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# Modeling Culture in Trade: Uncertainty Avoidance*

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**Abstract**

A model is presented of the way that our cultural attitude towards the unknown influences the decisions we make in trade. Uncertainty avoidance is one of Hofstede's five cultural dimensions. The paper presents a model of how this dimension affects trade. This influence has been explicated for the decisions regarding trade: partner selection, negotiation behavior, trust, and the interpretation of the trade partner's behavior. It has been verified in simulations showing that the generic tendencies as attributed to uncertainty avoidance are reflected in the simulation results. Our approach is an example of instantiating generic knowledge on the influences of culture on decision-making in general.

## 1. INTRODUCTION

The international food economy is rapidly changing. Important issues are concentration and globalization, growing information intensity, consumer demands, and social responsibility [Kinsey 2001]. An important issue in current food trade research is the emergence and performance of international supply chain networks [Lazzarini et al. 2001]. Agent-based modeling extends the understanding of processes in society and economy. It enables simulation of the emergence of macro-level phenomena from micro-level interactions between individual agents [Tesfatsion and Judd 2006]. It is therefore well-suited for modeling the emergence and performance of supply chains under different institutional and social arrangements.

Differences between national cultures are well-known to have their effect on trade at the micro-level: cultural differences hinder international business contacts - e.g., [Trompenaars 1993]. Relevant processes at the micro-level with respect to chain networks are strategy determination, trade partner selection, negotiation, delivery, and monitoring. The influence of culture on these processes and on trust as an enabler has been the subject of research. In particular negotiation had much research attention - e.g., [Gelfand and Brett 2004] - and the attention for trust, in particular in relation to the food economy, is growing - e.g., [Fritz et al. 2006]. [Gorobets and Nooteboom 2006] give evidence by means of a multi-agent simulation that different economic systems (trust versus opportunism) may be efficient in different societies. Other economic literature stresses the relevance of culture for international trade, but models it at the macro-level - e.g., [Bala and Long 2005] and [Kónya 2006]. Given that cultural differences exist and that they are recognized as relevant, realistic agent-based modeling of international trade requires culturally differentiated agent behavior.

This paper introduces an exercise in modeling of culture based on the work of [Hofstede 2001]. The context is a gaming simulation of trade in commodities with invisible quality properties [Meijer et al. 2006]. That game is designed as a research tool for study of human behavior with respect to trust in commodity supply chains and networks in different institutional and cultural settings. The work reported in this paper is a step toward modeling of cultural aspects of behavior in trade, that may eventually be validated in this or other games. It reports a multi-agent modeling step in the research cycle described in [Jonker et al. 2006]. Figure 1 schematically depicts this cycle.

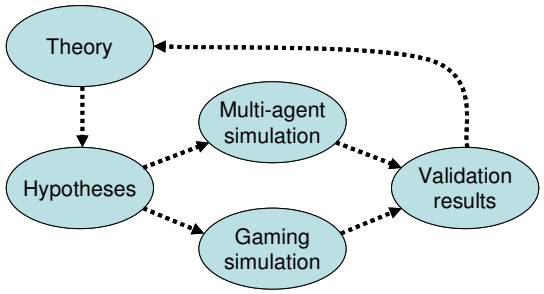


**Figure 1.** Research cycle, schematically after [Jonker et al. 2006].

Hofstede recognized five dimensions of culture. The present paper focuses on the dimension of uncertainty avoidance. The other dimensions are dealt with in other publications - e.g., [Hofstede et al. 2006]. Isolating a single dimension and analyzing it separately from the other dimensions is artificial, but it brings the opportunity to verify the partial

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model and validate it against specifically designed gaming simulations. In future work, integrating all the dimensions should lead to more realistic agents; this paper represents an intermediate step.

The paper is structured as follows. Section 2 introduces culture and the uncertainty avoidance dimension. Section 3 elaborates on the dimension of uncertainty avoidance in trade processes. Section 4 models the dimension of uncertainty avoidance for application in agents. Section 5 presents some experimental results. Section 6 concludes the paper and discusses future research.

## 2. CULTURE AND UNCERTAINTY AVOIDANCE

People live in groups. Any one person is a member of several groups, e.g. nuclear family, extended family, village, region, club, political organization, religion, country, company. The existence of a group implies that there is an outer boundary. Some cultures like to draw strict, solid boundaries between the various group identities that exist, while in others, group boundaries are not a big issue. Why this is so, is a matter of speculation. From an evolutionary point of view, human beings are in a state between a purely solitary life and one as a perfect group – between a bear's lair and a bee hive. This implies that in almost all human social interactions, the question "are we part of the same group?" is relevant. The practical implications are that more trust is placed in members of the same group. It is evolutionarily natural for people to collaborate with group members against other groups. At the same time we are more or less flexible in our group memberships. The details are dependent on group culture. [Hofstede 2001] identified five major issues that a society has to resolve in order to function as a group: issues of (1) individual freedom versus group loyalty, (2) division of power, (3) aggression and permissiveness against offenders, (4) gratification of needs, and (5) the unpredictable. This last issue will be examined in the present paper, artificially tearing it apart from social life as a whole.

The world is an unpredictable place, and people are aware of this. This knowledge is stressful, but not equally much to all people, nor to all societies. Individual people who cannot cope with unpredictability are likely to score high on neuroticism tests. Cultures that practice strong rituals and beliefs to cope with unpredictability are called uncertainty avoiding. [Hofstede 2001, p. 161] defines this 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 computable risk. It is about fear of situations in which "anything can happen and one has no idea what" [ibid., p. 148]. Hofstede goes on to explain

> "*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.*"

People from societies or groups that are highly uncertainty avoiding do not tolerate ambiguity as to who is a member of their group. In case of doubt they have a tendency to close the ranks and shut strangers out. 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 who speak their language, people of their gender, or similar clear-cut criteria. People from such societies will not easily engage in interactions with others who do not share their most salient group characteristics. It follows that trade will often be a within-group activity, and contacts with alien groups are not easily made. Within-group contacts, on the contrary, are charged with tokens of loyalty, often through intricately prescribed shared ritual that is needed to counteract the stress that people experience. The average person in such a society is more neurotic, and less agreeable, than in an uncertainty tolerant culture [Hofstede and McCrae 2004]. According to [Hofstede and Hofstede 2005] countries high on uncertainty avoiding are: Central and Latin Europe, Latin America, Japan, South Korea, Russia, Middle East, and Pakistan. On the other hand, societies or groups that are uncertainty tolerant are easy travelers, and will engage in novel activities without needing much time to adjust. They will strike up trade relations with foreigners if the opportunity presents itself. Their social interactions tend to be laid-back. Countries with this orientation are China and Southeast Asia, Scandinavia, Anglo countries and India.

The origin of differences on this dimension is not clear. Presumably, uncertainty avoiding societies have occurred where evolution favored conservatism and closed social networks, and uncertainty tolerant societies have occurred where evolution rewarded exploration and mixing. Societies with an old tradition of agriculture are frequently uncertainty avoiding and those that involve fishing or trading are uncertainty tolerant; but there are exceptions. Current pressures of globalization may change the situation; yet evidence for the moment does not indicate that worldwide differences in uncertainty avoidance have been changing over the last decades. Thus, in discussing trade behaviors, uncertainty avoidance can be considered a causal factor. Pairs of countries that differ much on this dimension of culture and less on others, where the first is the more uncertainty avoiding, are Japan-China, Germany-Great Britain, South Korea-Singapore, Italy-Ireland, Finland - Denmark. Table 1 displays some distinctions that characterize the difference between uncertainty avoiding and uncertainty tolerant societies.

**Table 1.** Some distinctions - relevant for trade - between norms in uncertainty avoiding and uncertainty tolerant societies)

| Uncertainty tolerant | Uncertainty avoiding | |
|---|---|---|
| Being busy is not a value per se | Inner urge to be busy | (1) |
| Suppression of emotions | Expression of emotions | (2) |
| Openness to change and innovation | Conservatism, law and order | (3) |
| Willingness to take unknown risks | Only known risks are taken | (4) |
| What is different is curious | What is different is dangerous | (5) |
| Tolerance of diversity | Xenophobia | (6) |
| Comfortable with ambiguity and chaos | Need for clarity and structure | (7) |
| Appeal of novelty and convenience | Appeal of purity | (8) |

source: [Hofstede 2001, p. 161]

## 3. UNCERTAINTY AVOIDANCE IN TRADE

The core of trade is the execution of transactions: exchange of commodities or rights for money. Transactions are based on a contract that may specify additional conditions, to enforce delivery according to the contract. From the perspective taken in this paper, contracting is not the only relevant activity of trading agents. Figure 2 presents a process model of trading agents.

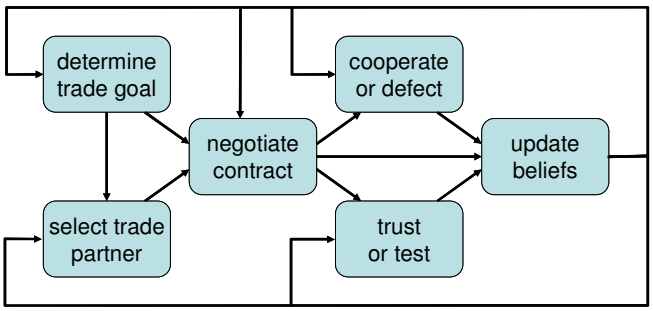


**Figure 2.** Processes and internal information flow of trading agents

Before entering negotiations, agents have to select each other as partners to negotiate with, based on their trade goals (sell or buy?; which commodity?; which quality?; what risk is acceptable?) and knowledge about potential partners. This information also plays an important role during the negotiation process. Once a contract has been agreed upon, the traders have to deliver. In this phase of the transaction they can either cooperate (deliver according to the contract) or defect, deliberately or as a flaw of their control system. Traders may either trust their partner to deliver truthfully or monitor the delivery (put it to the test). The latter usually incurs some cost, while trust is for free. The decisions about cooperation and trust are based on personal preferences and cultural background, as well as beliefs about the trade partner and the trade environment. Delivery and monitoring and the decisions about cooperation and trust are relevant for both sellers and buyers. However, the research reported in the present paper models trade in the Trust And Tracing game [Meijer et al. 2006]. In this context the cooperation decision is relevant for agents in the selling role and the trust decision is relevant for agents in the buying role.

Experience from the negotiation and delivery processes may change a trader's beliefs about the trade environment or about individual trade partners. The beliefs will, in addition to a trader's preferences, guide decision making in future trading. In the present paper we limit ourselves to beliefs about trade partners. For the purpose of modeling trade processes three traits about partners can be defined that trading agents maintain a belief about:

- the belief about another agent's *fairness*

represents an agent's expectation that a fair contract can be negotiated in a fair way with the other agent;

- the belief about another agent's *trustworthiness*

represents an agent's expectation that the other agent will deliver according to contract;

- the belief about another agent's *benevolence*

represents an agent's expectation that the other will accept deliveries without putting them to the test, in other words that the other agent will trust. (Note that what the authors call benevolence may in other cultures be seen as credulity.)

The effect that uncertainty avoidance has on these beliefs, and on the decision making in trade processes, is also influenced by the agent's cultural background with respect to the other dimensions. This mutual influence is not taken into account for the moment.

Based on the works of [Hofstede 2001, 2005] and preliminary observations in the Trust And Tracing game [Meijer et al. 2006] hypothetical differences in behavior can be formulated for traders from different cultures. The following paragraphs describe expected differences across the uncertainty avoidance dimension. The descriptions are used in the next section to specify rules for agent behavior.

**Negotiation behavior.** The first bid of an uncertainty avoiding trader tends to be modest in the sense that it is a price he thinks is right. The uncertainty avoiding have an emotional style of negotiation, making sure that the opponents understand their feelings (see row 2 in table 1). They will not adapt their behavior to their opponent's. In the bargaining that follows they will not easily give in nor will much time be spent. After a few unsuccessful iterations, the uncertainty avoiding trader will break off the negotiation.

The uncertainty tolerant traders on the other hand have a relaxed style of negotiation. They try to adapt their behavior to their counterparty's, although they are not prepared to come to an agreement at all cost. They do not show their emotions and may be disconcerted if their opponents do. They are careful not be more yielding than

their counterparts are, not especially modest, and are ready to break off negotiations in case of insufficient progress.

**Trade goal selection.** In uncertainty avoiding societies the main concern of traders is not to be deceived. They are willing to pay a price for certainty. Although they prefer valuable high quality commodities, they will opt for cheaper low quality rather than valuable high quality if they do not feel certain about the high quality. Traders with a cultural background of uncertainty tolerance opportunistically trade both low and high quality products and have a neutral risk attitude. They prefer high quality, but only if the price is right, and they are not adverse of trading low quality if it brings them a profit.

**Maintenance of beliefs about partners.** In uncertainty avoiding societies the traders need some external justification (group membership or reputation) for doing business with new partners. The new partners will not be trusted. However, a low estimate of trustworthiness does not hinder a transaction. If the uncertainty avoiding know what to expect, they arm themselves and enter only into contracts with sufficient securities. Once, in the course of repeated transactions, sufficient evidence for trustworthiness has been found through tracing of deliveries, and partners have become familiar, the uncertainty avoiding will come to trust their partners and expect them to follow the rules like they do themselves. After they have come to trust, any unexpected revelation of deceit provokes furious reactions from uncertainty avoiding traders. They will not easily deal again with a partner that abused their trust. Like for uncertainty avoiding, uncertainty tolerant traders increase the partner's future acceptability if negotiations result in an agreement, and decrease it if negotiations fail. Uncertainty tolerant traders are not particularly distrusting, and trust will develop through repeated transactions. They will trace now and then, with decreasing frequency as trust develops. Revealed deceit will of course reduce trust and increase the frequency of tracing.

**Truthful or untruthful delivery.** After an agreement has been reached, it comes to delivery. If the quality of the commodity is invisible at first sight, the supplier can be opportunistic and try to deliver a lower quality product than agreed upon, thus making an extra profit. An uncertainty tolerant trader may be tempted to do so, calculating the risk of being exposed as a deceiver and the damage that would do to his reputation and future trading opportunities. An uncertainty avoiding trader may have a lot of rules and contracts that forbid defecting, but that does not mean that he will follow the rules. Depending on the other dimensions of culture, traders from uncertainty avoiding cultures may just as easily or even more defect than uncertainty tolerant, especially when dealing with out-group partners.

**Trust or distrust.** An uncertainty avoiding trader does not expect the rules to be broken and will trust, unless he is dealing with a stranger. A new partner will be distrusted until sufficient evidence for the contrary has been found. In uncertainty tolerant societies, the other dimensions of culture determine the level of trust. The rules and contracts do not have a value per se for the uncertainty tolerant.

**Partner selection.** In both uncertainty avoiding and uncertainty tolerant societies, traders prefer to deal with familiar relations, because that brings the experience gathered in previous transactions to value. However, in uncertainty tolerant societies traders will not hesitate to propose or enter negotiations with strangers, if for some reason dealing with familiar relations is inconvenient. Uncertainty avoiding traders on the other hand have a high threshold for entering into new relations. They feel uncomfortable proposing to parties they did not deal with before. For acceptance of new partners, they need an external justification, for instance based on group membership or a good reputation. In addition, they prefer to deal with counterparts having equal status (and profession if applicable).

## 4. REPRESENTATION IN AGENTS

This section defines production rules that formalize the knowledge about the influence of uncertainty avoidance on trade processes. The rules are formulated for one-to-one verification of the agents in DESIRE [Brazier et al. 2002]. The simulation applies many more rules, but because of space limitations we only present the rules that involve the uncertainty avoidance index of culture.

The relevant attributes of transactions are the economic value of the transaction, the quality of the traded goods as a status attribute in its own ("we deal in superior quality products") and a perceived risk that the trade partner will not fulfill its contractual obligations. The latter is based on trust, contractual conditions, and other attributes of the transaction, including product quality: higher valued products like organic food, designer clothes, and jewelry are a more likely target for swindle and counterfeiting than lower valued products.

The negotiation model for both traders, i.e. buyer and seller, uses a utility function to compare bids. [1]

$$U_{\text{bid}} = w_1 f_1(\text{value}) + w_2 f_2(\text{quality}) + w_3 f_3(\text{risk}) \qquad \textbf{(1)}$$

with $w_1+w_2+w_3=1$, and $w_i$ in [0, 1], for all $i$. $f_1$ presents normalized economic value of the bid in the interval [0, 1]; it is more or less objective in terms of cost and market value, but is calculated differently for buyers and sellers: e.g., a high price for low quality has a high value for sellers, but a low value for buyers. $f_2$ presents normalized additional

[1] In the context of the current research, we apply equation (1). If for some reason another utility evaluation function were used, the knowledge presented in this section would remain valid, but some rules might need to be reformulated.

value in [0, 1] that is attached in society to trading high quality; it is subjective and its value may differ according to personal preferences and cultural background. $f_3$ evaluates the risk of swindle normalized in [0, 1], with 1 representing a transaction without any risk; for a buyer it is based on the opportunity for the seller to deceive and the buyer's belief about seller's trustworthiness; for a seller it is based on opportunity and belief about the buyer's benevolence.

Weight factors <$w_1$, $w_2$, $w_3$> characterize an agent's strategy, e.g., <*high*, *high*, *low*> represent an *opportunistic* trade strategy, <*low*, *high*, *high*> a *quality-minded* strategy, and <*high*, *low*, *high*> represent a *thrifty* strategy.

Traders in uncertainty avoiding cultures strongly prefer a quality-minded strategy, while traders in uncertainty tolerant societies tend to follow an opportunistic strategy (see rows 4, 7, and 8 in table 1). Uncertainty avoiding agents have an increased risk aversion for "strangers". In our simulation we use labels to distinguish groups of agents and societal status. The following rule uses these variables as indicators of similarity of agents. Let the relation `agent_trait_value: ISSUE × Real`, stand for the natural inclination of the agent to weigh an issue. Then the effect of uncertainty avoidance and agent labels of both negotiation partners can be implemented as follows.

```
/* 1 calculate w-factors using UAI and group and status labels*/
if cultural_script_contains(uncertainty_avoidance_index(U: Real))
   and agent_label(status, S: Real)
   and agent_label(group, G: Group_label)
   and partner_model_contains_belief(T: Trader, status, Y: Real)
   and partner_model_contains_belief(T, group, L: Group_label)
   and group_distance (G, L, D: Real)
   and agent_trait_value(value_preference, P: Real)
   and agent_trait_value(quality_preference, Q: Real)
   and agent_trait_value(risk_aversion, R: Real)
   and N: Real = (P + Q + R+(1-R)*U*(1+max(D,abs(S-Y)))/2 )
then weight_for_value_toward( T, P / N )
   and weight_for_quality_toward( T, Q / N )
   and weight_for_risk_toward(T,
      (R+(1-R)*U*(1+max(D,abs(S-Y)))/2) / N );
```

Traits, status, and uncertainty avoidance index are real numbers in [0, 1]; N is the sum of the the weight factors $w_i$ before normalization. The divisions by N normalize the sum of the weight factors to 1.

Agents use the utility function to decide whether to accept or to refuse a bid, and, in the latter case, whether to break off the negotiation or to make a counteroffer. The simulated negotiation process applies the negotiation architecture of {Jonker and Treur 2001]. Parameters in this approach are *utility gap*, *impatience*, *concession factor*, and *negotiation speed.* Furthermore the algorithm uses a *cut-off value* and a *minimal progress value* as criteria to break off negotiations. All parameters are implemented as agent traits, i.e. they are represented in real values in the interval [0, 1]. Some are influenced by the value of the uncertainty avoidance index. Realistic base values of the parameters were established in human experiments [Bosse 2004].

Agents accept offers if the difference of their own bid's utility and partner's bid utility is less than the *utility gap*, realistically valued 0.02 according to human experiments.

If an agent does not accept an offer, it has to decide whether to stop the negotiation or to make a counteroffer. The simulated agents use a random generator for this decision. The following rules - involving *impatience*, *cut-off value*, and *minimal progress value* – express that impatient agents (impatience is an agent trait) and agents from uncertainty avoiding cultures are more likely to stop (rows 1 and 2 in table 1). In these rules a uniform random variable *Z* in [0, 1] is used. The probability of stopping if the other conditions in rules 2 and 3 hold is equal to the maximum of the cultural uncertainty avoidance index and the impatience as a personality trait.

```
/* 2 rather stop if impatient or UA and cut-off value is not met */
if cultural_script_contains(uncertainty_avoidance_index(U: Real))
   and current_negotiation(T: Trader, X: Integer, L: Commodity_list)
   and agent_trait_value(cut_off_value, C: Real)
   and agent_trait_value(impatience, I: Real)
   and current_round(X)
   and others_bid_utility_in_round(B: Real, X)
   and B < C
   and random(0, 1, Z: Real)
   and max(I, U) > Z
then stop_negotiation(T, X, L, gap);

/* 3 rather stop if impatient or UA and partner makes little progress */
if cultural_script_contains(uncertainty_avoidance_index(U: Real))
   and current_negotiation(T: Trader, X: Integer, L: Commodity_list)
   and agent_trait_value(minimal_progress, M: Real)
   and agent_trait_value(impatience, I: Real)
   and current_round(X)
   and X > 3
   and progress_in_bids(X-3, X, P: Real)
   and P < M
   and random(0, 1, Z: Real)
   and max(I, U) > Z
then stop_negotiation(T, X, L, no-accom);
```

If an agent does not stop following rules 2 and 3, it tries and makes a counteroffer. In the process of preparing a counteroffer the agent may still stop if no room for further concessions can be found, taking the minimum utility into account. The minimum utility is related with the opening bid through the *concession factor* $\gamma$: $U_{\text{minimum}}=(1-\gamma)U_{\text{opening\_bid}}$. We assume that $U_{\text{minimum}}$ is not significantly different across the cultural dimension of uncertainty avoidance, but that agents in uncertainty avoiding cultures are more modest in their opening bid and have a lower concession factor (rows 3 and 7). They also have a lower *negotiation speed*, i.e. their relative concessions from their previous bid towards the minimum utility are smaller. As an example we present the rule for the maximal concession.

```
/* 4 uncertainty avoiding agents make smaller concessions */
if cultural_script_contains(uncertainty_avoidance_index(U: Real))
   and current_round(X: Integer)
   and my_bid_utility_in_round(B: Real, X-1)
   and agent_trait_value(minimum_utility, M: Real)
```

```
   and base_negotiation_speed (S: Real)
   and ua_negotiation_speed (V: real)
then maximal_concession_in_round (X, (B-M)*((1-U)*S+U*V) );
```

The agents stop the negotiation if the maximal concession is less than 0.01. In this rule and some other decision rules linearly weighted sums are used, with the uncertainty avoidance index as weight factor. Future validation of the models must decide if this simplification is justified.

After successful negotiations the supplier has to deliver the commodities. If the agreement was to deliver a high quality commodity, the supplier may deliver low quality, if the difference is invisible at first sight. Whether an agent actually defects or cooperates depends on many factors, including the quality of the relation with the customer and the estimate of the customer's benevolence. An uncertainty avoiding agent's has a lower threshold for defection of strangers than for similar partners (table 2, rows 5, 6, and 7).

```
/* 5 uncertainty avoiding have a low deceit threshold for strangers */
if cultural_script_contains(uncertainty_avoidance_index(U: Real))
   and agent_label(status, S: Real)
   and agent_label(group, G: Group_label)
   and current_partner(T: Trader)
   and partner_model_contains_belief(T, status, Y: Real)
   and partner_model_contains_belief(T, group, L: Group_label)
   and group_distance (G, L, D: Real)
   and agent_trait_value(honesty, H: Real)
then deceit_treshold_toward(T, H * (1-U*max(D,abs(S-Y)));
```

The deceit threshold is used in the rules for the decision whether to cooperate or to defect. The latter rules are not presented in this paper for space limitations. They do not differ across the dimension of uncertainty avoidance.

The customer has to decide whether to trust the delivery or put it to the test (trace it). The likelihood that a customer will rather test, depends on his trust in the partner, but an uncertainty avoiding customer will rather trace if he has little in common with the supplier (rows 4, 5, 6 in table 2).

```
/* 6 uncertainty avoiding agents do not trust strangers */
If cultural_script_contains(uncertainty_avoidance_index(U: Real))
   and deal_in_round (T: Trader, B: Bid, X: Integer)
   and current_round (X)
   and agent_label(status, S: Real)
   and agent_label(group, G: Group_label)
   and partner_model_contains_belief(T , trustworthiness, W: Real)
   and partner_model_contains_belief(T , status, Y: Real)
   and partner_model_contains_belief(T , group, L: Group_label)
   and group_distance (G, L, D: Real)
   and random(0, 1, Z: Real)
   and (1-U)*(1-W) + U*max(D,abs(S-Y),(1-W)) > Z
then to-be-traced(B);
```

Tracing results are a source for trust update. Trust update can be modeled as follows.

$$t_{C,x} = (1-\delta^{+})\, t_{C,x-1} + \delta^{+}\, e_{C,x} \text{ if } e_{C,x} \geq t_{C,x-1}$$
$$t_{C,x} = (1-\delta^{-})\, t_{C,x-1} + \delta^{-}\, e_{C,x} \text{ if } e_{C,x} < t_{C,x-1} \qquad \textbf{(2)}$$

with $\delta^{+}$ and $\delta^{-}$ in the interval [0,1]; $t_{C,x}$ represents trust in agent $C$ after round $x$; $e_{C,x}$ represents the experienced result with $C$ in round $x$. In this case the result of tracing $e_{C,x}$ is either 1 (partner cooperated) or 0 (partner defected). An uncertainty avoiding agent has a low value of $\delta^{+}$ and an high value of $\delta^{-}$ (table 2, rows 3 and 7), in particular if it has little in common with its trade partner (rows 5 and 6).

```
/* 7 trust comes slowly and vanishes rapidly in UA societies */
if cultural_script_contains(uncertainty_avoidance_index(U: Real))
   and agent_label(status, S: Real)
   and agent_label(group, G: Group_label)
   and partner_model_contains_belief(T: Trader, status, Y: Real)
   and partner_model_contains_belief(T , group, L: Group_label)
   and group_distance (G, L, D: Real)
   and agent_trait_value(base_neg_update_factor, N: Real)
   and agent_trait_value(base_pos_update_factor, P: Real)
   and max_ua_neg_update_factor(E: Real)
   and min_ua_pos_update_factor(F: Real)
then neg_update_factor_toward(T,
       N*(1-U)+E*U*(1+max(D, abs(S-Y))/2)
   and pos_update_factor_toward(T,
       P*(1-U)+F*U*(1+max(D, abs(S-Y))/2);
```

In this rule the UA-factors differ a factor of at least 3 with the base-factors.

Fairness, as defined in section 3, is used to select a future trade partner. Agents will rather select a partner they believe to be fairer than another partner. The belief about a partner's fairness is maintained similar to equation (2) after a negotiation has stopped. For a successful negotiation, the utility is taken as experience value; the experience value of an unsuccessful negotiation is 0. Uncertainty *tolerant* agents select their partners primarily on the basis of fairness. The following rule expresses that uncertainty *avoiding* agents have additional preferences for common group membership and common status (table 2, rows 5 and 6).

```
/* 8 uncertainty avoiding agents prefer similar partners */
if cultural_script_contains(uncertainty_avoidance_index(U: Real))
   and agent_label(status, S: Real)
   and agent_label(group, G: Group_label)
   and partner_model_contains_belief(T: Trader, fairness, F: Real)
   and partner_model_contains_belief(T , status, Y: Real)
   and partner_model_contains_belief(T , group, L: Group_label)
   and group_distance (G, L, D: Real)
then acceptability (T, F*(1-U*max(D,abs(S-Y))) );
```

## 5. EXPERIMENTAL RESULTS

In order to verify the correct formulation of the rules presented in section 4, one-to-one scenarios were simulated step by step. For reasons of space, the results are not included in this paper. Results are available from the authors. Subsequently, the behavior was implemented in a multi-agent model of a trade process, based on the gaming simulation in Meijer *et al.* (2006). In this simulation sellers and buyers can

- select each other for negotiation,
- exchange bids,

- deliver commodities, and
- send received commodities to a tracing agent for testing.

By tracing they incur a tracing fee. The tracing agent is authorized to punish deceivers by a fine.

The multi-agent simulation is implemented in Cormas (http://cormas.cirad.fr). Source code is not included in this paper, but is available from the authors. The Cormas simulation is synchronized in time steps. In the first step each buyer may send a bid to a seller of its choice. In each following time step each agent may:

- either wait for a reply to a bid it made,
- or stop the ongoing negotiation and propose a new one to any agent in the opposite role by sending it a bid,
- or reply to a received bid with a counter bid,
- or accept a bid and, in case it is selling, send a delivery,
- or receive a delivery and decide whether to forward it to the tracing agent or not.

In the last two cases it may subsequently propose a new negotiation by sending a bid to any agent in the opposite role. The agents cannot negotiate synchronously with more then one partner. They send no (if they wait for a reply) or one bid per time step.

Table 2 presents typical results of example runs for simulation runs of 100 time steps. The agents have a group label that is visible for other agents. The agents interpret other agents carrying a label different from their own as having maximal group distance. One label was attached to uncertainty tolerant agents (UAI=0.2), two different labels were attached to uncertainty avoiding agents (UAI=0.8). Both sellers and buyers either belonged to a single group of eight or were divided into two groups of four in which all group members have an equal group label and UAI. All agents have equal negotiation parameters and other initial settings.

Table 2 presents the total number of successful transactions. This number results from the combination of all processes. There may be variance because of the occasional selection of partners, the occurrence of defection that may lower trust in individual relations, and the failure of negotiations if agents lose their patience or do not sufficiently accommodate their partners.

If all agents are uncertainty tolerant and belong to a common group, trade goes smoother than if all agents are uncertainty avoiding and belong to a common group (compare run 1 and run 2). If uncertainty avoiding agents can find in-group partners, stratification occurs: the uncertainty avoiding agents exclude out-group traders (see runs 3 and 4). Trade stagnates if the uncertainty avoiding agents cannot deal with in-group partners, but it goes a bit smoother with uncertainty tolerant partners (run 6) than it does with uncertainty avoiding (run 5). The latter effect vanishes in the mixed settings like run 7, where uncertainty avoiding agents are holding up trade. They spend much time on negotiations that fail because of insufficient progress and impatience of the uncertainty tolerant agents. In run 8 one group of uncertainty avoiding agents (group 1) can find each other; as a result, group 2 and the uncertainty tolerant can speed up.

**Table 2.** Number of successful transactions between two groups of 4 sellers and two groups of 4 buyers, with different values of uncertainty avoidance index, in simulation runs where sellers and buyers can individually select each other for negotiation (*UT*: UAI = 0.2; *UA1*: UAI=0.8; *UA2*: UAI=0.8; group distances *UT-UA1*, *UA1-UA2*, and *UA2-UT* are all 1.0, so maximal)

| **run 1** | | buyer groups | |
|---|---|---|---|
| | | *UT* | *UT* |
| seller groups | *UT* | 13 | 25 |
| | *UT* | 18 | 25 |

| **run 2** | | buyer groups | |
|---|---|---|---|
| | | *UA1* | *UA1* |
| seller groups | *UA1* | 5 | 12 |
| | *UA1* | 14 | 14 |

| **run 3** | | buyer groups | |
|---|---|---|---|
| | | *UA1* | *UT* |
| seller groups | *UA1* | 36 | 0 |
| | *UT* | 1 | 46 |

| **run 4** | | buyer groups | |
|---|---|---|---|
| | | *UA1* | *UA2* |
| seller groups | *UA1* | 26 | 1 |
| | *UA2* | 3 | 33 |

| **run 5** | | buyer groups | |
|---|---|---|---|
| | | *UA2* | *UA2* |
| seller groups | *UA1* | 7 | 4 |
| | *UA1* | 9 | 9 |

| **run 6** | | buyer groups | |
|---|---|---|---|
| | | *UT* | *UT* |
| seller groups | *UA1* | 19 | 14 |
| | *UA1* | 11 | 13 |

| **run 7** | | buyer groups | |
|---|---|---|---|
| | | *UA2* | *UT* |
| seller groups | *UA1* | 7 | 10 |
| | *UA1* | 12 | 4 |

| **run 8** | | buyer groups | |
|---|---|---|---|
| | | *UA 1* | *UT* |
| seller groups | *UA1* | 25 | 2 |
| | *UA2* | 4 | 17 |

## 6. CONCLUSIONS AND FUTURE WORK

This paper contributes to the research into trade processes by offering a model of the influence of the uncertainty avoidance dimension of culture on trade processes. The work in this paper is a sequel to Hofstede et al. (2006), in which the influence on trade of the masculinity / femininity dimension of culture is modeled. Our choice to model the dimensions first in isolation is deliberate. Despite its partial nature the model is applicable for traders from cultures that differ mostly on this dimension, e.g., Japan-China, Germany-Great Britain, South Korea-Singapore, Italy-Ireland, Finland - Denmark. By modeling only the influence of one dimension, the model can be validated with respect to the general theory, and with respect to dedicated human simulation games. The model is based on the theory of [Hofstede 2001], as well as on the experience of the authors with the Trust and Tracing Game [Meijer et al., 2006], in which people from different cultures participate in a gaming simulation. Trade aspects considered were: trade goal selection, partner selection, negotiation behavior, maintenance of beliefs about trade partners, and related to these trust and the truthful or untruthful delivery of goods.

The model has not been validated against human negotiators and this remains to be done. The results do however show good face validity. Uncertainty tolerant agents find it easy to trade with partners they do not know

and their negotiations are often successful. Whether they trust their trade partner or not does not so much depend on group membership. Neither does their selection of trade goods, or their decision to deliver truthfully or not. Furthermore, their interpretation of the behavior of their trade partners, which determines the way they maintain beliefs about these partners, does not depend on the groups they belong to. This is different for people from uncertainty avoiding cultures. They base their selection of trade goals on a minimization of risk, they would rather trade with people they know, are reluctant to trust strangers, progress more slowly during negotiations, and have a low threshold regarding deception of people they have little in common with. *Vice versa* they are looking for a pretext to see their suspicions confirmed, thus when deceived, they tend to respond furiously, and tend to avoid that partner if possible. The model has been tested in simulations showing that the generic tendencies as attributed to uncertainty avoidance are reflected in the simulation results.

Our work shows how the influence of culture on decision-making processes can be modeled. So far, the literature on the influence of culture is largely generic in nature and not formalized into working simulations and/or agent-based systems. The pattern in our approach is that for each possible decision-making rule two aspects are considered. Would the cultural background:

- make the rule inappropriate, and
- change the parameters of the rule?

With this in mind, the normal decision making process for the task at hand is considered in all its stages.

**Future work.** The authors' aim to validation and calibration the model against experiments with human participants, as depicted in Figure 1. Future work comprises experiments with questionnaires and one-to-one negotiation gaming simulations. As a preparation for this work, more extensive sensitivity analyses are required.

When all five dimensions have been modeled and validated in isolation, the next step is to combine models of several dimensions. The main problem here is to maintain validation; by entering too many variables at once, attributing behavior to some of them is hard. For that reason, combinations of two dimensions are aimed for. Combinations will be selected with respect to available pairs of cultures comparable with respect to the remaining dimensions, and differ with respect to the selected two dimensions. The various models that combine the influence of two dimensions are of direct use to model traders coming from the cultures for which only those two dimensions differ, and for traders from cultures for which only one of those dimensions differ. The final model combining five dimensions can be used to model traders from any cultural background.

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