Simulations with Values

Samaneh Heidari[0000−0002−1947−8480], Maarten Jensen[0000−0002−6117−8019], and Frank Dignum[0000−0002−5103−8127]

Utrecht University, Princetonplein 5, Utrecht 3584 CC, The Netherlands
{s.heidari**, m.l.jensen, F.P.M.Dignum}@uu.nl

Abstract 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 paper, 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.

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 [1], 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 [2]. Using the ideas and theories presented by Schwartz [1], Weide [2], and Dörner et al. [3], 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

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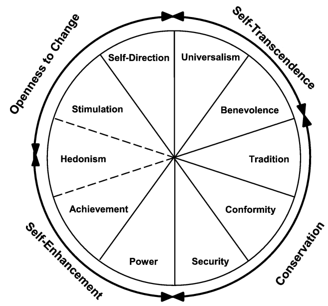


Fig. 1: Schwartz value circle, categorization and dynamicity of abstract personal values [1]

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.

In section 2 we give some background on the value framework of Schwartz and the way we can connect these abstract values to concrete values and decisions on actions as described by Weide [2]. In section 3 we will discuss the framework that we propose to use to translate this theory into an implementable framework that can be used in agent based social simulations. In section 4 we illustrate an implementation of the framework in an agent-based model regarding fishery management. Section 5 gives some conclusions and directions for future work.

2 Related work

Schwartz et al. proposed ten basic values according to the universal needs of humans [1]. The Schwartz values are defined in the most abstract way that includes all the core values of every human all around the world.

As shown in figure 1, Schwartz value theory describes 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, the compatibility level of values in the Schwartz value circle decreases when the distance of them increases in the circle. The least distance belongs to two values next to each other and the most distance belongs to two values that are on opposite sides of each other in the circle.

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 [4–7]. For example, the effects of individual values of a society on the general behavior of a complex system (including society, ecology, and economy) are studied Heidari et al. [8].
Bench-Capon et al. [9] show that promoting different values will lead to different arguments. Dechesne et al. [4] investigate how personal values (and other social phenomena) affect the behavior of people when introducing a smoking ban rule.

Mercuur [10] categorizes 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) [11], and they can be used for justifying a decision of doing an action [2, 12].

Weide [2] 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. However, the relation between compatible and opposite values in the Schwartz value circle is not included in his model. Inspired by his formal model, we propose a framework for Schwartz value theory which not only considers translating Schwartz values into concrete values, but also the relation of values in the circle (Figure 1), using values as pre-condition (filter) and justifying an action at the same time.

3 Framework

In this section, we propose a framework to make value-based decisions. 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 paper 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 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. Now we will explain the formalization of the framework.

In order to model the value circumplex of Schwartz, we 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 = $ *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 indexes are important to consider 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.

Assume that we define a 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, we defined the following condition that shows the importance of any member of $Values$ is more related the closer the indexes are to each other.

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

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

c is a constant real number between [1..100] and 5 is the number of abstract values in one half of the Schwartz circle. Regarding symmetric distances of abstract values in the Schwartz circle, we 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 codependencies between values exists. We 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 [13].

In condition 1, we assume 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 To model the conflicting relation between values we created the following condition.

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

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 ($\tau(V_i) = 0$).

3.1 Value based selection

Value satisfaction In addition to the importance, values have a level of satisfaction. In other words, people need to satisfy all of their values from time to time. But, the frequency of satisfaction differs due to their personal values. Function $\tau(V_i)$ shows how often value V_i should be satisfied. Therefore, there is a need to consider satisfaction level in the framework as well. To model changing in needs over time, we use the water tank model that determines the priority of satisfaction requirement for each value.

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.

To model these dynamics, we use the water tank model represented by Döner et al. [3]. We consider one tank for each $V_i \in Values$. Each tank has the following

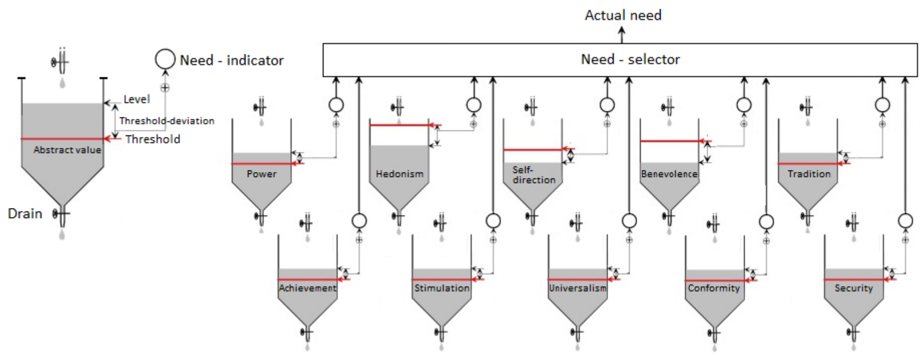


Fig. 2: Example figure of the water tank model for an agent

base parameters: fluid level λ_i where $0 \leq \lambda_i \leq 100$ to indicate how much the value is satisfied, threshold $\rho(V_i)$ where $0 \leq \rho(V_i) \leq 100$ to indicate when a value gets salient. 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.

A sample of the water tank model for an agent is shown in Figure 2. Each agent has ten tanks, each with the same capacity and the same draining level. Though, the value thresholds are different for various agents.

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 it is easier to track their contribution to 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 [14]. 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 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 [15], 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.

Value-based filtering Using values agents make initial selections among the available actions to perform. We find the highest priority value that needs to be satisfied using the following formula:

$$\operatorname*{arg\,min}_{V_i \in Values} \rho(V_i) = \{V_i | V_i \in Values, \forall V_j \in Values : \rho(V_j) > \rho(V_i)\}$$

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 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 satisfy his *Universalism* value (increasing the filled level of *Universalism* water tank) and not the *Power* value.

3.2 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.

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 [10]. For instance, if the *Universalism* value gets promoted in a society (τ(*Universalism*) is high), the probability of hurting the environment decreases accordingly. As described in our previous

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*}.
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 1: General simulation components

study [8], one point that we want to include in our experiments is to consider the feedback 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 1. The simulation code is accessible via Git-hub [16].

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 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 $\sigma = 1$.

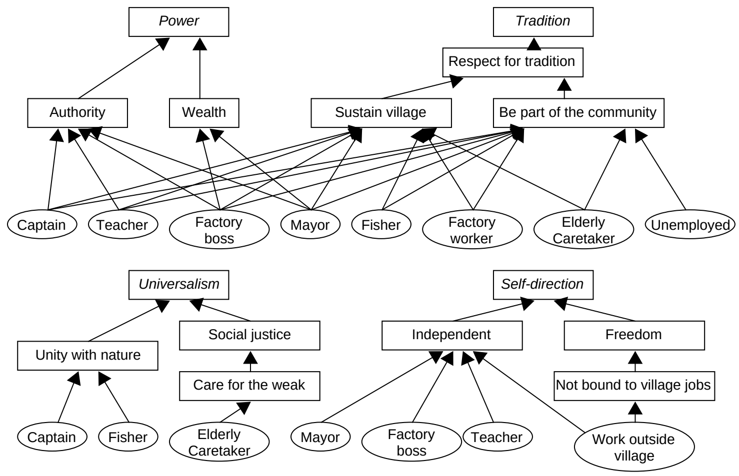


Fig. 3: Value tree of getting a job

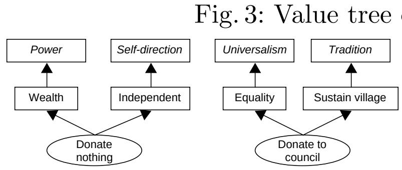


Fig. 4: Value tree of donation

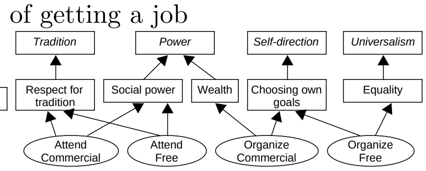


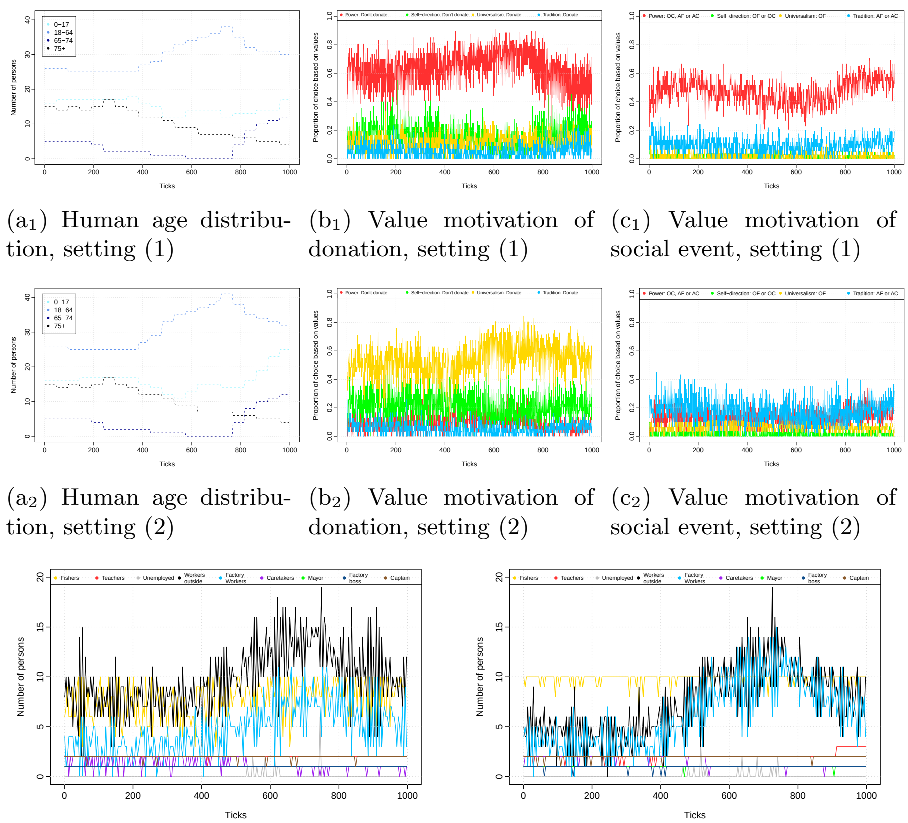
Fig. 5: Value tree of social events

The event trees are denoted in figure 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 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).

4.2 Results

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. The figures 6 show the dynamic behavior of the systems in two different settings. Figures 6a$_1$ to 6c$_1$ and 6d$_1$ 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 6a$_2$ to 6c$_2$ and 6d$_2$ 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



(a_1) Human age distribution, setting (1)

(b_1) Value motivation of donation, setting (1)

(c_1) Value motivation of social event, setting (1)

(a_2) Human age distribution, setting (2)

(b_2) Value motivation of donation, setting (2)

(c_2) Value motivation of social event, setting (2)

(d_1) Work distribution, setting (1)

(d_2) Work distribution, setting (2)

Fig. 6: Results of simulation with two settings: (1) $p = 80, s = 50, u = 30, t = 50$ and (2) $p = 20, s = 50, u = 70, t = 50$.

high priority for *Universalism*, means that agents need to do actions that satisfy *Universalism* more. As shown in figure 6b_2, agents satisfy their *Universalism* through donating to the council and there is almost always a maximum amount of fishers and captain, since these also satisfy *Universalism*. 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.

As shown in figure 6d_2, 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 $6d_1$, 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, eventhough people have to satisfy *self-direction* and *tradition* equally.

The 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. 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.

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.

References

1. S. H. Schwartz, "Universals in the content and structure of values: Theoretical advances and empirical tests in 20 countries," in *Advances in experimental social psychology*, ser. Advances in Experimental Social Psychology, M. P. Zanna, Ed. Academic Press, 1992, vol. 25, pp. 1 – 65.
2. T. van der Weide, "Arguing to motivate decisions," PhD dissertation, Utrecht University, 2011.
3. D. Dörner, J. Gerdes, M. Mayer, and S. Misra, "A simulation of cognitive and emotional effects of overcrowding," in *In Proceedings of the 7th International Conference on Cognitive Modeling*, 2006, pp. 92–98.
4. F. Dechesne, G. Di Tosto, V. Dignum, and F. Dignum, "No smoking here: Values, norms and culture in multi-agent systems," *Artificial Intelligence and Law*, vol. 21, no. 1, pp. 79–107, 2013.
5. T. J. M. Bench-Capon and P. E. Dunne, "Argumentation in artificial intelligence," *Artificial intelligence*, vol. 171, no. 10-15, pp. 619–641, Jul. 2007.
6. J. Groeneveld, B. Mller, C. Buchmann, G. Dressler, C. Guo, N. Hase, F. Hoffmann, F. John, C. Klassert, T. Lauf, V. Liebelt, H. Nolzen, N. Pannicke, J. Schulze, H. Weise, and N. Schwarz, "Theoretical foundations of human decision-making in agent-based land use models a review," *Environmental Modeling and Software*, vol. 87, pp. 39 – 48, 2017.

7. K. L. O'Brien and J. Wolf, "A values-based approach to vulnerability and adaptation to climate change," *Wiley Interdisciplinary Reviews: Climate Change*, vol. 1, no. 2, pp. 232–242, 2010.
8. S. Heidari and F. Dignum, "Value based Agents for Social Simulation of Fishery Management," *Social Simulation Conference*, 2017.
9. T. J. M. Bench-capon and C. Science, "Persuasion in Practical Argument Using Value-based Argumentation Frameworks," *Journal of Logic and Computation*, vol. 13, no. 3, pp. 429–448, 2003.
10. R. Mercuur, "Interventions on Contextualized Decision Making: an Agent-Based Simulation Study," Master thesis, Utrecht University, 2015.
11. S. H. Schwartz, "An Overview of the Schwartz Theory of Basic Values," *Online readings in Psychology and Culture*, vol. 2, no. 1, pp. 1–20, 2012.
12. G. D. Tosto and F. Dignum, "Simulating Social Behaviour Implementing Agents Endowed with Values and Drives," *Multi-Agent-Based Simulation XIII*, vol. 7838, pp. 1–20, 2012.
13. S. H. Schwartz, "A theory of cultural values and some implications for work," *Applied Psychology*, vol. 48, no. 1, pp. 23–47, jan 1999.
14. S. Cranefield, M. Winikoff, V. Dignum, and F. Dignum, "No Pizza for You: Value-based Plan Selection in BDI Agents," in *Proceedings of the Twenty-Sixth International Joint Conference on Artificial Intelligence*, 2017, pp. 178–184.
15. A. Bardi and S. H. Schwartz, "Values and behavior: Strength and structure of relations," *Personality and social psychology bulletin*, vol. 29, no. 10, pp. 1207–1220, 2003.
16. M. Jensen and S. Heidari, "Social-simulation-fishery-village," https://github.com/maartenjensen/Social-simulation-fishery-village/commit/6ca2f612af6cdc14bfb79d509c59186306c65054, 2018.