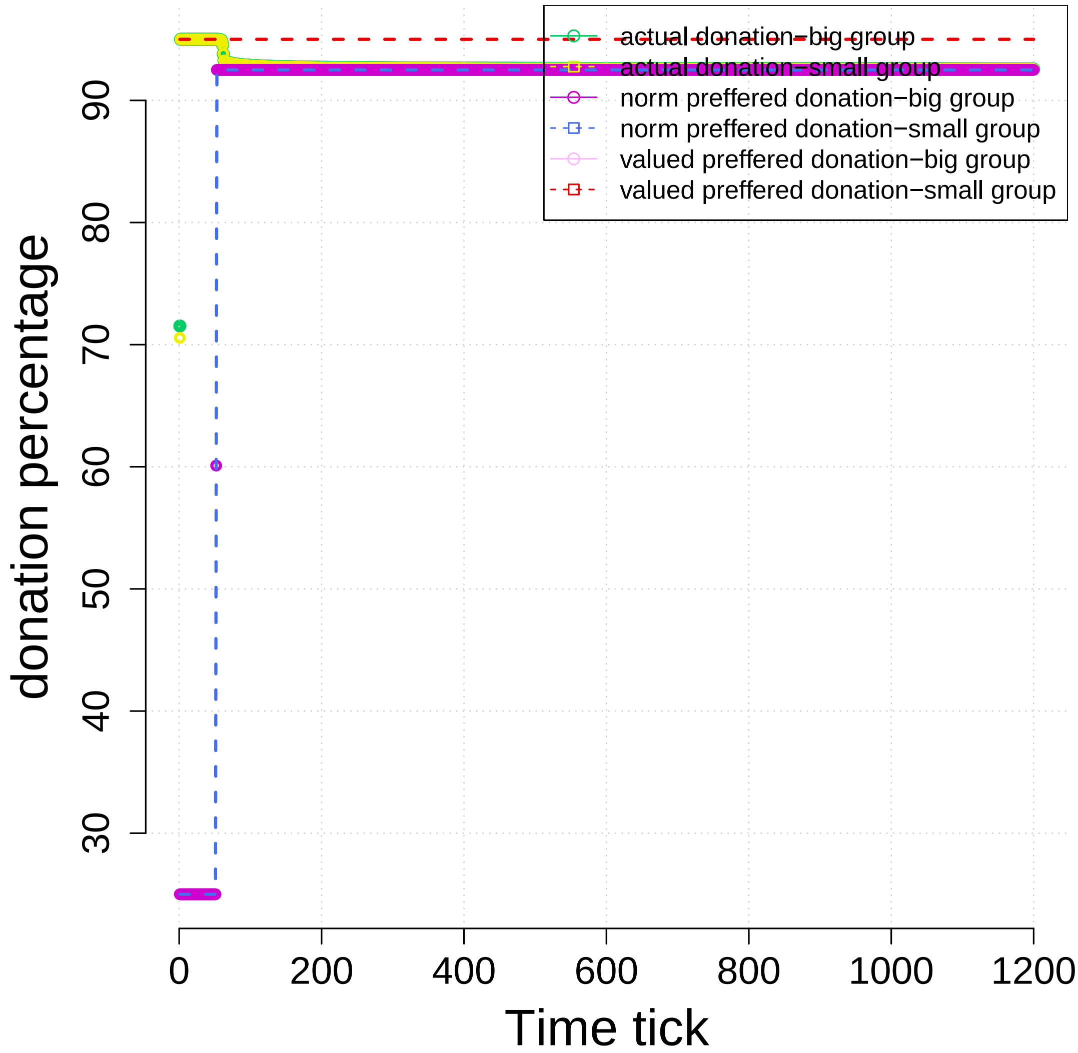

Figure 8.19: Donation amount in the big group and the small group without any change in the value distribution of the groups, when the value distribution of groups are not compatible with the initial norms

environmental changes, or norms appearing insensitive to enforcement attempts through sanctions.

We presented our novel normative framework for use in agent simulations and showed that it captures the under-explored norm dynamics: In this chapter we introduced a conceptual normative framework that helps us building multi-agent simulations and models to answer the following questions related to social norms:

1. **How does a social norm emerge in a society?**
   Social norms are not explicit global rules/limitations (as it has been considered this way in most simulation and modeling research) that agents must decide to follow or violate. But rather, each agent has its implicit interpretation of norms in his groups. Therefore, each agent decides what to do based on his personal values and his interpretation of norms. Over time, a norm might emerge on values of the group members. Norm emergence in our framework is not only appearing a behavioral pattern. Considering values as a norm director, a social norm will emerge according to the group members' values in a distributed manner.

2. **What influences make a social norm to be more stable or more adoptive to environmental changes?**
   Considering norms as pre-defined rules that may only be changed from an external source or considering norms as behavioral patterns make them either rigid or quickly reactive toward changes. This is a pitfall in most of the simulation and modelling research. To address this question, we connected social norms (as a dynamic social phenomenon) to personal values (as an individual static phenomenon). Such a connection prevent social norm to be quickly reactive to any changes; but not completely rigid.

3. **What will cause preventing a norm violation if there is not any sanction or reward for violators?**
   Sanction has been used as a mechanism to enforce social norms to society in many research efforts. However, norms can be learned through interactions (observation, conversation, etc.). In our framework, agents observe the behavior of others and perceive the social norms if there is any. Therefore, a new agent might violate a norm as he did not observe enough time to have his interpretation; but, he will not be punished because of his violation.

4. **How does a norm disappear?**
   Many studies on simulating and modeling social norms have missed norm disappearance. However, it is a part of the norm life cycle. Also, it is part of a dynamic norm transformation. In our framework, agents might not follow a norm due to environmental conditions (i.e. having no money to donate). However, even if all the agent does not perform a normative action, they will not forget the norm immediately. Instead, it will take some time to forget a norm completely or replace it with an alternative action.

   We then operationalized the framework by means of an agent model and simulations with norms and values. We chose to use the model to test our hypotheses that norms in our framework are mostly insensitive to sanctions, and that norm emergence, transformation, and disappearance are greatly influenced by group size and growth/shrink rates.

8.6 Future work

We are interested in extending our framework further by allowing normative goals and plans in addition to the existing normative actions. This can be achieved by mapping the abstract values to goals and plans.

As for future simulation work, we would like to move beyond the simple simulation presented here that we used to test our hypotheses. An interesting direction would be to flesh out the group dynamics by the addition of a network structure, which can then allow us to calculate social network metrics (density, diameter, number of nodes and edges etc.) and provide further insight into normative dynamics. We are also interested in the impact of contextual groups, such as workplace colleague groups, which exist during work hours, but cease to exist as soon as everyone goes home for the day. Yet another extension involves the addition of social status. In this chapter we considered all agents as having equal influence, but in the real-world high-status individuals have disproportionate power to affect the behaviour of other group members and there are many scenarios (especially where policy design is concerned) that cannot be properly studied without a status element.

9

Conclusions and Future Work

9.1 Conclusions

According to rational choice theory, people employ rational calculations to make rational decisions and obtain outcomes that are in line with their own personal goals. These outcomes are also linked to maximizing an individual's self-interest. In many research attempts, this theory has been interpreted as maximizing a utility function to maximize profit. However, instead of making profit, people discount their self-interest and profit under certain circumstances. This behavior can be explained by Max Weber's theory of human behavior. According to this theory, human beings adjust their activities based on social contexts that have a close link between personal and social values, as well. In other words, using rational choice theory to propose a new policy without taking into account the social context of the policy's intended audience would not yield the desired outcome.

Researchers in the field of social simulation and modeling, use some kind of prizing mechanism to formulate effects of social context on behavior in order to study a socio-ecological complex systems. In addition, personal values and how they affect a socio-ecological complex system are all explored in great detail in agent-based simulations and models. However, there are still some questions remained unanswered regarding personal values and social norms.

Social norms are influential factors on human decisions. Social norms are unwritten agreements in a society that govern behavior in the absence of a central monitoring system. This is the opposite of legal conventions that are written agreements and monitored by authorities. Unlike legal conventions, violating social norms may not necessarily have predetermined (written or unwritten) consequences; Similarly, obeying social norms may not necessarily have direct social advantages. On other words, there is not always a penalty for violating social norms or a prise for adhering to social norms. Social norms might be followed by people because of variety of reasons; for example, a desire to feel included in their culture. Considering these characteristic of social norms, understanding and acknowledging them is very difficult. However, it is critical for effective policy-making to take into account social norms as those are the factors that regulate behaviour of people.

Social norms are more macro-level agreements. These macro-level agreements are formed without explicit discussions by all members of a society. Therefore, these should be connected to micro-level factors. Studies show social norms are strongly associated with personal values. In social simulation and modeling however, the relation between social norms and values is barely covered. In the past studies, norms are considered as certain actions that will not change over time. But in the context of policy making the social norms should also be seen as dynamic and adapting to the circumstances over time. To be able to describe these norm adaptations there appeared the need to have a stable criteria that could be used to describe the change. It seems that personal values might be a good candidate for such a criteria. Therefore, I started my study with personal values, then continued on studying social norms and the relation between social norms and personal values.

9.1.1 Values

Values, as micro-level factors, affect human decisions. In many research studies, the presented simulations and models of values are overly simple. In other words, those might associate an action to a value to compare the preference. For example, a fisher who values “Universalism” might decide to not fish the endangered species, despite the financial benefits of those species. But, a person who values “Power” will choose making more money by catching any fish species that is more economically beneficial. But, what if there is a situation that a universalist need to support his children to pursue their higher education study? Does this mean that this person still will not consider making money as much as possible with respect to the endangered species? The answer is that it depends. According to Schwartz study, people have 10 generic values and these values are related. In most of the agent-based simulations, the relation between the values are not recognized. In addition to the values’ relation in Schwartz’ circumplex, satisfaction of the complete value system is not addressed in the previous studies. According to Schwartz value theory, the priority of the values for a person are related. Values that are closer in the value circle, have a similar importance; Values that are opposite in the circle, have opposite importance. For example, the importance of ’Universalims’ is close to the importance of ’Self-direction’ and opposite to ’Power’. In other words, if ’Universalism’ has high importance for a person, he may value 'Self-direction' highly and assign a low value to 'Power'. This means that this person still need to satisfy all 10 values, but he needs to satisfy Universalism' more than 'Power'. This is the missing piece in the previous agent-based simulations and models of personal values. These simulations and models cover the value stability, but they do not incorporate its dynamic influence on ecological and economic systems, and hence they do not address their infinite feedback loop on ecological and economic systems.

In the area of natural resource management, such as fishery management, great attention is paid to social issues and their effects on ecology and the economy. One critical question is what function social components - i.e. values and norms - play in other parts of such a complex system (economy and the environment). Studying fishery societies involve a variety of social factors. Some studies, for example, have emphasized the role of fishers' gender as a social factor. Many factors can influence the role and proportion of men and women who participate in the whole fishing process, including pre-process jobs, on-boat fishing, and post-process activities. One of these factors might be personal values; however, the role of personal values in gender studies was not mentioned explicitly in the studies to the best my knowledge.

My hypothesis was that society (as a collection of individual agents with personal values), economy, and ecology are inter-connected. In other words, changes in one aspect will influence the other two aspects. For example, changing the value distribution of society initiates and leads transformation of economy and ecological situation as well. However, there was no research that simulates such inter-connection. Therefore, to verify such interconnection, I started with simulating a simplified system in chapter 4. In this system, there are male and female fishers with different values that affect their daily decisions. The decisions are simply about how much to fish and how much money to make. This simulation is not about gender studies, but rather is more about the relation between values, value-based behaviors, and the mutual effect between collective behavior, economy, and the environment. In this simulation, agents consider only two categories of values - Universalism and Power- which are named as female and male categories. The simulation results shows the hypothesis that the values can explain the difference in behavior and some historical differences between men and women fishing. However, most important is that it gives an explanation about the mutual effect of the three sub-systems (social, economy, and ecology).

After proving the core of the hypothesis, I wanted to make each part of the sub-systems more realistic. Specially, I was more interested in the social part which required studying social norms in depth. As previously stated, values serve as the foundation for all decisions, while social norms regulate behavior, and the two are strongly linked. Therefore, I continued my research by examining personal values in more details. The most accepted definition is introduced by Schwartz, known as Schwartz' theory of values. Schwartz proposed his theory based on a huge survey, conducted on more than 60.000 individuals in 64 nations. As a result, he came up with 10 abstract values. This theory is the most widely recognized definition and yet it is conceptual. In chapter 5, I defined multiple actions, assign them to the values based on Schwartz' theory of values and presented simulation experiments in which agents have more complex value systems. In other words, agents could have multiple values and have different priorities to satisfy their values. The simulation experiments comply with the hypotheses and the dynamic mutual effects of the three sub-systems (social, ecological, economic) are shown in the results. However, these simulations still do not completely formulate the Schwartz' theory of values; the relation between the values is missing. Therefore, I used the result of these simulations to formulate Schwartz theory in chapter 6.

According to Schwartz theory, a universal set of abstract values can be imputed to people. These abstract values are context independent. Therefore, those need to be attributed to more concrete values and behavioral choices. A precise way of such a translation for practical purposes had not been developed. In chapter 6, I designed a practical yet formal framework for studying the value-driven behavior of agents in social simulations. I demonstrated the framework's usage by creating agent based simulations for a fishery villages that use this framework. This framework allows the researchers to interpret actions from abstract values, to apply this value implementation in the decision-making process of each agent, and to construct a model for micro and macro level analysis of behavior. This framework can be used as a reference by researchers that are interested in investigating, modeling, or implementing values. Furthermore, it enables them to reuse previous efforts in terms of values that are based on this framework.

9.1.2 Social Norms

After clarifying the position of values in the decision processes of agents I continued studying the influence of social norms on behaviour using agent-based models and simulations. Despite earlier work on this topic there were some important unanswered questions. They all relate to one of the following issues about social norms and their effect on behavior:

- Many researchers employ pre-defined social norms in the system. It is not possible to study norm emergence with such an assumption, since it does not allow a new norm to emerge or an existing norm to transform to another norm.

- Some researchers consider social norms to be reactive to changes (not some changes but ALL changes) in the system. In the presence of such assumption, norms cannot be studied as regulators of societies as they are entirely responsive to the changes and therefore unstable.

- Defining social norms as implicit state of agents is another problem. When social norms are not explicitly stated, analyzing them is not feasible either.

- Social norms and values are mostly considered as separate factors. Social norms are not linked to a more stable component, such as personal values. This assumption does not allow investigating norm transformation or norm persistence.

- Social norms are characterized as a utility function that is followed due to repercussions for violators and/or rewards for followers. According to these simulations, if there is not any fine or reward, the norms will not be followed. However in reality, people follow some norms even when there is no one to watch or judge them.

Given the above issues the current state of the art in agent-based simulations and models could not answer the following questions about social norms (which comprised my research questions):

- **RQ1.** Which factor can be used as a guiding principle for decisions and defining the boundaries of behavior?

- **RQ2.** How does a social norm emerge in a society?

- **RQ3.** What factors keep norms stable in the face of environmental changes?

- **RQ4.** What prevents norm violations in the absence of sanctions for violators?

- **RQ5.** How does a norm disappear?

The answers to all of these questions are essential when trying to understand the effect of a new policy on a community. The way such a new policy interacts with existing social norms and values can only be understood if we have a better grasp on how norms themselves behave and adapt over time and influence behaviour in society. Understanding social norm from social science is the first step to study it using agent-based simulations. I researched several definitions of social norm and chose the most thorough definition of social norm. One of the most important part of studying social norm is understanding its life cycle and the definition of each stage of the life cycle. The definitions of these stages

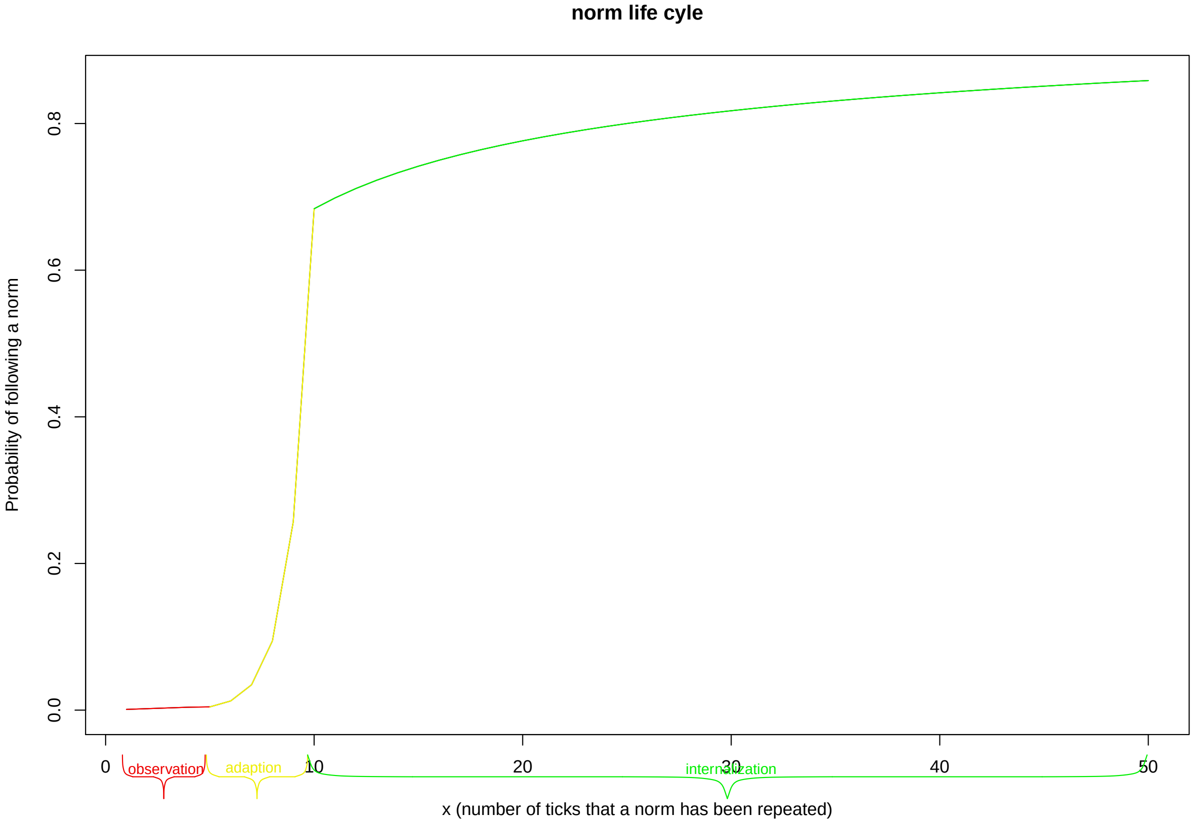

Figure 9.1: Probability of following a norm in different stages of its life-cycle for each agent

may appear apparent, yet they are not. For example, the first step is norm emergence, which indicates the stage at which a norm is generated; It must be determined how many times and for how long a new collective behavior must occur before it can be termed a social norm. Such details must be taken into account in developing social norms. Based on the sociological definitions, I formulated the conceptual definitions of the norm life cycle, which is presented in chapters 2 and 3. Figure 9.1 depicts the chance of adhering to a norm during the first three phases (observation, adaptation, and internalization) of a norm's life-cycle in our simulation. As shown in the figure, the chance of following a norm during the observation phase is very low. In the adaption phase, the probability increases exponentially until it enters the internalization phase. In the internalization phase the probability of following the norm stays almost stable. A norm will disappear if it is not adhered enough times by enough agents, as demonstrated in figure 9.2.

Answering the first research question required studying the micro level behavior and

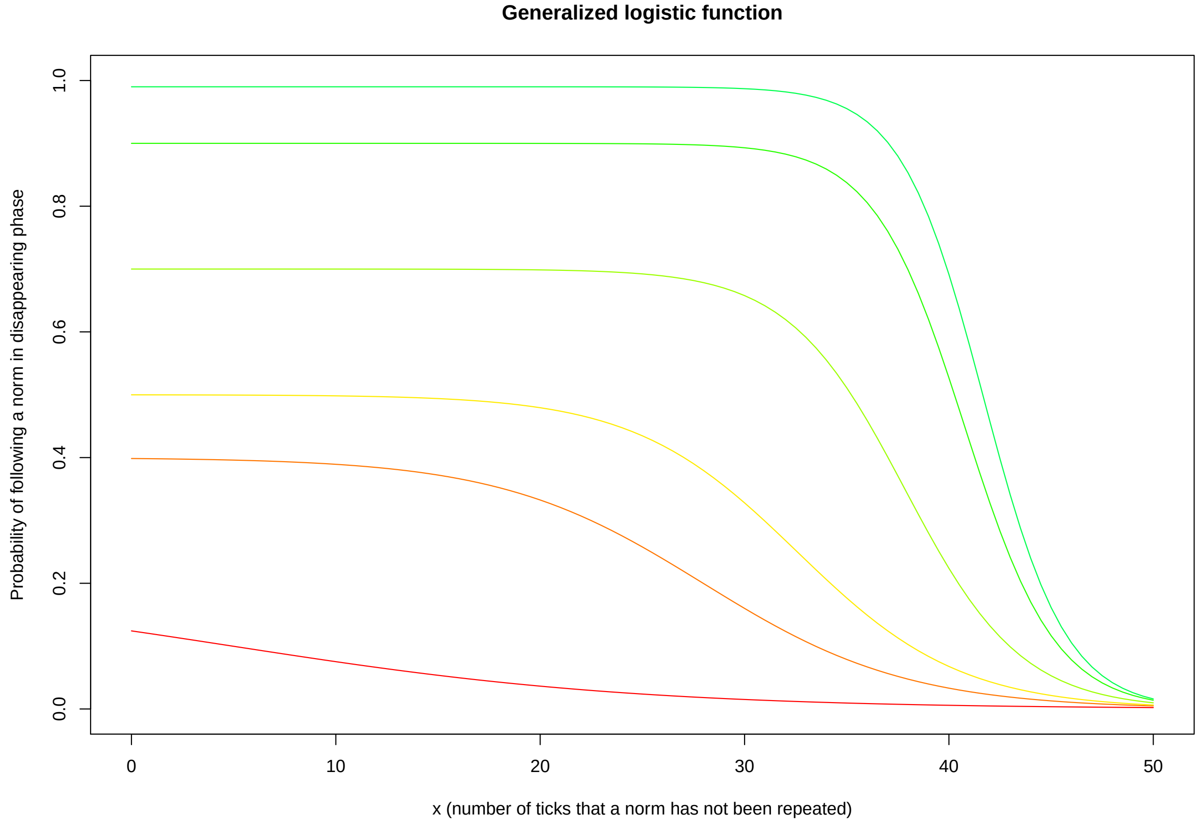

Figure 9.2: Probability of disappearing a norm (depending on the last time the norm has been repeated)

its relation to macro level behavior. Personal values as the stabilizing factors had been studied in chapters 4 to 6. In these chapters, as mentioned before, I formulated the Schwartz' value of theory and implemented agent-based simulations using the formulation. The simulations show how values can direct behavior of the agents.

For example, figure 9.3 - from chapter 5 - depicts fish population in a fisheries village when they do not place a high value on 'Universalism' vs when fishers place a high value on 'Universalism'. When the majority of agents are unconcerned about the environment, fishers catch the most priced species, causing its population to decline. Fisher agents do not fish cheaper species because there are not enough of them in the environment to cover the expenses of fishing and living. On the other hand, if a large number of agents care for the environment, the ecosystem will be more sustainable. When the fish population is low, fisher agents do not overfish and fish less than what is destructive to the ecosystem.

Subsequently, I introduced behavioral dynamics by modifying various elements in each

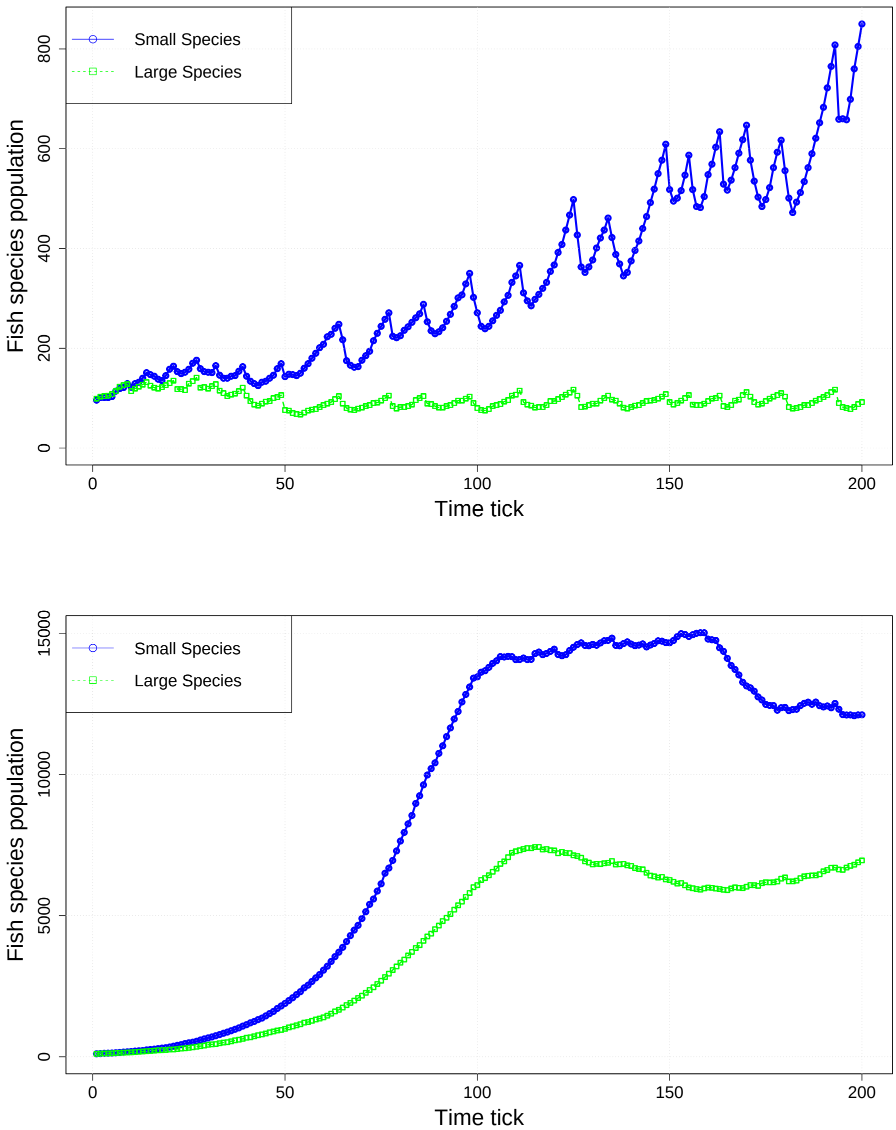

Figure 9.3: Comparing fish populations in societies that place a low priority on universalism (top figure) to societies that place a high value on universalism (bottom figure). This figure is taken from chapter 6)

of the three sub-systems (social, economy, and ecology). I demonstrated, using numerous agent-based simulations, that social norms may remain stable in the face of some changes while still being reactive to other system changes owing to their interaction with personal values (Chapter 7). I showed that personal values work as stabilizing factor. Agents desire to fulfill their values while adhering to social norms. When norms are incompatible with their values, they will make a compromise. I demonstrated that the ultimate behavior of a society is not necessarily predictable until numerous aspects, including value distributions, existing norms, economic position, and ecological situations, are considered. I showed that social norms may still alter or disappear in response to certain conditions. In addition, I discussed how agents will adhere to norms even when there is no central monitoring element in this simulation to discipline violators. This outcome was only achievable due to the use of personal values as an underlying guiding force of social norms. These simulations proved that norms may emerge, evolve, and disappear without the intervention of a centralized authority. In chapter 8, I accumulated all factors and finally addressed my research questions (which I have also briefly stated above) to the fullest. For example, figure 9.4 in chapter 8 shows the stability of a norm in the more populated group when the norm and value distribution are compatible and a change happens gradually. It shows the new power-oriented agents (depicted with red color), that are joining the group at ticks 50, 120 and 200, slowly getting along with the existing norm of the group (which is $|donation| = 95\% \pm 5\%$). In contrast, figure 9.6 shows norm disappearance when a group is less populated, the value distribution is not compatible with the existing norms, and a change applies at once.

In summary, determining the answer to **RQ1** necessitates a thorough study of personal values (chapters 4 to 6). Personal values establish boundaries for behavior. Also, societal phenomena such as social norms affect personal behavior. Chapter 2 studied the link between personal values (micro-level) and social norms (macro-level) in previous research. This research demonstrated the route to answering question **RQ3**. Formulating this link and translate it into agent-based simulations is done in a simple but fundamental way in chapter 7 and in depth in chapter 8. **RQ2**, **RQ4**, and **RQ5** are all answered together at the end in chapter 8; as these are all related and cannot be answered without considering the other elements. Studying norm disappearance without studying norm emergence, or norm stability might mislead the study and create a rule (not a norm according to the given definitions) in the simulation which is totally reactive to any change. As a practical matter, I constructed a normative framework that addresses the link between social norms and values, the dynamics of social norms, explicitly defined social norms, and all the stages of social norm life-cycle from emergence to disappearance (chapter 8). Moreover,

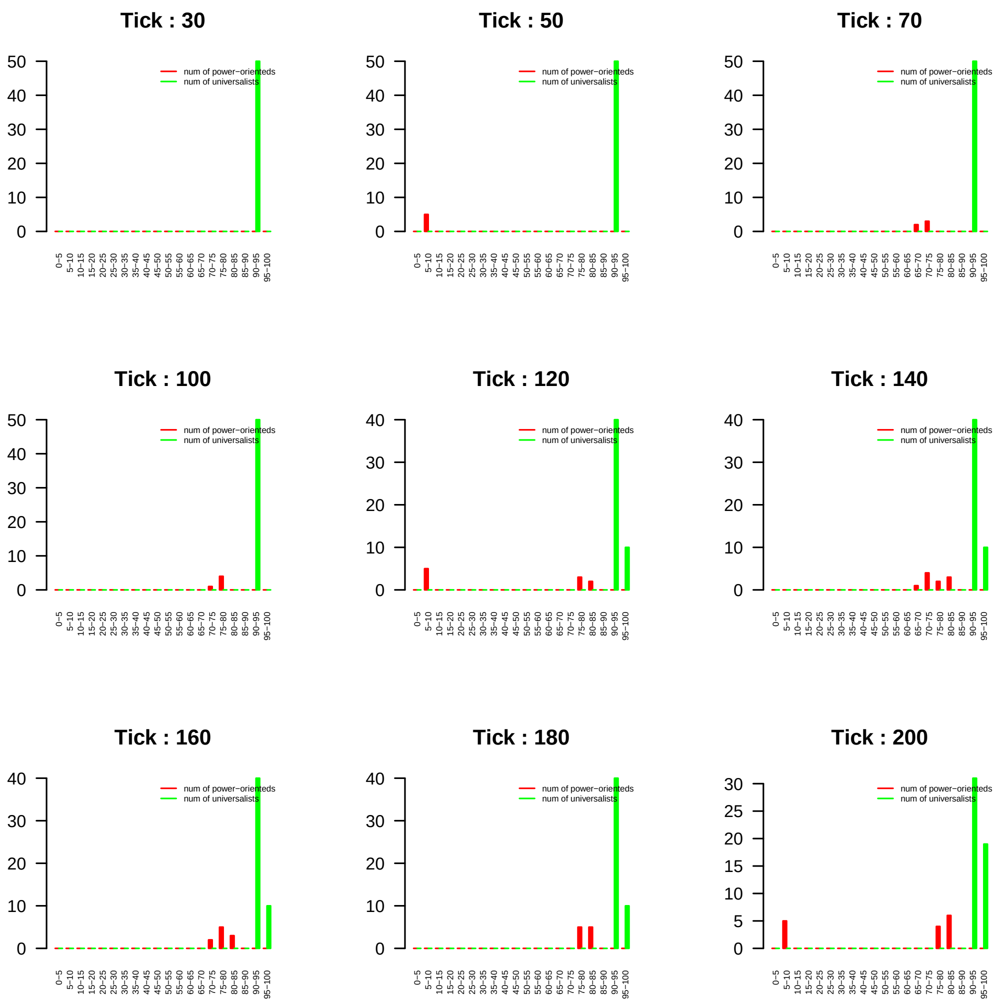

Figure 9.4: Clusters of agents based on their donation in the big group at different ticks (30 to 200), when the change in value distribution of groups happens gradually (slow rate). In these scenarios, the initial value distribution is compatible with initial norms that are internalized.

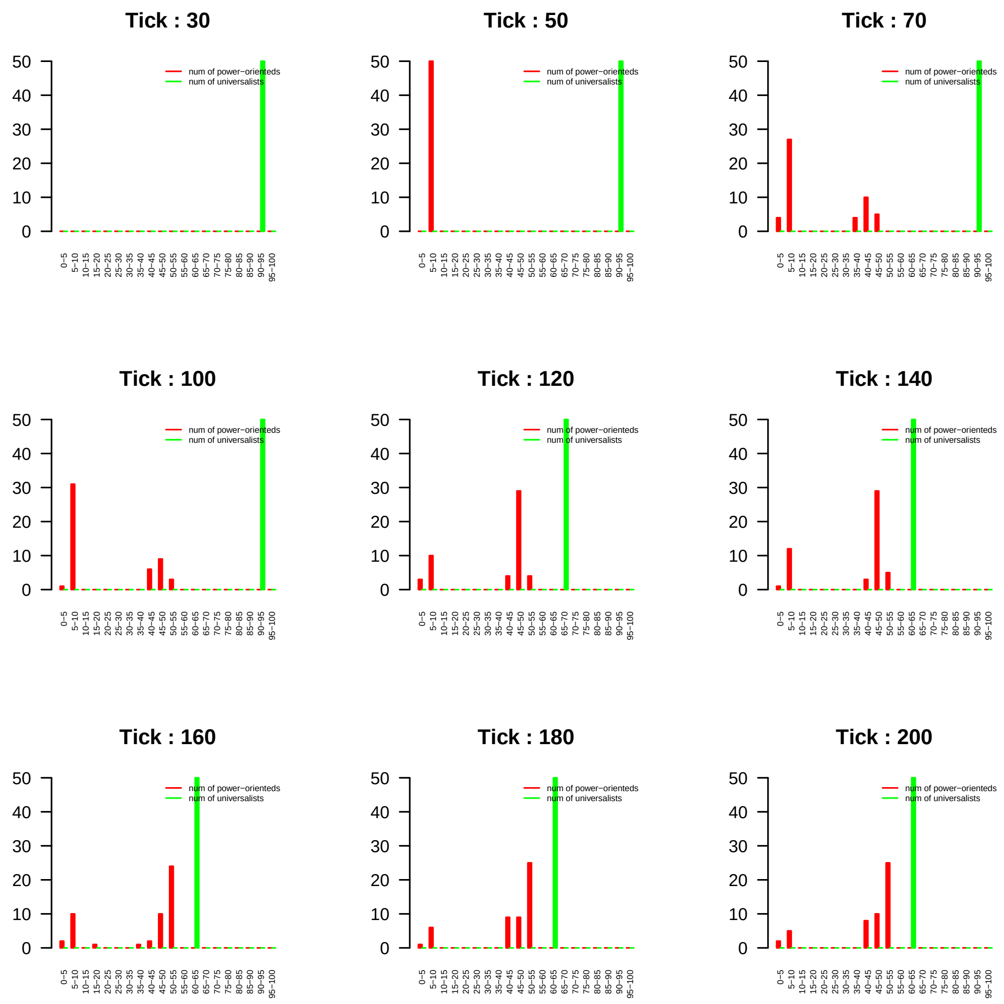

Figure 9.5: Clusters of agents based on their donation in the big group, when the change in value distribution of groups happens at one tick (fast rate), at different ticks (30 to 200). In this scenarios, the initial value distribution is not compatible with initial norms which is internalized.

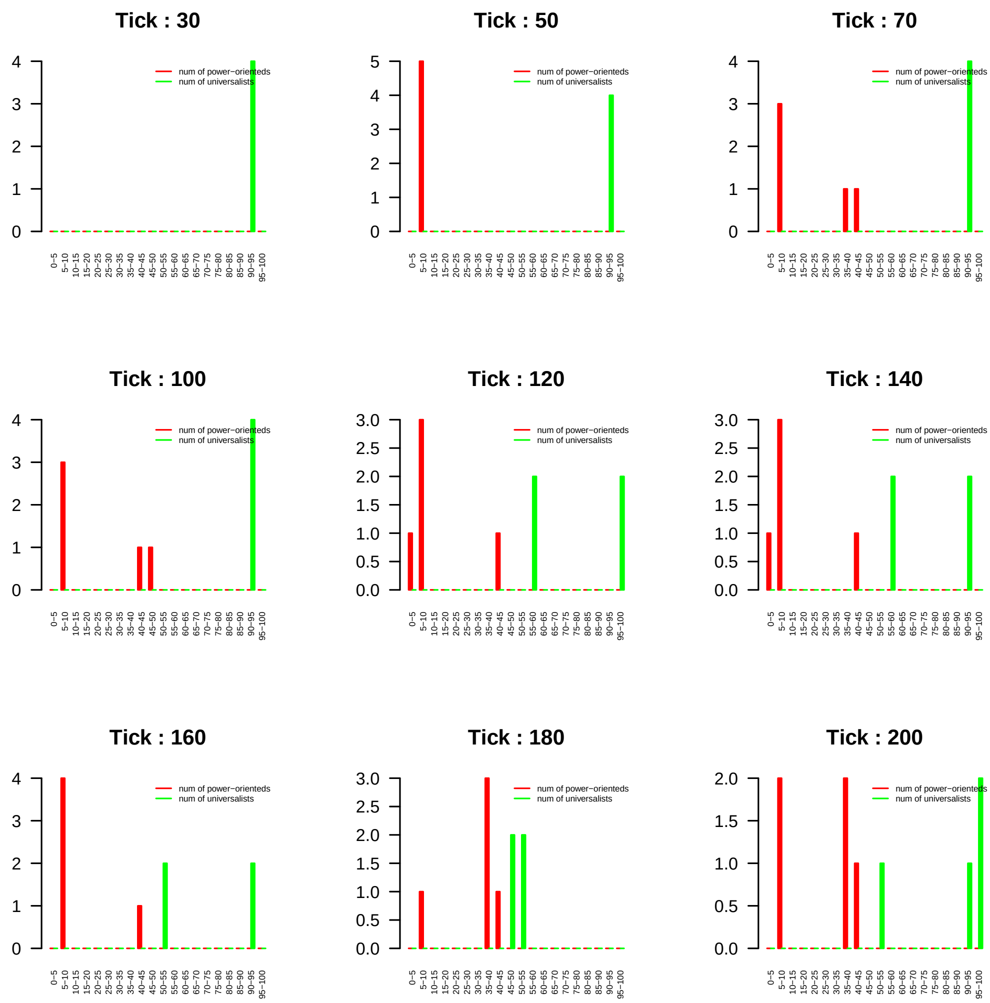

Figure 9.6: Clusters of agents based on their donation in the small group, when the change in value distribution of groups happens at one tick (fast rate), at different ticks (30 to 200). In this scenarios, the initial value distribution is not compatible with initial norms which is internalized.

I illustrated how this framework works by conducting agent-based simulations base on the proposed framework. Using such a coherent framework for modeling and simulating social norms that connects personal values and social norms, creates more detailed and realistic models that are less impacted by personal interpretations of modellers of the simulations. As an additional result (that we did not explore in this thesis), former agent-based simulations and models can be compared and reused.

9.2 Future Work

In this study, I made a normative framework that includes personal values, social norms, and their connection. This framework can be used to create agent-based simulations and models, as well as to analyze micro- and macro-level behavioral studies. Such a simulation, based on my framework, can provide an explanation for the occurrence of a given collective behavior under certain conditions, as well as how social norms emerge, transform, or disappear. Thus this framework is very useful for both researchers and policymakers. Researchers can compare the outcomes of their simulations and models based on this framework. They can also reuse simulations and models that have already been presented based on my framework. Policymakers may be interested in this framework as well, particularly if they seek to discover an explanation for a macro-level behavior of society in the face of a new policy. Of course it is even more useful to get insights on how society will react when a new policy is introduced. In that case, they must get insight in the social fabric of society, including its social norms and the individual values. The new policy cannot be in conflict with strong social norms of the society, nor can it be in conflict with the value distribution of the individuals. Otherwise, the consequence of executing such a policy will not be as expected.

As I demonstrated in earlier chapters, the combination of personal values and social norms results in a complex system. Consequently, there is still a lot of research that can be done on this topic in the future.

Population Size

In my research, I primarily explored having two groups with opposing value distributions or social norms to examine the extreme case; the number of villagers was also restricted. I illustrated that the population size matters; when a group has more members, developing a new norm takes longer and transforming an existing one is more difficult. It means that in a small group, any individual agent's actions have a stronger influence on the whole group where it can easily be lost to noise or pass unnoticed in the face of a large and uniform majority. I showed when agents move to the other group, depending on the norm stage and group size, they will influence the norm of that group. In my study for the purpose of showing the influence of value distribution change on social norms, I considered two groups that agents could move in between. Having multiple groups can increase the dynamicity of the simulation and makes it closer to real life examples. Specially when the social context of the groups are slightly different, taking a norm from one group and translate it to a concrete action in another group can create novel interactions. Studying such a system would be beneficial for societies with higher diversity. However, in order to increase the number of groups, we need to increase population size. Larger populations can provide some kind of segregation between groups and have groups that still have a large enough size to create their own norms. If a populations is too small relative to the number of groups will lead to situations where every agent is the member of many groups or that groups are very small. Both situations will lead to chaotic and erratic (non-realistic) behaviour. However, creating large scale populations for the simulations puts severe pressure on the computational resources, because the agent deliberations are relatively complex and thus take considerable computational resources. Thus in order to explore these larger populations we also need to develop more efficient simulation platforms that can both support complex agents and have large scale populations.

Social Context

One interesting experiment is having multiple societies. Each society with its own value distributions and social norms but in a different social context. One of the interesting studies would be scaling up the number of agents and let them be part of multiple societies. In such scenarios, concrete actions in a group with a value distribution and social norms are interpreted as different concrete actions in another group with the same values and norms. Such study requires recognition of the social context. For example, respecting environment in low precipitation countries will not only be preventing water waste but also saving water in all scales (from individual households to industrial levels). But, in countries with high precipitation, not wasting water is a good practice, but saving water in daily activities may not be that vital. In these countries, respecting the environment might appear as for example not dumping waste into the sea/ocean. Setting up these mixed contexts in the simulations can provide ways to start answering questions like how a new agent in a new society will pick up the social context. How will the new agent adapt himself to the society and new way of interpreting norms and values? How will the other agents react to the new agent's actions and his way of interpreting values and norms to concrete actions?

Social Network Graph

Another influential factor is the social network. In bigger societies it is not possible to have a complete graph connecting all agents, but rather, agents are connected with a limited number of other agents. This can be interpreted as being a member of multiple groups. Multiple membership is covered by the normative framework introduced in chapter 8. However, I did not take into account that these groups might not be connected. For example, people living in a city are direct or indirect neighbors of each other. In other words, a citizen is connected to another citizen with some distance in the graph of social connection. In such a case, it would be interesting to study how a social norm would propagate to the whole society. What are the factors that help a norm from one group to penetrate in the more distant groups of a society? Which norms have the chance of disappearance or persistence in the presence of extreme cases such as natural disaster, war, economic crisis, etc. Such a simulation requires a larger population size. Because having small population with multiple groups will be the same as no group at all.

Social Influence

People's social standing and influence in a society are not equal. For example, the influence of parents on young children is high, while the influence of a famous actor is high on teenagers. Based on that, the influence of social influencers on decisions has been extensively employed in marketing for a long time. There are many famous cases about increasing public awareness about a health issue through well-known people as well. For example, scientists progressed in research and cure of breast cancer, however, public awareness was only raised when a celebrity revealed her mastectomy; known as 'Angelina Jolie' effect (107). Although this example is not a social norm, but it demonstrates the power of social influencers. Studying the impact of social influencers on social norms would be helpful to understand the behavioral changes. How celebrities can influence a society to form and transform social norms? What are the factors that intensify or diminish this influence? Considering the international celebrities, how the celebrities from other societies with different value distribution, contrasting social context, and distant culture can impact behavior of people. The celebrities promote a certain norm to many groups in a society, without being actively a member of all of them. Therefore, there would be no direct feedback from those group.

Normative Goals and Plans

For the next phase, I would like to propose other normative components such as plans and goals into the framework. Personal values determine normative objectives and goals, which are also influenced by societal level influences such as social norms and culture. For example, if a person highly values power and lives in a country with a society that strongly emphasizes education, he may come up with a plan to lead an educational institute in order to satisfy his power value while also pleasing his culture. If a person places a high value on power and lives in a society that places importance on physical excellence, he may consider becoming a general in the army. The goal necessitates a plan, which is a series of required actions that aid in the achievement of the goal. These behaviors are distinct from daily tasks such as driving to work, going grocery shopping, waste separation, etc. When a person violates a norm or a value in their daily activities, they may feel guilty; nevertheless, missing the actions scheduled for a goal may have long-term consequences such as missing a long-term objective. So, including goals and plans seems necessary to create more long term simulations. However, adding extra mental constructs in the agents with their dependencies on the already incorporated concepts will further complicate an already complex design of the agents. Thus this would require a careful design and methodology to be used properly.

Modular Framework and Culture

Besides personal values and social norms, there are numerous additional elements that influence human decisions. Of course, it is not practical to include all of the elements that affect decisions; I propose developing a framework that allows for the addition or deletion of any element depending on the needs of the research. Culture, which is more persistent than social norms, is another key factor that influences human decisions and often comes up in larger scale simulations for policy making. Studying culture requires an intense research on its definition and especially its connection to personal values! It needs examples, formal representations, formal framework, presented simulations, presented models, and applications of culture simulations. Following these steps will help developing a formal framework for culture. Such a framework can be quite insightful; even though there are many excellent agent-based models and simulations of culture, they are extremely simplistic and most of them are detached from social norms, personal values, personal goals, and plans.

Conclusions

As can be seen from the above, continuing with completing the normative framework represented in this research, more components normative goals, normative plans, social influence, and culture can be added. Maintaining the framework modular can be helpful. This implies that components can be readily added or removed without disrupting other components of the system. As a result, users of the framework can activate/deactivate any component based on the needs of their research. However, keeping the design modular limits the way dependencies between the different concepts can be represented. Whether this will turn out to be a too big limitation can only be seen from exploring this path in the future and designing many more large scale simulations.

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List of Figures

List of Tables

Appendix A

SIKS Dissertation Since 2016

Year	#	Title
2016	01	Syed Saiden Abbas (RUN), Recognition of Shapes by Humans and Machines
	02	Michiel Christiaan Meulendijk (UU), Optimizing medication reviews through decision support: prescribing a better pill to swallow
	03	Maya Sappelli (RUN), Knowledge Work in Context: User Centered Knowledge Worker Support
	04	Laurens Rietveld (VU), Publishing and Consuming Linked Data
	05	Evgeny Sherkhonov (UVA), Expanded Acyclic Queries: Containment and an Application in Explaining Missing Answers
	06	Michel Wilson (TUD), Robust scheduling in an uncertain environment
	07	Jeroen de Man (VU), Measuring and modeling negative emotions for virtual training
	08	Matje van de Camp (TiU), A Link to the Past: Constructing Historical Social Networks from Unstructured Data
	09	Archana Nottamkandath (VU), Trusting Crowdsourced Information on Cultural Artefacts
	10	George Karafotias (VUA), Parameter Control for Evolutionary Algorithms
	11	Anne Schuth (UVA), Search Engines that Learn from Their Users
	12	Max Knobbout (UU), Logics for Modelling and Verifying Normative Multi-Agent Systems
	13	Nana Baah Gyan (VU), The Web, Speech Technologies and Rural Development in West Africa - An ICT4D Approach

14 Ravi Khadka (UU), Revisiting Legacy Software System Modernization

15 Steffen Michels (RUN), Hybrid Probabilistic Logics - Theoretical Aspects, Algorithms and Experiments

16 Guangliang Li (UVA), Socially Intelligent Autonomous Agents that Learn from Human Reward

17 Berend Weel (VU), Towards Embodied Evolution of Robot Organisms

18 Albert Meroño Peñuela (VU), Refining Statistical Data on the Web

19 Julia Efremova (Tu/e), Mining Social Structures from Genealogical Data

20 Daan Odijk (UVA), Context & Semantics in News & Web Search

21 Alejandro Moreno Célleri (UT), From Traditional to Interactive Playspaces: Automatic Analysis of Player Behavior in the Interactive Tag Playground

22 Grace Lewis (VU), Software Architecture Strategies for Cyber-Foraging Systems

23 Fei Cai (UVA), Query Auto Completion in Information Retrieval

24 Brend Wanders (UT), Repurposing and Probabilistic Integration of Data; An Iterative and data model independent approach

25 Julia Kiseleva (TU/e), Using Contextual Information to Understand Searching and Browsing Behavior

26 Dilhan Thilakarathne (VU), In or Out of Control: Exploring Computational Models to Study the Role of Human Awareness and Control in Behavioural Choices, with Applications in Aviation and Energy Management Domains

27 Wen Li (TUD), Understanding Geo-spatial Information on Social Media

28 Mingxin Zhang (TUD), Large-scale Agent-based Social Simulation - A study on epidemic prediction and control

29 Nicolas Höning (TUD), Peak reduction in decentralised electricity systems - Markets and prices for flexible planning

30 Ruud Mattheij (UvT), The Eyes Have It

31 Mohammad Khelghati (UT), Deep web content monitoring

32 Eelco Vriezekolk (UT), Assessing Telecommunication Service Availability Risks for Crisis Organisations

33 Peter Bloem (UVA), Single Sample Statistics, exercises in learning from just one example

34 Dennis Schunselaar (TUE), Configurable Process Trees: Elicitation, Analysis, and Enactment

	35	Zhaochun Ren (UVA), Monitoring Social Media: Summarization, Classification and Recommendation
	36	Daphne Karreman (UT), Beyond R2D2: The design of nonverbal interaction behavior optimized for robot-specific morphologies
	37	Giovanni Sileno (UvA), Aligning Law and Action - a conceptual and computational inquiry
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