A Model of Culture in Trading Agents

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A Model of Culture in Trading Agents

Gert Jan Hofstede, Catholijn M. Jonker, and Tim Verwaart

Abstract Geert Hofstede's five-dimensional framework is widely used in social sciences and management science to characterize cultures. It has been suggested to build culturally consistent agent characters based on his framework. This chapter stresses the relevance of culture and trust for trade, substantiates why a dimensional model offers a good basis for cultural differentiation of agents, and presents an approach to apply Hofstede's model to develop culturally differentiated agents. The approach is based on knowledge acquisition on a dimension-by-dimension basis and a computational method to integrate the acquired knowledge. The approach has been applied to a multi-agent simulation of a trade game. It is instantiated for the processes of partner selection, negotiation, and the interaction between deceit and trust in trade.

Keywords Cultural dimensions • Trust • Trade • Multi-agent simulation

1 Introduction

Great differences in personality may exist between people. On the other hand, all people around the world have their human nature in common. Human nature includes life in society. One can observe groups of people, on scales ranging from

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clans to nations, living together and having common behaviors that distinguish them from other groups.

Hofstede (2001, p. 9) defines culture as "*the collective programming of the mind that distinguishes one group or category of people from another*". This implies that culture is not an attribute of individual people, unlike personality. It is an attribute of a group that manifests itself through the behaviors of its members.

A shared understanding of the world is essential for social life. From early childhood on the cultural meaning systems are anchored in the minds of people and permanently reinforced and extended by joint activities with other group members. Kashima (2009) concludes that the joint activities members of a culture engage in "*are in fact the very activities that get their society and culture going. They produce and reproduce the social relationships and cultural resources that enabled these joint activities to begin with*" (Kashima).

Groups share value systems and practices – Hofstede refers to rituals, heroes, and symbols as practices. These are transferred from generation to generation. The practices are the observable characteristics of a culture. Over time and under the influence of contacts with other cultures, practices may change far more easily than the value systems that constitute the core of a culture (Hofstede, 2001).

The present work focuses on the way culture influences trade. The relevance of cultural conflict in trade grows with the current trend of globalization. In a trading situation, culture of the trader manifests itself in four ways. First, culture filters observation. It determines the salience of clues about the acceptability of trade partners and their proposals. Second, culture sets norms for what constitutes an appropriate partner or offer. Third, it sets expectations for the context of the transaction, e.g. the enforceability of regulations and the possible sanctions in case of breach of the rules. Fourth, it sets norms for the kind of action that is appropriate given the other three and, in particular, the difference between the actual and the desired situation.

One of the most prominent, problematic, issues in trade that depend on culture is trust between trade partners (Hofstede, 2006; Hofstede, Spaans, Schepers, Trienekens, & Beulens, 2004). Trust is the aspect of trade where lack of common ground pre-eminently manifests itself. Trust is an important issue in trade, because of the information asymmetries between suppliers and customers, which become more salient in longer supply chains, and because of the inevitable incompleteness of contracts (Williamson, 1985, 1998). Many definitions have been given for trust. For the present work a pragmatic definition is used. Customer's trust in a particular supplier is defined as the customer's estimate of the probability that the supplier will deliver as agreed, even if the supplier has the incentive and the opportunity to defect.

Agent-based modeling offers new opportunities to study trust and culture in trade. Agent-based modeling enables the study of emergent phenomena at an aggregated level that originate from the behaviors and interactions of individuals. As such it provides an analogue to culture: culture has no other representation than in the minds of its members. Culture is a form of collective intelligence, physically represented in the brains of individuals, grounded during the common activities where its observable properties emerge. Trade is such a common activity.

Agent-based models can be applied as a research tool in combination with simulation gaming (Tykhonov, Jonker, Meijer, & Verwaart, 2008). Observations in gaming simulations can lead to theorizing about the decision models of participants. These models can be implemented in the multi-agent simulation, in order to validate that the hypothetical models lead to the behavior that was observed in the gaming simulation.

The context of the agent-based model presented in the present chapter is the TRUST & TRACING (T&T) game. In runs of this gaming simulation, considerable differences in outcomes are observed across cultures. These observations were the reason to develop this model. Meijer (2009) discusses the validity of the gaming simulation, according to validation aspects as defined by Raser (1969): psychological reality, structural validity, process validity, and predictive validity. The T&T game is an abstract game, not representing or predicting the performance of an actual instance of a real world supply chain. It offers process validity in a laboratory environment, based on psychological reality.

This chapter is structured as follows. The first sections to follow are devoted to related work, including the T&T game, the modeling approach, and the research questions. Then Hofstede's dimensions of culture and their hypothetical effects on the processes in the T&T game are discussed. The last three sections present an integrated model of the five dimensions' joint effect, examples of simulation results, and the conclusion of this work.

2   Related Work

There is a wealth of literature on trade and culture that so far has not been considered in formalized models of trade. In agent-based economics, individual traders are modeled as intelligent agents cooperating in an artificial trade environment. The agents are modeled to mimic authentic human behavior as closely as possible. In recent papers the differences between such agents are no longer solely attributed to differences in their individual economic situations. Aspects such as personality and attitude are considered as well, see, e.g. (Jager & Mosler, 2007). Without considering such aspects, the simulations will not correspond to reality. With respect to formalizing the important influence of cultural background on trade, we only found a few papers. These papers study trade at the macro-level, e.g., (Kónya, 2006). That paper presents an equilibrium analysis on the amount countries invest in learning another language and culture and the size and welfare of those countries. Another example is (Bala & Long, 2005). That paper presents a formal model of the influence of trade on culture, i.e., the reverse direction of influence as studied in the current chapter. Other literature also uses macro-level models, such as the gravity model to study the correlation between culture and trade (Guo, 2004).

Kersten (2002) urges the necessity of cultural adaptation of e-Business systems and proposes an architecture that adapts both business logic and user interface. The

rationale for adapting systems to user's cultures is given by Kersten, Köszegi, and Vetschera (2002), who report significant differences in expectations, perception of the opponent, negotiation process, and outcomes of electronic negotiations across cultures. However, no actual implementations of models of culture in e-Business were found. Blanchard and Frasson (2005) report an application of Hofstede's dimensions in a model to adapt e-Learning systems to the user's culture. Recent research on cultural modeling in agents mostly focus on Embodied Conversational Agents (ECA), including non-verbal behavior like facial expressions, gestures, posture, gazing, and silence in conversations (Payr & Trappl, 2004; Rehm, Nishida, André, & Nakano, 2008). CUBE-G (Rehm et al., 2008) is based on Hofstede's dimensions and focuses on modeling into virtual characters the processes of first meeting, negotiation, and interaction in case of status difference.

All models discussed so far have in common that they model culture with the purpose to support human decision making or to improve human-computer interaction. The purpose of the model proposed in the present chapter is to realistically simulate emergent behavior in multi-agent based simulations for research in the social sciences. The aspects of ECA are of less relevance in this context. Agent behavior may be modeled in a more stylized way. An approach that does so for the purpose of multi-agent simulations is that of Silverman et al. (2007) and Silverman, Johns, Cornwell, and O'Brien (2006). They model agents as a composition of biological, personal (personality, culture, emotions), social (relations, trust), and cognitive (decision) modules, completed with modules for perception, memory, and expression. Their approach is a generic structure for modeling the influence of culture on agent behavior – along with factors like stress, emotion, trust, and personality – through Performance Moderator Functions (PMF). It differs from our approach in that it is an environment to implement validated models of culturally differentiated behavior, while our approach aims to develop and validate such models.

The model presented in this chapter is based on the TRUST & TRACING (T&T) game (Meijer, 2009), a research tool designed to study human behavior in commodity supply chains and networks. The focus of study is on trust in stated quality of commodities. The game is played by a group of 12 up to 25 persons that play roles of producers, middlemen, retailers, or consumers. The goal of producers, middlemen and retailers is to maximize profit. The consumers' goal is to maximize satisfaction. Each player receives (artificial) money. Producers receive envelopes representing lots of commodities. Each lot is of a certain type of product and of either low or high quality. High quality products give more satisfaction points than low quality products. A ticket covered in the envelope (so it is not visible) represents quality. The producers know the quality. Other players have to trust the quality statement of their suppliers, or request a product trace at the cost of some money and some damage to the relations with their suppliers. The game leader acts as a tracing agency and can on request and at the cost of a fee determine product quality. In case of deception the game leader will trace transactions and punish deceivers with a fine and public disgrace.

3 Modeling Approach

One must lean on social sciences literature to model culture. Two main streams of research can be distinguished. First, there is the anthropological approach of "thick description", in which specific cultures are studied by detailed and close observation of behaviors during an extensive time-span. Examples are the works of Lévi-Strauss (1992) and Geertz (1973). 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 Hofstede (2001), Schwarz (2009), Trompenaars (1993) and GLOBE (House, Hanges, Javidan, Dorfman, & Gupta, 2004). The approach of that type of 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 sets of respondents that are required. Questionnaire studies will be more reliable predictors of behavior if they are about the desired (for self) than if they are about the desirable (for everyone), and also if they are asked to a broad range of types of respondents as opposed to just one type (e.g., students or managers). The resulting models provide a linear ordering of cultures along each dimension, where implicit norms are hypothesized to be stronger or weaker according to the index on the dimension. As authors of dimensional models stress, these same implicit norms carry over to all relationships in society. In all social situations, they act as filters on perception and on action range. This means that there are no specific values for activity x, e.g. 'trade values', in a dimensional model. It also means that a dimensional model is suited for modeling any process that involves social intercourse, including trade and its sub-activities.

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 chapter 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 need to posit the model at an impartial distance from any single culture. A dimensional model of culture is more suited than a collection of incommensurable rich descriptions. Dimensional models are culture-level abstractions. They do not depict individuals, but average group characteristics, and therefore the agents in our simulation will be iconic for a culture, not specific for any individual.

The work of Hofstede (2001) focuses on differences between national cultures, particularly on differences in value systems across nations. The computational models of the effects of culture proposed in this chapter are based on that work. Although other dimensional models of culture could certainly be used for similar purposes, Hofstede's framework was chosen over possible other candidates (such as Hall, 1976; House et al., 2004; Schwarz, 2009; Trompenaars, 1993) for various

reasons. First, Hofstede's work is parsimonious and accessible, with only five dimensions[1] compared to GLOBE's 18, and with its 1–100 scales. Second, it has a wide scope, compared to Trompenaars', whose dimensions are statistically correlated and can be described as aspects of only individualism and power distance (Smith, Dugan, & Trompenaars, 1996) or Hall who focused on the dimension of individualism (low-context communication) versus collectivism (high-context communication). Those models miss out on issues related to gender roles, anxiety and Confucian values. Third, it has the greatest empirical base of these studies, with a well-matched sample of 117,000 respondents to the original study plus hundreds of replications during a quarter century that validate the model (Kirkman, Lowe, & Gibson, 2006; Schimmack, Oishi, & Diener, 2005). Fourth, it is the most widely used. It has survived fashions and hasty storms of criticism (Smith, 2006; Sóndergaard, 1994). Fifth and most important, it shows continued predictive value for many societal phenomena (Hofstede, 2001; Smith, 2002).

For the endeavor documented in this chapter, not only a model of culture is essential, but also a model of trade. A process model comprising six main processes was elaborated, where possible based on validated models reported in social science or artificial intelligence literature. The six main processes are:

1. trade goal selection (e.g., buy or sell), based on agent role and stock position
2. partner selection, based on the model of Weisbuch, Kirman, and Herreiner (2000)
3. negotiation, based the ABMP architecture (Jonker & Treur, 2001)
4. delivery, truthfully or untruthfully according to results from social psychology
5. acceptance of deliveries, and decision to trust or trace, based on dynamic trust
6. belief updates and trust dynamics (Jonker & Treur, 1999)

Having decided on a model of trade and a dimensional model of culture, the next step was to model the interaction between the two models. The effects of culture were modeled on a dimension-by-dimension basis, using a classical expert systems knowledge acquisition approach: literature study, expert interviews, formalization and verification of the model, and face validation of results. The results of the dimension-by-dimension analysis are described in separate papers per dimension (Hofstede, Jonker, Meijer, & Verwaart, 2006; Hofstede, Jonker, & Verwaart, 2008a; Hofstede, Jonker, & Verwaart, 2008b; Hofstede, Jonker, & Verwaart, 2008c; Hofstede, Jonker, & Verwaart, 2009a). An overview is given in this chapter in Sect. 5.

Subsequently, the models for the individual dimensions were integrated on a process-by-process basis, except for the trade goal selection, which is not modeled to depend on culture. The resulting culturally adapted decision models of the agents are described in separate papers (Hofstede, Jonker, & Verwaart, 2009b, 2010a, 2010b), as is the computational approach to integration of the

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[1]A sixth dimension 'Indulgence versus Restraint' was added in 2010 (Hofstede, Hofstede & Minkov (2010), after completion of the present model.

dimension-by-dimension expertise (Hofstede, Jonker, & Verwaart, 2011). Section 5.6 presents an overview of the process models and the effects of culture.

The integration into an all-singing, all-dancing model has been verified through a meta-modeling based sensitivity analysis (Burgers, Hofstede, Jonker, & Verwaart, 2010).

The model has been implemented in the CORMAS multi-agent environment.[2]

4 Research Questions

This work aims to differentiate the behavior of artificial agents that simulate aspects of human behavior, as if the agents had a cultural background. Two assumptions underlie this attempt. The first is that it is possible to define models of agents that share universal, globally valid, properties with human behavior at least in the selected processes of trade. The second is that it is possible to formalize expertise about how culture differentiates these models.

To give an example of the first assumption: to a Western mind negotiation may well be perceived as a sequence of alternating explicit proposals, but would another model fit better to practices in other parts of the world? In this research we do not attempt to answer this kind of questions. We assume that social science literature can provide the modeler with a set of theories of human behavior that have universal coverage for the domain of study and that may have parameters that may be different between cultures.

The main hypothesis of this work is related to the second assumption. This hypothesis is that a composition of universal models of human decision making in a particular domain and a dimensional model of culture can simulate believable differentiation of behavior across cultures. With believable we mean that the behavior simulated by the agents can pass face validation by experts in the cultural differentiation in the domain of application.

The main research question "how can a model be formulated that adapts universal decision functions to culture according to a theory about the dimensions of culture" entails the following, more specific questions.

- Given a universal model of human behavior in some domain, can the model of culture's effects be formulated, following an expert systems knowledge acquisition approach?
- Having formulated the knowledge about the effects of culture on model parameters per dimension, how can a believable model of their joint effect be formulated?

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[2]http://cormas.cirad.fr/indexeng.htm

- How can the sensitivity of such a model be assessed for variation of cultural dimension indices, relational configurations regarding power and group membership, and universal model parameters?
- Can such a model be applied to fulfill its function as a social sciences research instrument in combination with simulation gaming? This function comprises (Meijer & Verwaart, 2005):

  – Validation of models of behavior induced from game observations
  – Testing of hypotheses about dynamics of aggregated results in relation to parameter changes in individual behavior
  – Test design: selection of useful configurations for games with humans

The questions are answered in the context of the T&T game, by applying Hofstede's dimensional theory of culture to three universal domain models, for partner selection, negotiation, and the interaction between deceit and trust.

5 Hofstede's Dimensions and Their Effects on Trade

Hypothetical differences in behavior can be formulated for traders from different cultures on the basis of the works Hofstede (2001) and Hofstede, Hofstede, and Minkov (2010) and observations in the T&T game (Meijer, 2009). While in reality, individual behaviors are co-determined by historical, contextual and personality factors, these can be abstracted away in the present study of trends of behavior in groups of people. Before creating an integrated model, the behavioral tendency associated with each dimension will be reviewed. The dimensions in Hofstede's model, to be discussed in the following subsections, are masculinity versus femininity, individualism versus collectivism, power distance, uncertainty avoidance, and long-term versus short-term orientation. Each of the dimensions is briefly characterized and expected distinctions between the extremes are specified, based on the work of Hofstede and expert consultations.

5.1 Masculinity Versus Femininity

In masculine societies people are expected to place value on measurable performance criteria such as size, speed and quantity. Big is beautiful. Money is good. Rich people are admired. Life is conceptualized as a series of contests and winning is paramount while losing is a disaster. Implicit trust is low; if you get cheated it is your own fault and you are a loser. If you do good, you do it in the large. If you commit crimes, they are large, not petty ones.

Feminine societies are the opposite. Winners are at risk of awakening feelings of jealousy. Small is beautiful, implicit trust is high, and cheaters are looked down upon. Yet small-scale cheating occurs a lot because society is permissive and, in the case of small misdemeanors, forgiving. Penalties are mild. Good intentions are more important than good performance.

Table 1 Expected behavioral distinctions between traders in the T&T game having masculine versus feminine cultural backgrounds

Masculine	Feminine
Deal with anyone	Build relationships
Rapid deals, as many goods as possible	Take time to negotiate, accept small deals
Be a tough negotiator	Show mutual willingness to accommodate
Cheat and expect to be deceived	Trust
Show off with highly valuable goods	Purchase for practical use
Trace and enforce delivery to contract	Avoid notorious deceivers

Sources: Hofstede (2001), and expert consultations

The meaning of trust across cultures is related to the dimension of masculinity versus femininity. In fact, the statement 'Most people can be trusted' was one of the constituents of the dimension in Hofstede's original research. In feminine cultures, people agree with it more. Since then, many others have investigated the variations of the meaning of the concept across cultures. See e.g. Hofstede et al. (2004) for a discussion of the dynamics of trust and transparency across cultures. Hofstede (2006) distinguishes *intrinsic trust* from *enforceable trust*. Intrinsic trust is trust that accepts vulnerability, while enforceable trust is trust in good performance that is backed up by the option of rewarding and punishing the trustee. To sum it up in a simplified way: the former is what people mean by trust in feminine cultures, and the latter is what people mean by trust in masculine cultures.

Table 1 summarizes expected distinctions reported by Hofstede et al. (2006).

5.2 Individualism Versus Collectivism

The variation in basic group size and cohesion between societies has been shown by sociologists, e.g., in the distinction between *Gemeinschaft* (community) and *Gesellschaft* (society) that Tönnies introduced as early as 1887 (Tönnies, 1963). In a *Gemeinschaft*, people share everything, both material and immaterial, whereas in a *Gesellschaft,* private property and other individual-centered institutions are possible. This variation has been confirmed by social-psychological cross-national studies of practices or values. Triandis (1995) and Hofstede (2001) speak of the distinction between *individualism* and *collectivism*. Minkov (2007) showed that the individualist-collectivist continuum is visible in World Values Survey data (he names it universalism versus exclusionism). This dimension has become the main ingredient of theories about cross-cultural business, e.g., in the work of Trompenaars (1993) who posits a number of dimensions of culture that were shown by Smith et al. (1996) to be correlated with individualism versus collectivism. The relevance of this dimension to the management literature lies in the fact that Anglo countries are at the extreme individualistic end of the scale, so business partners from almost any country are bound to have more collectivistic cultures.

Table 2 Expected behavioral distinctions between traders in the T&T game having collectivistic versus individualistic cultural backgrounds

Collectivistic	Individualistic
Maintain harmony, avoid confrontation	Speak your mind
Show favor to in-group customers	Treat all customers equally
No business without a personal relation	Task is more important than a good relation
Relations are given	Build and maintain relations actively
Do not terminate negotiations	Terminate if progress is insufficient
Do not show distrust to in-group members	Show distrust as it is
High relational endowment effect[a]	Low relational endowment effect
Deceive if it does not conflict with group interests	Deceive according to personal morality

Sources: Hofstede (2001), and expert consultations

[a]The effects of deceit, if revealed, and showing distrust by tracing deliveries do more damage to relationships in collectivistic than in individualistic societies

In an individualistic society the various spheres of life, e.g., family, business, and leisure, tend to be separated. To collectivist mindsets, relations are more important than business – and so, business tends to be done among friends and family. The term "in-group" is often used to denote this kind of self-evident unit of social life.

Table 2 summarizes expected distinctions reported by Hofstede et al. (2008b).

5.3 Power Distance

Where the salience of common group memberships for social interaction makes the difference between individualistic and collectivistic societies, the dimension of power distance is about the importance of hierarchy in societies. The dimension runs from egalitarian (*small power distance*, e.g., Anglo, Germanic, and Nordic cultures) to hierarchical (*large power distance*, most other cultures). Hofstede (2001) defines power distance as the extent to which the less powerful accept and expect that power is distributed unequally. In large power distance societies political, economic, and judicial power are interwoven. In small power distance societies a person's power is limited to the purposes of a role and to the situations in which the person plays the role.

Table 3 summarizes expected distinctions reported by Hofstede et al. (2009a).

5.4 Uncertainty Avoidance

Hofstede (2001, p. 161) defines the uncertainty avoidance dimension of culture as "*the extent to which the members of a culture feel threatened by uncertain or unknown situations*". It is important to realize that this has nothing to do with risk avoidance. Uncertainty avoidance is about fear of situations in which "*anything*

Table 3 Expected behavioral distinctions between traders in the T&T game having hierarchical versus egalitarian cultural backgrounds

Large power distance (hierarchical)	Small power distance (egalitarian)
Might is right	No privileges and status symbols
Formal speech; acknowledgement	Talk freely in any context
Dictate, obey	Negotiate
Negotiate only in case of equal power	
Prefer equal status partners	Treat all (potential) business partners equally
Avoid more powerful business partners, but show favor when unavoidable	
Be patient and conceding with powerful partners	
Be careful not to deceive more powerful partners	
Do not show distrust to more powerful partners	
No need to distrust less powerful partners	
Trade products of quality according to status	

Sources: Hofstede (2001), and expert consultations

can happen and one has no idea what" . . . "*Uncertainty-avoiding cultures shun ambiguous situations. People in such cultures look for structure in their organizations, institutions, and relationships, which makes events clearly interpretable and predictable. Paradoxically, they are often prepared to engage in risky behavior in order to reduce ambiguities – such as starting a fight with a potential opponent rather than sitting back and waiting*" (Hofstede, p. 148).

People from highly uncertainty avoiding societies or groups do not tolerate ambiguity as to who is a member of their group. They tend to have strict moral criteria as to who fits in: adherents of the same religious subgroup, perhaps, or people from the same region, people with the same profession or status, people who speak their language, people of their gender, or similar clear-cut criteria. Since people from such societies do not easily engage in interactions with others who do not share their most salient group characteristics, trade will often be a within-group activity. Within-group contacts are charged with tokens of loyalty, often through shared ritual that is needed to counteract the stress that people experience.

Societies or groups that are uncertainty tolerant are easy travelers, and will engage in novel activities without needing much time to adjust. Their social interactions tend to be laid-back and they will strike up trade relations with foreigners if the opportunity presents itself.

Table 4 summarizes expected distinctions reported by Hofstede et al. (2008a).

5.5 Long-Term Versus Short-Term Orientation

Behaving as a good, upstanding member of the group is at the core of the lives of all beings that live in social groups (Wilson, 2007). Human beings are intensely

Table 4 Expected behavioral distinctions between traders in the T&T game having uncertainty tolerant versus uncertainty avoiding cultural backgrounds

Uncertainty tolerant	Uncertainty avoiding
Suppression of emotions	Expression of emotions; strong emotions when deceit is revealed
Willingness to take unknown risks	Only known risks are taken
Openness to innovations	Distrust, strong endowment effect
Tolerance of diversity	Avoid strangers
Comfortable with ambiguity and chaos	Need for clarity and structure
Appeal of novelty and convenience	Appeal of purity, high quality
Relaxed negotiation style	Impatient, time is money
Frequency of deceit depends on relationships	Low deceit threshold toward strangers

Sources: Hofstede (2001), and expert consultations

social and they exemplify the point very well. Ensuring the successful functioning of our social groups is a basic requirement for survival. We spend up to 20 years being taught how to act as virtuous members of society. But how to be virtuous? It turns out that different societies have found different answers to that question. The issue of whether the sources of virtue are to be found in the past and present, or in the future, is one of the basic dimensions of culture found by Hofstede (2001). This fifth dimension, called 'long-term versus short-term orientation' by Hofstede, is very important for trade. Its strong correlation with economic growth across 39 countries in the period 1970–2000 testifies to its relevance for trade (Hofstede & Hofstede, 2005, p. 223).

Hofstede (2001, p. 359) gives the following definition of the LTO-dimension: "*Long Term Orientation stands for the fostering of virtues oriented towards future rewards, in particular, perseverance and thrift. Its opposite pole, Short Term Orientation, stands for the fostering of virtues related to the past and the present, in particular, respect for tradition, preservation of 'face', and fulfilling social obligations*". Long-term orientation is correlated with self-effacement. This was found by Minkov (2007) in a meta-analysis of data from the World Values Survey. The individual thinks of itself as a small element within the continuity of life. Hence, learning and developing one's capacities is more important than winning a particular game, or obtaining a particular result. In contrast, short-term orientation correlates with self-enhancing values in which being successful in a game is a desirable thing that will improve one's reputation.

Table 5 summarizes expected distinctions reported by Hofstede et al. (2008c).

5.6   *The Joint Effects of Hofstede's Dimensions*

The preceding subsections describe how agent behavior in trade is expected to vary across cultures along a single dimension. This approach enables knowledge acquisition. An expert can explain the effects of individual dimensions, but cannot oversee the consequences of varying the indices simultaneously. As was shown

Table 5 Expected behavioral distinctions between traders in the T&T game having short-term versus long-term oriented cultural backgrounds

Short-term oriented	Long-term oriented
Immediate gratification of needs expected	Deferred gratification of needs accepted
Short-term virtues taught: social consumption	Long-term virtues taught: frugality, perseverance
Spending, top quality demanded, impatient	Saving, investing, patient
The transaction bottom line, quick profits	Building a strong market position
Show off, by trading with high status partners	Invest in long-term relations

Sources: Hofstede (2001), and expert consultations

by Hofstede et al. (2006, 2008a, 2008b, 2008c, 2009a), the expertise laid down in narrative form can be formalized into production rules that work in two ways: modify (i.e. either increase or decrease) the values of parameters in decision functions and modify the relevance of some decision functions.

The formal rules can be implemented in agents. In multi-agent simulations results can be generated for different values of the particular cultural index and for different relational configurations (status differences, different in-groups, differences in initial trust etc.). These results can be used for verification of the implementation of the rules, for face validation of results, and even for educational purposes. However, to simulate actual national cultures, all dimensions must be taken into account simultaneously. A computational approach to this integration has been developed (Hofstede et al., 2011). This approach, like the models of the individual dimensions, is based on the adaptation of default parameter values in decision models. The adaptation is made on the basis of the values of "cultural factors". Some dimensions adapt the perceived relevance of relational attributes, such as group membership (in-group versus out-group), status difference, and trust. Cultural factors combine dimension scores and relational attributes (see Table 10 at the end of this chapter). 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 $\vec{x}'$:

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

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.

The computational integration approach is based on the following assumptions.

1. Given that dimensional models of culture aim to provide for each dimension a linear ordering of the strength 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 that can be indexed by the labels of cultural factors and parameters as arguments.

2. 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 $\varepsilon_{ijk}^- < x_i$, with ε_{ijk}^+ and ε_{ijk}^- universal, i.e. not dependent on culture, for a particular domain.

3. The interaction between decision function parameters does not depend on culture. This assumes that a decision model can be formulated in such a way that any parameter can be modified for culture without taking the values of the other parameters into account. This is not a very restrictive assumption. For instance if a decision function $\Delta(x_i, x_{i'})$ requires parameters $x_i < x_{i'}$, the parameters cannot independently be modified, but they can after substitution: $\Delta(x_i, x_{i'}) = \Delta(x_i, x_i + x_{i''}) = \Delta'(x_i, x_{i''})$ with $x_{i''} > 0$.

4. The joint decreasing and the joint increasing effect of cultural dimensions can compensate for each other. This expertise is confirmed by expert statements, e.g. (in cultures with high power distance) "*The powerful dictate the conditions. The less powerful have to accept. In feminine or collectivist cultures the powerful may exercise restraint, …*".

5. For the increasing and for the decreasing effects, the effect with maximal influence is dominant: effects in the same direction do not reinforce each other. According to expert knowledge, if several factors influence a parameter in equal direction, it is sufficient for one to be maximal in order to sort maximal effect (disjunctive factor influence, see e.g. "*feminine or collectivist*" under 4. above).

6. Cultural factors working in the same direction do not reinforce each other. For instance, in Table 2 three factors are identified to have increasing effect on deceit threshold d_b. If two of the factors have effect 0.5 and one has effect 0.2, their joint effect is 0.5; not 0.4 (the average) or another linear combination (see 5. above); not 0.8 (probabilistic) or another product combination.

Under these assumptions, the mapping h can be written as a set of functions g_i, one function for each parameter (Hofstede et al., 2011):

$$g_i\left(\vec{f}, x_i\right) = x_i + \left(\hat{\varepsilon}_i^+ - x_i\right) \max\{f_{jk} | l_{jk} \in L_i^+\} + \left(\hat{\varepsilon}_i^- - x_i\right) \max\{f_{jk} | l_{jk} \in L_i^-\}. \tag{2}$$

The inputs to this equation are the (domain-dependent) default, minimal and maximal values of the parameter, and the actual values f_{jk} of the cultural factors labeled l_{jk}. The cultural factors are identified in the dimension-by-dimension knowledge acquisition. L_i^+ stands for the set of cultural factors indicated to have increasing effect on x_i and L_i^- stands for the set indicated to have decreasing effect.

In order to apply this approach, one needs models for the decisions that the agents make in the simulated processes. The following subsections propose models for the trade processes of partner selection and negotiation in the pre-contract phase of transactions, and deceit and trust in the post-contract or delivery phase.

5.7 Partner Selection

The decision model for partner selection (Hofstede et al., 2009b) is based on the reinforcement learning of expected utility proposed by Weisbuch et al. (2000). According to the model of Weisbuch et al., agents select their business partners at random, with probability:

$$P_b = \frac{\exp(\beta J_b)}{\sum_{b'} \exp(\beta J_{b'})}, \tag{3}$$

where J_b represents the preference for business partner b, based on the agent's belief about the partner's fairness (defined as experience of utility of previous deals) and affected by the agent's culture and relationship with the partner. The effects of culture and relationship are computed according to Table 10 (at the end of this chapter). If the value of β is high, the agent has a tendency to be loyal to partners with which it has successfully dealt before. If the value of β is low, the agent is likely to display shopping behavior, frequently trying new partners. Weisbuch et al. have validated this model in their research at the Marseille wholesale fish market, where both types of agent behavior prevail: some agents are loyal and some consistently show shopping behavior.

Based on the descriptions of individual dimensions given in the preceding section, the value of β, representing loyalty, is expected to depend on culture: increased to a maximal value in long-term oriented societies, and decreased to a minimal value in uncertainty-avoiding or masculine societies.

For each partner, the agent maintains a belief J'_b about the partner's fairness:

$$J'_b(n) = (1 - \gamma) J'_b(n - 1) + \gamma U_b(n), \tag{4}$$

where γ represent a learning parameter and $U_b(n)$ the utility of the n-th negotiation result with j; $U_b(n) = 0$ if the negotiation was terminated without agreement. Based on the descriptions given in the preceding section, the value of γ is expected to depend on culture: increased in feminine, decreased in uncertainty avoiding cultures.

If an agent has no negotiation going on, it checks for recently received proposals. It may have recent proposals from several agents simultaneously. From the simultaneous proposers, it selects the agent z that has the maximal acceptability A_z of all proposers and subsequently decides whether to accept the proposal to negotiate with z or to start new partner search, and propose to a partner selected according to Eq. 3. This decision is modeled as a Bernoulli variable:

$$p(\text{start negotiation with } z) = A_z; \tag{5}$$

$$p(\text{start new partner selection}) = 1 - A_z. \tag{6}$$

Acceptability A_b of an agent b is set equal to J_b, but for agents from hierarchical societies the value is modified to express that agents having that cultural background are inclined to accept a higher-ranked proposer even if they do not prefer the partner.

Table 10 (at the end of this chapter) summarizes the cultural factors taken into account to modify the parameters and the variables of the partner selection process, applying Eq. 2 and using appropriate settings for the default, minimal, and maximal values of these parameters and variables.

5.8 Negotiation

The negotiation process (Hofstede et al., 2010a) is modeled according to the ABMP architecture (Jonker & Treur, 2001). The similarity of ABMP to human negotiations has been validated (Bosse, Jonker, & Treur, 2004). The ABMP process is an exchange of bids, starting with a bid by one of the partners. The agents evaluate bids using a utility function.

The agent model uses the utility function proposed by Tykhonov et al. (2008):

$$U = w_{value} V + w_{qual} Q + w_{risk} R, \tag{7}$$

with $0 \leq w_{value} \leq 1$, $0 \leq w_{qual} \leq 1$, $0 \leq w_{risk} \leq 1$, and $w_{value} + w_{qual} + w_{risk} = 1$. The terms of this function represent the economic value of the transaction and the effects of agent's quality preference and risk avoidance, respectively. For a further specification of the computation of the utility function's terms, we refer to Hofstede et al. (2010a).

ABMP is a multi-attribute concession strategy. An agent prepares a bid that is a utility concession to its previous bid. In the present simulation, the agent prepares the first bid by composing an attribute configuration according to its quality preference and risk attitude. After the price is set according to the agent's belief about the market price range for the product (a seller sets the price at the maximal value, a buyer at the minimal value), the utility U_1 of the first bid to be made is computed. In subsequent bids the partners make concessions with respect to the utility of their bid.

Concession factor η and negotiation speed χ are the parameters that govern the concession making. *Concession factor* η, $0 < \eta < 1$, is the fraction of the opening bid's utility that the agent is willing to give in during the negotiation. It determines the minimum utility that is acceptable to an agent, also called the reservation value:

$$U_{\min} = (1 - \eta) U_1, \tag{8}$$

where $U_{\min}$ represent the reservation value, and U_1 the opening bid's utility.

Negotiation speed χ, $0 < \chi < 1$, is the fraction of difference between the agent's previous bid and the minimum utility that an agent uses to determine the target utility of its next bid:

$$U_{n+1} = U_{\min} + (1 - \chi)\,(U_n - U_{m}in)\,, \tag{9}$$

where $U_{\min}$ represent the reservation value, and U_1 the opening bid's utility. In the current simulation a bid is composed by changing the attribute values at random and setting the price to yield the target utility.

After calculation of the utility of a partner's bid and the target utility of its own next bid, the agent decides whether to accept partners bid or not, governed by the utility gap parameter ω.

Acceptable utility gap ω is the maximal difference between own target utility and last partner's bid's utility for which an agent will accept partner's bid.

If the target utility minus the partner's last bid's utility is greater than the acceptable utility gap, the agent does not accept and has to decide about its next action. It can terminate the negotiation for several reasons. First, partner's bid may be interpreted as unrealistic if its utility is too far below the minimum utility. Second, an agent may be dissatisfied by the progress in partner's bids. Third, there may be no more room for a substantial change of attributes to make a bid with the target utility. In the latter case the agent terminates the negotiation. In the first two cases the probability that the agent terminates the negotiation depends on the impatience parameter ι, $0 < \iota < 1$. The agent terminates the negotiation with probability ι if partners bid is considered unrealistic, i.e. less than $(1-\iota)U_{\min}$, or partner makes insufficient concessions, i.e. less than $(1-U_{\min})\iota$ over the last three rounds.

The weight factors in the utility function and the ABMP parameters depend on the negotiation domain and on culture. Table 10 (at the end of this chapter) summarizes the effects of culture for the negotiation process. Equation 2 can be applied to modify the values of weights and parameters, given default, minimal and maximal values for a domain, e.g. the purchase of a supercomputer by a university or transactions in a wholesale food market.

5.9 Opportunism and Trust

For a simulation of human trust and deceit, a strictly rational model is not sufficient (Hofstede et al., 2010b). In intelligent agent research, much attention has been paid to trust. Little research has been published about the simulation of deceit. Some authors modeled deceit as a rational strategy to gain advantage in competitive situations (Castelfranchi, Falcone, & De Rosis, 2001; Ward & Hexmoor, 2003). A strictly rational approach of deceit neglects the emotional impact that deceit has, not only on the deceived, but also on the deceivers. Feelings of guilt and shame result from deceiving and the extent to which these feelings prevail differs across cultures (Triandis et al., 2001). People have emotional thresholds for deceit that cannot be explained from rational evaluation of cost and benefit, but that are based on morality and cooperative attitudes (Boles, Croson, & Murnighan, 2000; Steinel & De Dreu, 2004; Wirtz & Kum, 2004). Once deceived, people react to an extent

that goes beyond rationality (Boles et al., 2000), especially when they are pro-social rather than selfish (Steinel & De Dreu, 2004). In human decision making a model based on *fair trade* prevails over a model of *opportunistic betrayal* (Olekalns & Smith, 2009). In addition to psychological factors, rational economic motives can be given for the human inclination to cooperative behavior (Hwang & Burgers, 1999).

The decision to deceive depends on opportunity, motive, and attitude. A supplier has an opportunity to deceive if a high quality product has to be delivered and the customer did not require a certificate. A supplier has a motive to deceive if an extra profit can be gained by deceiving, for instance if the customer negotiated a guarantee and the supplier expects the customer to trust the delivery. Whether a supplier actually deceives when opportunity and motive are present, depends on the supplier's threshold toward deceit. The threshold depends on the supplier's morality and may be reinforced by recent penalties or the relationship with the customer. For agents in the TRUST & TRACING game, Hofstede et al. (2010b) model the decision to deceive as a Bernoulli variable with probability of deceit

$$p\,(\text{deceit}) = q\,(1-c)\,m_b\,(1-d_b),\tag{10}$$

where q represents the quality agreed in the current contract ($q = 1$ for high quality; $q = 0$ for low quality or no opportunity); $c = 1$ if certification has been agreed (no opportunity); $c = 0$ otherwise; m_b represents the supplier's motive or rationale to deceive customer b ($m_b = 1$ if the supplier expects an extra profit from deceit; $m_b = 0$ otherwise); d_b represents on the interval [0, 1] seller's threshold for deceit toward customer b, where $d_b = 1$ represents perfect truthfulness. d_b is influenced by seller's personal traits and values (like risk aversion and morality), power and group relations, and seller's estimate of customer's benevolence, i.e., seller's trust that the customer will accept deliveries without tracing. A more detailed description of the deceit model is given by Hofstede et al. (2010b).

Trust and distrust develop during social interactions. The only sources of information that can be taken into account in the simulation of the Trust and Tracing game are negotiation outcomes and tracing reports, which are relevant in reality as well. Every successful negotiation resulting in a transaction will strengthen partners' trust in each other. However, customers can decide to trace a delivery and this can have its effects on mutual trust. First, if tracing reveals deceit, the customer's trust in the seller will be reduced. Second, the fine and the reputational damage resulting from revealed deceit will reinforce the supplier's honesty. However, reinforced honesty will decay in the course of time. Third, the supplier delivering truthfully may be offended by tracing. To maintain a good relation, customers may exercise restraint to trace. Tracing will always reduce the supplier's belief about customer's benevolence. The following dynamics have to be modeled:

- development of trust and benevolence belief by successful negotiations;
- for customers: reduction of trust in case of revealed deceit;
- for suppliers: reinforcement of honesty in case of revealed deceit;

- for suppliers: decay of reinforced honesty to a base level;
- for suppliers: reduction of benevolence belief in case of tracing.

Jonker and Treur (1999) develop a classification of trust dynamics. The most realistic type for trading situations is slow positive – fast negative: it takes a series of positive experiences to develop trust, but trust can be destroyed by a single betrayal. A consumer's trust in supplier b after the n-th experience is updated as:

$$
\begin{aligned}
t_b(n) &= t_b(n-1) + u^+(1 - t_b(n-1)) && \text{if } n^{\text{th}} \text{experience is positive,} \\
t_b(n) &= t_b(n-1) - u^- t_b(n-1) && \text{if } n^{\text{th}} \text{experience is negative,} \\
t_b(n) &= t_b(n-1) && \text{if } n^{\text{th}} \text{experience is neither positive} \\
&&& \text{nor negative,} \quad (11)
\end{aligned}
$$

with $0 < u^+ < u^- < 1$, where $t_b = 1$ represents complete trust and $t_b = 0$ represents complete distrust; a successful negotiation counts as a positive experience; a tracing report revealing deceit counts as negative; all other experiences are considered neither negative nor positive with respect to trust.

A supplier's belief about a customer's benevolence is updated by the same mechanism. A successful negotiation counts as a positive experience. Tracing counts as a negative experience for a supplier, whether it reveals deceit or not. An additional effect of revealed deceit on the supplier's part is that supplier's current honesty $H(n)$ (a personal trait, representing the inclination to deliver truthfully) is reinforced to 1, representing maximal honesty. H will subsequently decay to a base value H_{min} on each interaction, whether it is successful or not, with a decay factor φ.

$$
H(n) = H_{min} + \varphi(H(n-1) - H_{min}), \quad \text{with } 0 < H_{min} < 1 \quad \text{and} \quad 0 < \varphi < 1.
\tag{12}
$$

Trust developed according to Eq. 11 represents an internal state of mind, a belief about a partner. It can be seen as a subjective probability that a partner will not defect even if motive and opportunity are present. According to Castelfranchi and Falcone (1998) trust exists as a state of mind, as a decision, and as a social behavior. Because of the repercussions distrust may have as a social behavior, the decision to trust does not necessarily correspond to trust as a state of mind. The inclination to trust depends on cultural factors. The decision to trust or to trace is modeled in the simulation as a Bernoulli variable, with

$$
p(\text{trace}) = T',
\tag{13}
$$

$$
p(\text{trace}) = 1 - T',
\tag{14}
$$

where the culturally adapted inclination to trace T' is computed by applying Eq. 2 on the base value of $T = q(1-c)(1-t_b)$, using Table 10. Table 10 (at the end of this chapter) summarizes culture's effects on the variables related to trust, deceit, and tracing.

6 Simulation Examples

This section presents some simulation results. The first example confirms that the model is sensitive to culture and offers face validation at extreme values of Hofstede's indices. The second example illustrates that model outputs are more sensitive to common group membership for agents configured with Japanese settings than for USA settings. Then, sensitivity analysis results are presented to confirm that in different cultures, different rules for agent behavior are relevant. The last example validates the feasibility of the model as a research instrument to be used in combination with gaming simulation, aiming to improve models of agent behavior. It uses results of games played in the Netherlands and the USA.

The simulation results should not be interpreted as to give exact quantitative values. The results illustrate stylized facts, such as "common group membership is more relevant in Japan than it is in the USA".

Table 6 presents aggregated outputs of games simulated in an environment where the agents can select a trade partner, negotiate, deceive or deliver truthfully, and update their beliefs. The results show that the ease with which agents reach an agreement, the frequency of negotiation failure, and the quality level depend on culture in a believable way. Table 7 displays the parameter values used.

Much of the literature on cultural difference focuses on individualism versus collectivism and the associated phenomena such as direct versus indirect communication styles. Common group membership determines social relations in

Table 6 Average results of simulated negotiations for cultural stereotypes, with the value for the particular dimension set to either 0.1 or 0.9 and the values for the other dimensions set to 0.5

Culture type	Conditions	Number of transactions	% Failed negotiations	% Top quality
Large power distance	All high status	44	57	97
	All low status	50	60	0
	Customer higher	77	45	98
	Supplier higher	4	92	0
Small power distance		72	49	2
Uncertainty avoiding	Similar partners	29	71	76
	Different partners	27	73	87
Uncertainty tolerant		49	58	1
Individualistic		66	50	1
Collectivistic	In-group partners	117	13	61
	Out-group partners	39	65	0
Masculine		36	71	80
Feminine		61	45	0
Long-term oriented		55	52	0
Short-term oriented	Equal status	24	72	95
	Diverse status	57	47	91

Data source: Hofstede et al. (2010a)

8 suppliers; 8 customers; 10 runs of 200 time steps for each configuration; parameter values as in Table 7

Table 7 Parameter values used in the simulation runs

Type of value	w_q'	w_r'	χ	η	ω	ι
Default value	0.1	0.1	0.7	0.2	0.02	0.3
Maximal value	0.5	0.5	1	0.5	0.1	1.0
Minimal value	0	0	0	0	0	0.1

w_q' quality preference, w_r' risk aversion, χ concession factor, η negotiation speed, ω acceptable utility gap, ι impatience
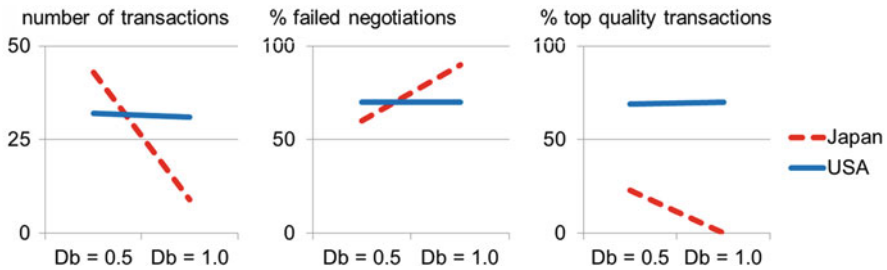

Fig. 1 Simulation results with different settings of group distance between suppliers and customers (Data source: Hofstede et al., 2010a)
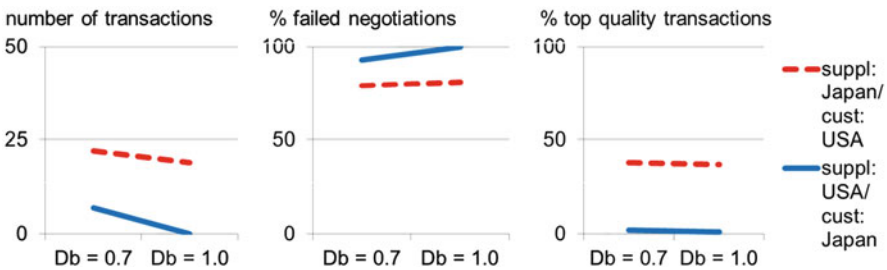

Fig. 2 Simulation results with different settings of group distance between Japanese suppliers and USA customers vice versa (Data source: Hofstede et al., 2010a)

collectivistic societies. Group membership is known to be very relevant in Japan (e.g., Hall, 1976). The cultures of Japan and the USA differ considerably on individualism versus collectivism, but also on other indices (Hofstede, 2001):

– Japan: $PDI^* = 0.54$, $IDV^* = 0.46$, $MAS^* = 0.95$, $UAI^* = 0.92$, $LTO^* = 0.80$;
– USA: $PDI^* = 0.40$, $IDV^* = 0.91$, $MAS^* = 0.62$, $UAI^* = 0.46$, $LTO^* = 0.29$.

It is interesting to see if the influence of group membership emerges in simulations, in spite of the differences on other dimensions. Figure 1 presents simulation results for Japan and USA, with parameter settings as in Table 7. For the "Japanese" agents, group membership considerably influences the success of negotiations and the trust required for trading high quality products.

Trade may run less smoothly between different cultures. Figure 2 presents simulated results of trade between Japanese and USA agents. The results show that for USA traders in Japan it pays to invest in personal relations in order to reduce

group distance. Overcoming distrust is hard for USA traders acting as suppliers to Japanese agents. This phenomenon is not associated with the difference on the IDV index, but with UAI and LTO.

The example of Japanese versus USA traders indicates that the salience of parameters may be different across cultures, in combination with trade roles. Burgers et al. (2010) present results of Monte Carlo based sensitivity analyses for the model proposed in the present chapter. Different outputs (e.g., number of transactions, number of certificates) are sensitive to different parameters. Table 8 displays contributions to variance of the number of transactions in a game. The table presents a mean value and shows that considerable differences between countries prevail. It should be noted that the values presented in Table 8 have no actual meaning for simulations results, but they indicate that it depends on culture which parameters should be given most attention to calibrate the model.

The remaining part of this section presents an example of a tour through the research cycle where a model based on theory is implemented in the multi-agent simulation, multi-agent simulation data is validated against gaming simulation observations, validation fails, theory and the model are adapted, the multi-agent simulation is adapted, and new simulation outputs are validated against the observations and are found to support the adapted theory. The example supports the validity of the multi-agent simulation as a research instrument in combination with gaming simulation. The example has been reported by Hofstede et al. (2010b).

The following hypotheses, to be tested against simulation results, can be formulated from observations in the TRUST & TRACING game (Meijer, 2009).

1. Average quality of products traded in games played in the USA is higher than in the Netherlands.
2. Certification ratio (i.e., the fraction of high quality transactions where a certificate was negotiated) is higher in the USA than in the Netherlands.
3. Defection ratio (i.e., the frequency of deceit in uncertified high quality deliveries) is higher in the USA than in the Netherlands.
4. Tracing ratio (i.e., the fraction of uncertified high quality deliveries for which a trace is requested after delivery) is higher in the USA than in the Netherlands.

To test these hypotheses, 310 simulations were run, with cultural indices for the USA and the Netherlands taken from Hofstede (2001):

– Netherlands: $PDI^* = 0.38$, $IDV^* = 0.80$, $MAS^* = 0.14$, $UAI^* = 0.53$, $LTO^* = 0.44$;
– USA: $PDI^* = 0.40$, $IDV^* = 0.91$, $MAS^* = 0.62$, $UAI^* = 0.46$, $LTO^* = 0.29$.

The other agent parameters are randomly generated for each run pair.

Analysis of the results confirmed hypotheses 1, 3, and 4, but did not confirm hypothesis 2. The certification ratio as defined in hypothesis 2 was approximately equal for the USA and The Netherlands. In these simulations the negotiation model reported in Hofstede et al. (2010a) is applied. According to that model, customers do not take a differentiation of certification cost between themselves and suppliers into account. This difference was found to be an important factor

Table 8 Mean top marginal variance values (of 62 countries) and data for the countries that have the maximum TMV score for a parameter

National culture	Group distance	Mean status	Initial trust	Partner pref.	Conces. factor	Negot. speed	Quality pref.	Risk avoid
Mean (n = 62)	4.1	1.0	3.4	1.8	24.8	30.2	0.5	1.6
Indonesia	16.9	0.1	0.2	0.0	11.6	40.9	0.0	0.0
Morocco	0.7	8.7	3.3	4.7	17.5	37.9	0.0	0.0
Hungary	0.0	0.0	11.5	1.9	37.6	1.4	2.4	11.5
Uruguay	4.9	1.7	8.5	5.5	23.4	24.1	0.0	0.0
Netherlands	0.7	0.0	1.6	0.3	46.2	28.8	0.0	2.1
Iran	1.3	3.1	0.9	0.4	10.3	56.2	0.6	0.0
Austria	0.0	0.0	3.8	2.6	27.1	11.5	4.8	6.9
Japan	0.5	0.0	8.3	1.6	30.8	0.9	0.1	15.8

Source: Burgers et al. (2010)

Table 9 Test data for 310 run pairs for USA and NL

Average of 310 runs	USA	NL	Test stat.[a]	Sample[a]	Probability[a]
Number of transactions	72	61	219	302	< 0.001
Quality ratio	0.37	0.15	277	285	< 0.001
Certification ratio	0.48	0.41	191	281	< 0.001
Defection ratio	0.25	0.13	128	154	< 0.001
Tracing ratio	0.40	0.07	169	177	< 0.001

Source: Hofstede et al. (2010b)
[a]Test statistic, effective sample size, and two-sided probability level for Sign test

in the gaming simulations in the USA. The negotiation model was modified to take tracing fee differences and probability to trace into account. The original equation for customers' risk in an uncertified deal is:

$$r_{customer} = (1 - c)(1 - t_b)q. \tag{15}$$

The modified equation is

$$r_{customer} = (1 - c)(1 - t_b)q + T'\phi_{customer}, \tag{16}$$

with $\phi_{customer}$ representing customers' tracing fee.

The simulation was repeated after replacing Eq. 15 with Eq. 16 and setting the tracing fee equal to 0.2 for suppliers and 0.3 for customers. Table 9 summarizes the results. The simulation results confirm hypotheses 1 through 4. Differences are found to be significant for all variables, with p < 0.001 according to the Sign test. This example illustrates how the combination of multi-agent simulation and gaming simulation can improve models of culturally differentiated agent behavior.

7   Conclusion

De Rosis, Pelachaud, & Poggi (2004) suggested to apply Hofstede's theory to build culturally consistent agent characters. The research presented in this chapter shows how this can be done. It shows that rules for cultural differentiation of universal models of aspects of human behavior can be formulated, following an expert systems knowledge acquisition approach. Working on a dimension-by-dimension basis reduces the complexity to a level where a domain expert can specify the rules and verify the results. Doing this for more dimensions simultaneously is too complex for an expert. Furthermore, this chapter proposes an approach to integrate the rules for individual dimensions into a joint effect, resulting in believable cultural differentiation of agent behavior. This approach has been applied to three domains in trade: partner selection, negotiation, and the interaction between trust and deceit. The resulting agent models have been applied in a multi-agent simulation.

A meta-modeling approach for sensitivity analysis of the simulation model has been developed (Burgers et al., 2010). Sensitivity analysis indicates that the outcomes and sensitivity for parameters in the universal models strongly depend on the cultural settings. It is found to be necessary to perform sensitivity analysis to statistics at the aggregated level as well to statistics of individual agent performance. However, the method for sensitivity analysis at the individual level needs further development (Burgers et al.).

Face validity of the results for the extreme cultural situations – called "Synthetic Cultures" by Hofstede and Pedersen (1999) – indicates that the approach proposed in the present chapter is feasible for the development of agents which can be used for training purposes and educational simulations. Application of this model in, for instance, affective agents as it has been suggested by De Rosis et al. (2004) would require further validation.

A model as described in this chapter is what Gilbert (2008) has called a middle range model. Gilbert asserts that the generic nature of such a model means that it is not possible to compare its behavior with any observable instance in the real world. Having found some instance where the model reproduces stylized facts that resemble real world or gaming observations, cannot serve as a general validation and does not guarantee the correctness of predictions made for other cultural situations. Validation of this type of model is an ongoing process. Confidence that the model can predict the effects of culture in new situations grows according to the number of cases where its outputs correspond with those of gaming simulations or other data.

The pragmatic validation of the model – for its use in combination with gaming simulation as a research tool for the social sciences – is also an ongoing process. The example given in the preceding section of this chapter supports the usability of the model for hypothesis testing and positively answers the research question "Can such a model be applied to fulfill its function as a social sciences research instrument in combination with simulation gaming?". In cases where the model does not correspond with data from games or other sources, these results can be used to improve the model and support the advancement of science.

Culture research is an ongoing process as well. The first version of Hofstede's model was defined in four dimensions. The dimension of long-term versus short-term orientation was discovered in a separate research program carried out in China, with questions devised by people with Asian mindsets. Hofstede's model has recently been extended with the dimension of "*Indulgence versus Restraint*" found by Minkov (2007) using World Value Survey data, and included in Hofstede et al. (2010). To include this new dimension into the agent model would require the acquisition and formalization of expert knowledge, as it has been performed for the other dimensions, eventually resulting in the representation of extra cultural factors and their effects in Table 10 (appendix).

Extensions of the width of modeled behavior are also to be considered, and might increase the simulation's validity. For instance, an important component not included in the present work but possibly very influential in real trade networks is contagion of behavior through imitation and social learning by means of a reputation mechanism.

Appendix

Table 10 Increasing (+) and decreasing (−) effects of relevant cultural factors per decision function variable

Dimension index	Culture and relational characteristics	Cultural factor[a]	Partner selection				Negotiation						Deceit and trust			
			β	γ	J_b	A_b	w_q	w_r	η	χ	ω	ι	d_b	T	$u-$	$u+$
PDI	Large power distance	PDI^*														−
	Self status high	$PDI^* s_a$					+									
	Self status low	$PDI^*(1-s_a)$					−									
	With higher ranked partner	max{0,$PDI^*(s_b-s_a)$}			−	+	+	+	+		+	−	+	−		
	With lower ranked partner	max{0,$PDI^*(s_a-s_b)$}			−			−						−	−	
UAI	Uncertainty avoiding	UAI^*		−			+			+	+	+			+	
	With stranger	$UAI^* \cdot D_b$						+					−	+		
	Uncertainty tolerant	$1-UAI^*$	−													
IDV	Individualistic	IDV^*														
	With trusted partner	$IDV^* t_b$			+											
	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)	$1-MAS^*$		+			−			−		−	−	−		
	With trusted partner	$(1-MAS^*)t_b$			+											
LTO	Long-term oriented	LTO^*	+				−	−					+	−	+	
	With trusted partner	$LTO^* t_b$			+											
	Short-term oriented	$(1-LTO^*)$					+									
	With well-respected partners	$(1-LTO^*)s_b$			+				+				+			
	With other partners	$(1-LTO^*)(1-s_b)$											−			

Hofstede et al. (2009b, 2010a, 2010b)

[a]PDI^*, UAI^*, IDV^*, MAS^*, and LTO^* represent Hofstede's indices; s_a the agent's status, s_b partner's status, D_b group distance, t_b trust; all in [0,1]

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