Computational modeling of culture's consequences

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Abstract. This paper presents an approach to formalize the influence of culture on the decision functions of agents in social simulations. The key components are (a) a definition of the domain of study in the form of a decision model, (b) knowledge acquisition based on a dimensional theory of culture, resulting in expert validated computational models of the influence of single dimensions (c) a technique for integrating the knowledge about individual dimensions. The approach is developed in a line of research, studying the influence of culture on trade processes.

Keywords: dimensions of culture, computational model, social simulation

1 Introduction

Being competent in trading depends on more than economic rationality. To model trade as it actually happens, creating agents that compute the most profitable deal is therefore not enough. The agents' incentives could be modeled using Williamson's framework [1] in which four time scales are used: resource allocation (for instance: trade) happens continuously, and it is subject to governance rules that may change on a time scale of 1 to 10 years. These rules are themselves subject to institutional changes, e.g. new legislation, at a time scale of 10 to 100 years. Institutions in their turn are based on and attuned to the hidden rules of the game (culture) that are embedded in society and change on a time scale of 100 to 1000 years. So this model states that people involved in trade use governance rules, institutions and cultural values to guide their behavior, albeit unconsciously. The present article takes this position as a basis for modeling the culture's effects oin agent-based social simulations.

Societies around the world differ greatly with respect to the value systems and ideas that govern patterns of human interaction.. Hofstede [2], p.9, defines culture as "*the collective programming of the mind that distinguishes the members of one group of people from another*". The behavior of people and their interpretation of the behavior of others are based on their norms for appropriate behavior. These norms vary from culture to culture.

In different cultures, different norms may prevail for behavior in trade; e.g., trade partner selection, bargaining style, trust that has to be shown, favor that is given to in-group relations or high-ranked society members, and opportunistic advantage that may be taken from partners. Different systems may be viable in different societies. For example, [3] used multi-agent simulations to show that economic systems based on trust and systems based on opportunism may both be viable.

When traders operate in foreign cultures, the programming of their minds may not be efficient. This explains the existence of practical guides for business behavior in different countries, e.g. [4] and [5], and the extensive body of scientific literature that has been developed. The scientific literature ranges from business oriented studies, e.g. Kumar [6], and cross-cultural surveys, e.g., Kersten et al. [7], to economic models, e.g., Guo [8] and Kónya [9].

The approach proposed in this paper aims to model culture at the mid-range level according to the classification by Gilbert [10], p.42. Mid-range models depend on a rich description of processes, but do not in facsimile model a particular situation. For mid-range models, observed trends should be similar to those observed in reality. This is important for our long-term research goal of improving the understanding of human decision-making in international supply chains with asymmetric information, see, for instance, [11]. The research method proposed in [11] combines multi-agent models with gaming simulation, but a general multi-agent model as proposed in [11] does not explain the cultural difference observed in the gaming simulations. Therefore, it is important to develop an approach to culturally adapt the models.

For the modeling of culture, one must lean on social sciences literature. Two main streams of research can be distinguished. First, there is the anthropological approach of rich description, in which specific cultures are studied by detailed and close observation of behaviors during an extensive time-span. Examplesare the works of Lévi-Strauss [12] and Geertz [13]. Second, there is the comparative approach that tries to identify dimensions on which different cultures can be ordered, aiming to develop a classification system in which cultures can be typed by a small number of qualifications. Examples are the models of culture by G. Hofstede [2], Schwarz [14], and Trompenaars and Hampden-Turner [15]. The approach of this research is to characterize cultures by their indices on a limited number of dimensions. The dimensions and the indices of cultures are typically created by factor analyzing massive surveys with standardized questionnaires in many countries. The value of such dimensions largely depends on the questionnaires used in combination with the matched sets of respondents that are required. The resulting models provide a linear ordering of cultures along each dimension, where particular values and practices are hypothesized (based on empirical evidence) to be stronger or weaker or occur more frequently or less frequently according to the index on the dimension. For instance, in cultures on one extreme of a particular dimension concerned with asymmetry of power relations, the implicit norm is for parents to treat children as equals, while in cultures on the other end parents are supposed to teach children obedience.

Cultural descriptions of the first type provide rich details about values, norms, symbols, beliefs, rituals, social structure, behavioral patterns etc. in a particular culture. These will prove very useful for facsimile modeling of specific social systems. The model proposed in the present paper aims to compare the influence of a great diversity of cultures in the standardized environment of a gaming simulation which is by itself an abstraction of social life. For that purpose we do better to build upon a dimensional model of culture. Of these, the most widely used is Hofstede [2]. His work is accessible, sparse, and based on a very large, very well stratified sample that continues to give it great explanatory value. No other model matches society-level variables so well to date [17].

The hypothesis of this research is that computational models of culturally differentiated agents can be deduced from social scientific theories that differentiate cultures along a limited number of dimensions. An agent-based model can be developed to incorporate behavior that is realistically differentiated along each of the cultural dimensions. Note that the model based on the cultural indices may reliably reproduce general trends, but will not differentiate up to the detail of actual individuals. For the long term, a computational model based on a dimensional theory of culture in multi-agent simulations can provide insights into the functioning of social systems and institutions in different cultural contexts.

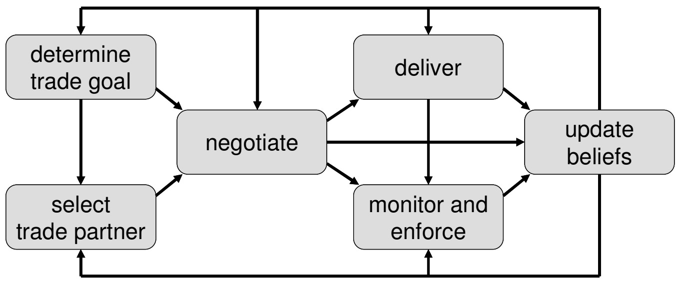

Fig. 1. Processes and internal information flows of trading agents (adapted from [17]).

To develop computational models of culturally differentiated agents in a specific domain of application we take a general agent-based model for that domain of application as a point of departure. That general model should be based on either a task, process, or activity analysis of the domain of application. An example of elementary processes for trading agents is given in Fig. 1. A dimensional theory of culture can be used to determine the required adaptations to the model to reflect the way culture influences behavior trends. Such adaptations also pertain to the way the agents perceive their environment and the behavior of other agents. For instance, if the theory describes that in some cultures favor is to be shown to in-group customers, while in other cultures the norm is to treat all customers equally, the agents need a cognitive model in which they can be aware of what group they belong to and maintain models of other agents in which they maintain beliefs about other agents' group memberships (e.g., "I belong to group x and he/she does/does not belong to that group"). For each of the processes of the general model, an adaptation must be developed that models the adaptation of decisions by culture. This paper describes an approach to develop computational adaptations of the processes within the agent that are based on a dimensional model of culture, and expert knowledge about cultural effects on decisions and interpretation of behaviors.

The paper is organized as follows. Section 2 presents an overview of the method that was followed in knowledge acquisition and model formulation. Section 3 formulates the computational model. A discussion of results concludes the paper.

2 Modeling method

The exercise of modeling culture in trading agents could be carried out in a multitude of ways, using a variety of theories. The present article describes one such attempt. It also presents the choices and the line of reasoning behind this method. This could enable other researchers to choose which of the principles, choices and practices of this approach to adopt and from which ones to deviate.

In order to model cultural differentiation in agents the following steps were taken, once the domain to be modeled had been defined. Agent roles and network, agent communications, the environment and entities in it, their observable properties and possible actions of agents were defined. For the agents, a process model had been established. Throughout this paper, specific examples are taken from the domain of trading agents, see Fig. 1 for a process model.

In each process the agents take decisions based on decision rules. For these rules, models were preferred that had in empirical research been validated to simulate actual human behavior. For instance, in the model of culture implemented by the authors, the ABMP negotiation architecture is applied. It has been validated in experiments with Dutch adolescents and adults [18]. If no validated model can be found in literature, a dedicated model has to be formulated based on empirical data or research; see, for instance, [19].

Typically, decision rules are parameterized. For instance, parameters in the rules of the ABMP negotiation strategy have names like *concession factor*, *negotiation speed*, *impatience*. Our next step was to determine for every decision function a set of parameterized rules and a set of parameters used in those rules (Fig.2).

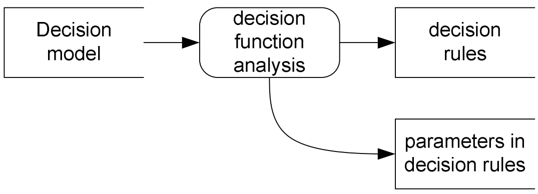

Fig. 2. Decision function analysis

The decision rule parameters are the point of application for cultural differentiation. It is important to start from process models that allow for such adaptation. Validations of behavior with subjects from one culture are no guarantee for the occurrence of similar behavior in other cultures. This is amply shown by a multitude of experimental studies published in journals such as the Journal of Cross-Cultural Psychology, and in review volumes such as [20].

For the cultural differentiation a dimensional model of culture was selected, in this case Hofstede's five-dimensional model [2]. Two criteria were important in the selection. First, the model had to be applicable for the social processes to be simulated, based on the contexts in which it has been developed and validated, and the availability of research results that provide rules for decision parameter adaptation. Second, the modelers had to have access to expertise on the cultural model to be applied, for knowledge acquisition and expert validation of results.

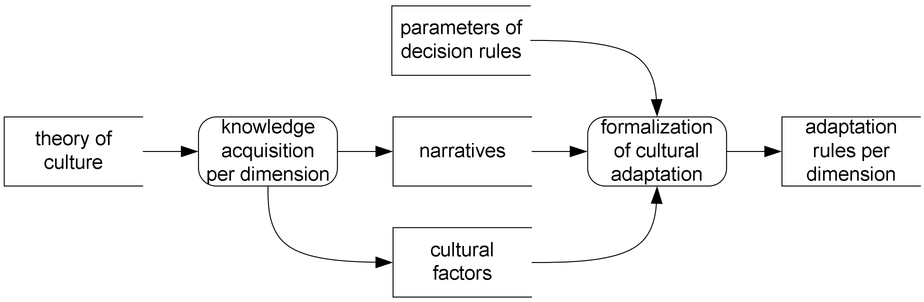

Fig. 3. Knowledge acquisition and formalization

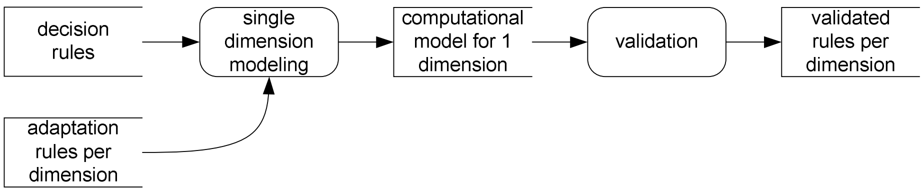

Fig. 4. Computational modeling and validation for a single dimension

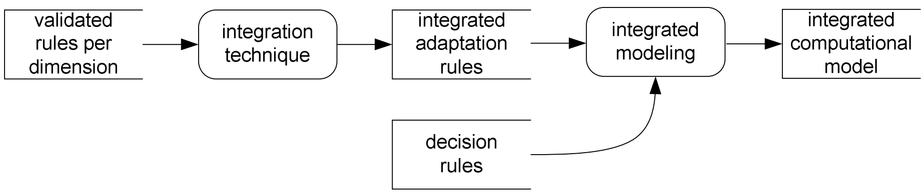

Fig. 5. Integration and computational modeling of joint dimensions

Knowledge about the influence of individual dimensions of culture on the decision functions of the process model was acquired, using an expert systems approach. Literature and expert knowledge are mostly based on differentiation along the dimensions. It is feasible to acquire knowledge on the differentiation along a single dimension, whereas it proved to be impossible in practice to interpret the joint influence of multiple dimensions on general rules. A classical knowledge acquisition approach was followed for each dimension: interview experts on the cultural theory, read literature, write narratives of expected system behavior, have experts validate the narratives, correct until the experts have confidence in the narratives. In addition to the narratives, the knowledge acquisition resulted in a list of relevant cultural factors[1]

[1] Some dimension adapt the perceived relevance of certain relational attributes. For instance, the salience of common group membership (in-group or out-group) is adapted by the culture dimension of individualism versus collectivism. Other such relational attributes are status difference and interpersonal trust. The 'cultural factors' combine dimension scores and relevant relational attributes.

for each dimension. On the basis of the knowledge gained, the influence of the relevant factors for a single dimension on each parameterized decision rule can be formalized as a set of rules that modify the parameter values. See Fig. 3 for an overview of these steps.

The next objective was to implement the rules in a multi-agent model to simulate results that can be validated in the usual ways, such as expert validation, experiments, and real-world observations, as depicted in Fig. 4.

Finally, the parameter adaptation rules of the individual dimensions were combined into an integrated set of rules, as the basis for a computational model of the simultaneous influence of all dimensions (Fig. 5). The next section presents the approach taken to model the integrated effect.

3 Integrated Computational Model

Assume for some domain of application that a set of adapted decision rules per dimension (see Fig. 3) and accompanying sets of parameters and cultural factors are given. This section discusses an approach to integrating all this knowledge into one integrated computational model that reflects the influence of culture on decision making in the domain. The key concepts used in our approach are described as follows (see Table 1 for an overview).

The *m* parameters used in the domain model are labeled p_1 through p_m, with associated default values x_1 through x_m, and values adjusted by culture x_1' through x_m'. For each culture dimension *j*, there is a range of q_j cultural factor labels l_{j1} through l_{jq_j} with associated values f_{j1} through f_{jq_j}. Variable *i* is consistently used in this paper to range over parameters (values or labels), whereas *j* ranges over dimensions, and *k* over cultural factors per dimension *j*. For each factor label l_{jk} and each parameter p_i, there is a function r_{ijk} that maps factor value f_{jk} and default value x_i to adjusted parameter value x_i'. Table 1 presents an overview of these key concepts.

Table 1. An overview of the key concepts

Dimensions	*Cultural factors*		*Parameters ranging over 1≤ i≤ m*			
ranging	Factor	Factor	Label set *P*:	p_1	…	p_m
over	label set	value set	default value:	x_1	…	x_m
$1 \le j \le n$	*L*	*F*	adjusted value:	x_1'	…	x_m'
1	l_{11}	f_{11}		r_{111}		r_{m11}
	…	…		…		…
	l_{1q_1}	f_{1q_1}		r_{11q_1}		r_{m1q_1}
…						
n	l_{n1}	f_{n1}		r_{1n1}		r_{mn1}
	…	…		…		…
	l_{nq_n}	f_{nq_n}		r_{1nq_n}		r_{mnq_n}

The integrated effect of culture on agent behavior can be modeled as a function h that maps a vector of cultural factors $\vec{f}$ and a vector of default values of model parameters $\vec{x}$ to a vector of culturally adjusted parameters $\vec{x}'$:

$$h\left(\vec{f}, \vec{x}\right) = \vec{x}' \quad . \qquad (1)$$

The hypothesis of this work entails that, given the set of decision functions, a dimensional theory of culture can be used (a) to identify the cultural factors to be taken into account and (b) to define the mapping h. If this is possible, the agent modeling can benefit from vast bodies of social sciences literature that describe the differentiation of many behaviors along the dimensions of the cultural model. This literature can be used to define h for the wide range of behaviors described in it, assuming that we can formulate parameterized decision functions governing the behaviors. The literature is the basis for finding the attributes of agents and their relations which are relevant for moderation of the model parameters.

In expert-systems based knowledge acquisition the effect of culture can be formulated in statements like: "*In hierarchical societies there are differences in selected trade strategy. The higher ranked prefer to trade high quality valuable commodities to underline their status that fits their position in life. They will not avoid deals where less powerful opponents technically have the opportunity to defect, because the higher ranked rely on their power to enforce cooperation*." [21].

This example refers to the effect of Hofstede's power distance dimension. It refers to multiple decision processes: partner selection, delivery, and monitoring and enforcing. It illustrates that research and experts can explain the differentiation of behaviors along a single dimension on the basis of dimensional theory. It also illustrates that it is hard to acquire knowledge about the processes in isolation. Therefore, the approach is taken to first model individual dimensions and then integrate the models process-by-process.

The example also illustrates that not just the values of the dimensional indices are relevant for modeling the effect of culture. Relational attributes are relevant as well. In this example Hofstede's power distance index (PDI) is relevant. It orders countries on a scale with the most hierarchical culture at the high end and the most egalitarian country at the low end. Conditional upon the value of PDI, the status of the agent and its partner are relevant: "*The higher ranked*" refers to agents that have a high status s_a in society; "*less powerful opponents*" refers to opponents with which the status difference $s_a - s_b$, where s_b refers to opponent's status, is high. So, in order to model cultural effects on decisions, not just the indices on the dimensions have to be taken into account as factors, but also relational attributes if their effect is differentiated across cultures. Based upon the example given, one can identify $\text{PDI}\cdot s_a$ and $\text{PDI}(s_a - s_b)$ as relevant factors in addition to PDI.

Based on the knowledge acquired for all individual dimensions, all relevant cultural, relational and situational factors can be identified. In the example of trade the following have been identified as relevant relational attributes: status, in-group versus out-group membership, and the trust relation between partners. For instance, the vector of cultural factors influencing the decisions to deceive and to trust identified by Jonker et al. [19] can be taken from the column labeled "Cultural factor" in Table 2.

Table 2. Relevant factors with respect to trust and deceit, adapted from [19]; PDI*, UAI*, IDV*, MAS*, and LTO* represent Hofstede's indices of culture, s_a the agent's own status, s_b partner's status, and d_b group distance between the agent and its partner; all variables were normalized to the interval [0,1]; + indicates an increasing effect on the parameter; – indicates a decreasing effect

Dim-ension index	Culture and relational characteristics	Cultural factor	Effect on			
			deceit thresh-old	inclin-ation to trace	negative update factor	positive update factor
PDI	Large power distance	PDI*				
	- with higher ranked partn.	Max{0,PDI*(s_b–s_a)}	+	–		
	- with lower ranked partn.	Max{0,PDI*(s_a–s_b)}		–		
	Small power distance	1– PDI*				
UAI	Uncertainty avoiding	UAI*			+	–
	- with stranger	UAI*·d_b	–	+		
	Uncertainty tolerant	1– UAI*				
IDV	Individualistic	IDV*				
	Collectivistic	(1–IDV*)			+	
	- with in-group partner	(1–IDV*)(1–d_b)		–		
	- with out-group partner	(1–IDV*)d_b	–			
MAS	Masculine (competitive)	MAS*	–	+	–	
	Feminine (cooperative)	1– MAS*		–		
LTO	Long-term oriented	LTO*	+	–	+	
	Short-term oriented	(1–LTO*)				
	- with well-respected part.	(1–LTO*)s_b	+	–		
	- with other partners	(1–LTO*)(1–s_b)	–			

Having identified $\vec{f}$ for a particular set of processes, and assuming that the vector of parameter values $\vec{x}$ follows from the chosen decision functions, it comes to the definition of the function *h*. *h* can be decomposed into a vector of functions g_i , i.e., one per parameter, that map *h*'s arguments to the individual culturally adjusted parameter values x_i':

$$h\left(\vec{f},\vec{x}\right)=\left(g_1\left(\vec{f},\vec{x}\right),\ldots,g_m\left(\vec{f},\vec{x}\right)\right)=\left(g_1,\ldots,g_m\right)\left(\vec{f},\vec{x}\right)=\vec{g}\left(\vec{f},\vec{x}\right)\ , \qquad (2)$$

so that

$$\begin{array}{l} x_1'=g_1\left(\vec{f},\vec{x}\right) \\ \ldots \\ x_m'=g_m\left(\vec{f},\vec{x}\right) \end{array} . \qquad (3)$$

The problem now is to find the functions g_i for i=1,…,m. For this purpose the following hypothesis can be formulated: given that dimensional models of culture aim to provide for each dimension a linear ordering of the strength or frequency of occurrence of phenomena associated with that dimension, the effect of each cultural factor may be modeled as a strictly monotonic function r_{ijk} that adapts the i-th parameter to the k-th factor associated with the j-th dimension. r_{ijk} can be seen as a member of a set of functions r that can be indexed by the labels of cultural factors and parameters as arguments. r_{ijk} maps the value f_{jk} of the cultural factor with label l_{jk} into an effect e_{ijk} on the parameter with label p_i:

$$r_{ijk} : f_{jk} \times x_i \rightarrow e_{ijk} \ , \qquad \textbf{(4)}$$

$$r_{ijk} \equiv r(p_i, l_{jk}) \ , \qquad \textbf{(5)}$$

and

$$e_{ijk} = r_{ijk}(f_{jk}, x_i) = r(p_i, l_{jk})(f_{jk}, x_i) \ , \qquad \textbf{(6)}$$

where $p_i \in P$, the set of parameter labels, and $l_{jk} \in L$, the set of factor labels.

As the r_{ijk} are strictly monotonic, they can be classified as either increasing or decreasing. For each parameter label p_i its set of factors L_i^+ that have an increasing effect and its set of factors L_i^- that have a decreasing effect can be defined:

$$\forall p_i \in P: \quad L_i^+ \equiv \{ l_{jk} \mid r_{ijk} \text{ is increasing} \} \ , \qquad \textbf{(7)}$$

$$\forall p_i \in P: \quad L_i^- \equiv \{ l_{jk} \mid r_{ijk} \text{ is decreasing} \} \ . \qquad \textbf{(8)}$$

By the knowledge acquisition process taken, the increasing and decreasing effects of the cultural factors can be identified, as illustrated in Table 2 [19]: L_i^+ is the set of factor labels that have a + sign in the column associated with the parameter labeled p_i; L_i^- is the set of factor labels that have a minus sign in the column associated with p_i.

The next problem to solve is the combination of these influences into a single effect on each parameter, i.e. to identify the functions g_i that moderate the effect of culture on the parameters. On the basis of expert knowledge the following rules can be formulated as hypotheses:

1. In g_i there is no interaction between the factors $\vec{f}$ and other parameters than x_i.
2. The joint decreasing and the joint increasing effect can compensate for each other.
3. For the increasing and for the decreasing effects, the effect with the maximal influence is dominant: influences in the same direction do not reinforce each other.

The first of these three hypotheses implies that the integration can be performed column-by-column using factor tables like Table 1 and Table 2, and we can write the functions as:

$$g_i\left(\vec{f},\vec{x}\right)=g_i\left(\vec{f},x_i\right)\ . \quad \textbf{(9)}$$

The second hypothesis implies that the functions g_i can each be defined as the sum of x_i and a function $g_i^+ \geq 0$ that combines the increasing effects and a function $g_i^- \leq 0$ that combines the decreasing effects:

$$g_i\left(\vec{f},x_i\right)\equiv x_i+g_i^+\left(\left\{r_{ijk}\left(f_{jk},x_i\right)\mid l_{jk}\in L_i^+\right\}\right)+g_i^-\left(\left\{r_{ijk}\left(f_{jk},x_i\right)\mid l_{jk}\in L_i^-\right\}\right)\ . \quad \textbf{(10)}$$

For the functions g_i^+ and g_i^- a range of function types were experimented with (probabilistic and linear combinations, to name the most obvious). However, the third hypothesis proved all except weak disjuntion to be untenable[2]. We found that both g_i^+ and g_i^- can be written as a weak disjunction:

$$g_i^+\left(\left\{r_{ijk}\left(f_{jk},x_i\right)\mid l_{jk}\in L_i^+\right\}\right)=\max\left\{r_{ijk}\left(f_{jk},x_i\right)\mid l_{jk}\in L_i^+\right\}\ , \quad \textbf{(11)}$$

$$g_i^-\left(\left\{r_{ijk}\left(f_{jk},x_i\right)\mid l_{jk}\in L_i^-\right\}\right)=\min\left\{r_{ijk}\left(f_{jk},x_i\right)\mid l_{jk}\in L_i^-\right\}\ . \quad \textbf{(12)}$$

Equations (11) and (12) enable the integration of the computational models constructed for the single dimensions. For this the form of the functions $r_{ijk}\left(f_{jk},x_i\right)=r\left(p_i,l_{jk}\right)\left(f_{jk},x_i\right)$ has to be defined. All that is known so far about these functions is that they are strictly monotonic. As long as there is no further evidence, a first order approach can be taken, i.e., let r_{ijk} adjust x_i proportionally to f_{jk} from its default value in the direction of the extreme values $\varepsilon_{ijk}^+ > x_i$ and $\varepsilon_{ijk}^- < x_i$:

$$\forall i\mid p_i\in P:\quad \forall j\forall k\mid l_{jk}\in L_i^+:\quad r_{ijk}\left(f_{jk},x_i\right)=\left(\varepsilon_{ijk}^+-x_i\right)f_{jk}\ , \quad \textbf{(13)}$$

$$\forall i\mid p_i\in P:\quad \forall j\forall k\mid l_{jk}\in L_i^-:\quad r_{ijk}\left(f_{jk},x_i\right)=\left(\varepsilon_{ijk}^--x_i\right)f_{jk}\ . \quad \textbf{(14)}$$

Under the chosen first order approach, using (11) and (12), (10) becomes:

$$g_i\left(\vec{f},x_i\right)=x_i+\max\left\{\left(\varepsilon_{ijk}^+-x_i\right)f_{jk}\mid l_{jk}\in L_i^+\right\}+\min\left\{\left(\varepsilon_{ijk}^--x_i\right)f_{jk}\mid l_{jk}\in L_i^-\right\}\ . \quad \textbf{(15)}$$

In practice, the values of ε_{ijk}^+ and ε_{ijk}^- are unknown. However, minimal and maximal values can be assumed not to depend on the cultural dimension j, and estimates $\hat{\varepsilon}_i^-$ and $\hat{\varepsilon}_i^+$ can be determined per model parameter. Under the assumptions

[2] Lack of space prohibits a full explanation of this part.

$$\forall i \mid p_i \in P: \quad \forall j \forall k \mid l_{jk} \in L_i^+: \quad \varepsilon_{ijk}^+ = \hat{\varepsilon}_i^+ \ , \tag{16}$$

$$\forall i \mid p_i \in P: \quad \forall j \forall k \mid l_{jk} \in L_i^-: \quad \varepsilon_{ijk}^- = \hat{\varepsilon}_i^- \ , \tag{17}$$

(15) can be written (N.B.: $\hat{\varepsilon}_i^+ - x_i > 0$ and $\hat{\varepsilon}_i^- - x_i < 0$):

$$g_i\left(\vec{f}, x_i\right) = x_i + \left(\hat{\varepsilon}_i^+ - x_i\right)\max\left\{f_{jk} \mid l_{jk} \in L_i^+\right\} + \left(\hat{\varepsilon}_i^- - x_i\right)\max\left\{f_{jk} \mid l_{jk} \in L_i^-\right\} . \tag{18}$$

Concluding, given default values and realistic minimal and maximal values for each parameter, the function in equation (17) can be used to estimate culture induced adjustments x_i' of the parameter values, using knowledge as represented in Table 1.

5 Conclusion

This paper presents an approach to the modeling of cultural differentiation in multi-agent based simulations. It argues that a dimensional theory of culture is a good basis for middle-range agent-based models that simulate differentiation over a broad range of cultures. The decomposition of cultural phenomena into a set of linear orderings on a limited number of dimensions enables dimension-by-dimension modeling of cultural effects. As the dimensions provide a linear ordering, it is reasonable to assume that each dimension (and relational attributes relevant for differentiation of behavior associated with it) has a strictly monotonic effect on decision rule parameters, if all other factors are kept constant.

The integration of effects of all dimensions is based on (1) a division of effects in a subset of increasing and a subset of decreasing effects per parameter, (2) the use of a weak disjunction of the effects per cultural factor, and (3) compensation of increasing effects for decreasing effects and vice versa. The approach has been applied in several simulations of trade processes and has been validated to produce realistic tendencies across cultures in expert-validations.

An approach as followed in this paper aims to reproduce general tendencies of behavioral differentiations across cultures at an aggregated level. It can be used as a research instrument to generate hypotheses about behavioral differentiation that can be validated in experiments, or to validate theories induced from experimental results. As a mid-range model, it cannot be used to predict effects of culture in actual situations or at the individual level.

The approach was applied to simulations of trade processes, on the basis of Hofstede's five-dimensional theory of culture, but it is not specific for this domain and this theory of culture. It could also be applied to other domains, or other theories of culture, provided that parameterized decision models are available that may be expected to have general validity across cultures, and that sufficient knowledge for cultural adaptation can be acquired from social sciences literature and experts.

References

1. O.E. Williamson: The New Institutional Economics: Taking Stock, Looking Ahead. Journal of Economic Literature 38: 595--613 (2000)
2. Hofstede, G.: Culture's Consequences, Second Edition. Sage Publications, Thousand Oaks (2001)
3. Gorobets, A., Nooteboom, B.: Agent Based modeling of Trust Between Firms in Markets. In: Advances in Artificial Economics, LNEMS 584, 121--132, Springer, Heidelberg (2006)
4. Acuff, F.L.: How to negotiate anything with anyone anywhere around the world. Amacom, New York (1997)
5. Olofsson, G.: When in Rome or Rio or Riyadh: Cultural Q&A's for successful business behavior around the world. Intercultural Press, Yarmouth Maine (2004)
6. Kumar, R.: Brahmanical Idealism, Anarchical Individualism, and the Dynamics of Indian Negotiation Behavior. International Journal of Cross Cultural Management 4(1), 39--58 (2004)
7. Kersten, G.E., Köszegi, S.T., Vetschera, R.: The Effects of Culture in Anonymous Negotiations: Experiment in Four Countries. In: Procs. of the 35th HICSS, 418--427 (2002)
8. Guo, R.: How culture influences foreign trade: evidence from the U.S. and China. Journal of Socio-Economics 33, 785--812 (2004)
9. Kónya, I.: Modeling Cultural Barriers in International Trade. Review of International Economics 14(3), 494--507 (2006)
10. Gilbert, N.: Agent-Based Models. Sage Publications, Los Angeles (2008)
11. Tykhonov, D., Jonker, C., Meijer, S., Verwaart, T.: Agent-Based Simulation of the Trust and Tracing Game for Supply Chains and Networks. Journal of Artificial Societies and Social Simulation 11(3), 1 (2008) http://jasss.soc.surrey.ac.uk/11/3/1.html
12. Lévi-Strauss, C.: Tristes Tropiques (originally in French, 1955). Penguin Books, New York (1992)
13. Geertz C.: The interpretation of cultures. Basic Books, New York (1973)
14. Schwarz, S.H.: Culture Matters: National value cultures, Sources, and Consequences. In: Wyer, R.S., Chiu, C.Y., Hong, Y.Y. (eds.) Understanding Culture. Psychology Press, New York (2009)
15. Trompenaars, F., Hampden-Turner, C.: Riding the waves of culture: understanding cultural diversity in business, 2nd edition. Economist Books, London (1993)
16. Smith, P.: Nations, Cultures, and Individuals: New Perspectives and Old Dilemmas. J. of Cross-cultural Psychology 35(1), 50--61 (2004)
17. Meijer, S., Verwaart, T.: Feasibility of Multi-agent Simulation for the Trust and Tracing Game. In: Ali, M., Esposito, F. (eds.) IEA/AIE 2005. LNCS, vol. 3533, pp. 14--154. Springer, Heidelberg (2005)
18. Bosse, T., Jonker, C.M., Treur, J.: Experiments in Human Multi-Issue Negotiation: Analysis and Support. In: Proceedings of the Third International Joint Conference on Autonomous Agents and Multi-Agent Systems, pp 672--679 (2004)
19. Hofstede, G.J., Jonker, C.M., Verwaart, T.: A Multi-agent Model of Deceit and Trust in Intercultural Trade. In: Nguyen, N.T., Kowalczyk, R., Chen S.-M. (eds.) ICCCI 2009. LNCS, vol. 5796, pp. 205--216. Springer, Heidelberg (2009)
20. Smith, Peter, Michael H. Bond & Cigdem Kagitçibasi: Understanding Social Psychology across Cultures. Sage Publications, Thousand Oaks (2006)
21. Hofstede, G.J., Jonker, C.M., Verwaart, T.: Modeling Power Distance in Trade. In: David, N., Sichmann, J.S. (eds.) MABS 2008. LNCS, vol. 5269, pp. 1--16. Springer, Heidelberg (2009)