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A Cross-cultural Multi-agent Model of Opportunism in Trade

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Abstract. According to transaction cost economics, contracts are always incomplete and offer opportunities to defect. Some level of trust is a sine qua non for trade. If the seller is better informed about product quality than the buyer, the buyer has to rely on information the seller provides or has to check the information by testing the product or tracing the supply chain processes, thus incurring extra transaction cost. An opportunistic seller who assumes the buyer to trust, may deliver a lower quality product than agreed upon. In human decisions to deceive and to show trust or distrust, issues like mutual expectations, shame, self-esteem, personality, and reputation are involved. These factors depend in part on traders' cultural background. This paper proposes an agent model of deceit and trust and describes a multi-agent simulation where trading agents are differentiated according to Hofstede's dimensions of national culture. Simulations of USA and Dutch trading situations are compared.

Keywords: trust and reputation management, deceit, negotiation, trade partner selection, culture

1 Introduction

A business transaction usually incurs cost on transaction partners, thus reducing the value of the transaction for the party bearing the cost. In transaction cost economics [1] opportunism and the incompleteness of contracts are central issues. Due to bounded rationality, contracts cannot specify solutions for all contingencies that may occur in transactions executed under the contracts. The incompleteness offers contract partners opportunities to defect. As Williamson [1] asserts, not every contract partner will take full advantage of every opportunity to defect. It is the uncertainty about a contract partner's opportunism that incurs transaction cost. *Ex ante* and *ex post* types of transaction cost can be distinguished. *Ex ante* are the cost of searching, bargaining, drafting, and safeguarding of contracts. *Ex post* are the cost of monitoring and enforcing task completion. Transaction cost economics is the basis for the process model of trading agents applied in this paper. The process model is depicted in Fig. 1.

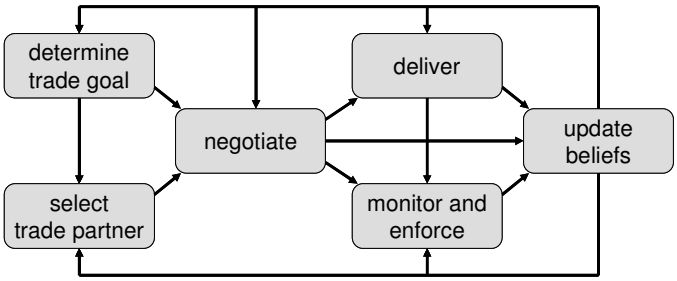

Fig. 1. Processes and internal information flows of trading agents

The outcome of successful negotiation is a contract. After that, it comes to delivery. An agent may deliver according to contract, or fail to do so intentionally (opportunism) or unintentionally (by incompetence or a flaw of its quality control system). At the same time, an agent may monitor the other party's delivery and either check if it is according to contract, or trust and accept without checking. Klein Woolthuis et al. [2] studied the relationship between trust and contracts. They concluded that trust can substitute or complement contracts: if trust is high, contracts can either be rather incomplete, because parties do not expect deceit, or more complete but not actively monitored and enforced, as a signal confirming the trusting relationship; if trust is low, a contract can either be rather complete as a safeguard against opportunism, or incomplete because of opportunistic intentions (so, contract incompleteness does not necessarily imply trust).

The trading situation of the simulation presented in this paper is based on the Trust And Tracing game [3]. In this game, players select trade partners and trade imaginary food products that have a value-adding quality attribute known by the supplier, but invisible to the customer, e.g. "organically grown". The customer can, at the cost of a fee, involve the Tracing Agency to test the actual quality. The Tracing Agency reports the test's outcome to both customer and supplier, and in case of untruthful delivery, punishes the supplier by a fine. Based on experience from negotiation and tracing results, agents update their beliefs about the market, potential partners, and the risks of opportunistic behavior. This paper focuses on the post-contract phase. The models for trust, deceit, and experience-based belief update are described in Section 2.

Human decisions to deceive and to trust are not strictly rational in the sense that is usual in neoclassical economics. Apart from financial benefits, human beings discount expectations of future deals and of social benefits that have to do with status and affiliation and can be succinctly described as 'reputation'. They do this for the simple reason that those of their ancestors who did it, or the groups and societies to which they belonged, have thrived and succeeded in reproducing [4]. The mechanisms that people use to guide their decisions to trust and deceive are largely unconscious. They include emotions [5] and intuition. Which emotions are felt in which circumstances, and which actions are taken as a result, depends on culture. As a result, the dynamics of trust and deceit depend on cultural background [6, 7]. G. Hofstede's five dimensions of national cultures [8] are widely used to identify cultural differences. G.J. Hofstede et al. described models for the influence of culture on trade processes, including deceit and trust, for each of the five dimensions separately [9, 10, 11, 12, 13]. However, the differentiation of human behavior cannot be described

along a single one of these dimensions. The present paper's goal is to integrate G.J. Hofstede et al.'s individual dimension models, focusing on the decisions whether to deliver truthfully or untruthfully (*deceit*) and whether to trace the delivery or to accept it without tracing (*trust*), and on experience- based belief update about partner's trustworthiness and benevolence (i.e. its inclination to trust). Section 3 introduces Hofstede's five-dimensional model of culture and the dimensions' effects on deceit and trust. Section 4 presents the computational model of the effects of culture on deceit and trust. Section 5 describes experimental results from multi-agent simulations. Section 6 concludes the paper with a discussion of the results.

2 Modeling Deceit, Trust, and Experience-Based Belief

The simulation model represents the trade process of the Trust And Tracing game [3], where a group of 15-20 participants repeatedly trade commodities of different quality levels for an a priori unknown time. Suppliers are informed about the quality; customers are not informed. Participants are free to select a partner for each transaction, and negotiate about price, quality to be delivered, and conditions of the contract. Fig. 2 provides a graphical summary in the form of the 'Trader's Predicament' [14], a payoff matrix in the style of the Prisoner's Dilemma.

	Seller offers		
Buyer responds	Low Q	High Q, trustworthy	High Q, deceitful
a) accepts	No-risk deal		
b1) accepts, trusts		B, S: reward	B: sucker's payoff S: temptation
b1′) accepts, trace		B: reward minus cost of tracing S: reward B,S: possibly damaged relation (distrust)	B: confirmation of distrust S: punishment
b2) requires guarantee; no trace		B, S: reward B,S: possibly damaged relation (distrust)	B: sucker's payoff S: temptation
b2′) requires guarantee; trace		B: reward minus cost of tracing S: reward B,S: possibly damaged relation (distrust)	B: confirmation of distrust, money back S: punishment, return money
b3) requires certificate		B, S: no risk; reward minus certificate cost	B: no product S: withdrawal

Fig. 2. Payoff matrix for the version of the Trust & Tracing game modeled in this paper (Q: quality; S: seller's payoff; B: buyer's payoff)

Customers may (a) avoid deceit by buying low quality or (b) buy high quality and either (b1) accept vulnerability and trust the supplier to deliver according to contract, or (b2) protect themselves by negotiating a guarantee, for instance money back in case deceit would be revealed, or (b3) have the commodity traced in advance (certification). Option (a) is free of cost and risk, and a low price may be negotiated, but the customer has to accept low quality. Options (b1) and (b2) incur risk on the customer (as they offer the seller an opportunity to defect), and additional cost only if the customer decides to monitor (trace) the delivery. The certification option (b3) excludes risk, but always incurs additional cost.

Although trust is relevant for the processes of partner selection and negotiation, the present paper focuses on the post-contract phase of transactions. It describes the decision whether to deceive or not in the delivery process, the decision whether to trust or to trace in the monitoring and enforcing process, and the update of beliefs resulting from confirmed or violated trust. The remaining part of this section discusses relevant literature from the social sciences and introduces the agents' decision models applied in the simulation.

In experiments using a repetitive ultimatum game with asymmetric information, Boles et al. [5] found that most people do not choose deceptive strategies. However, deceit occurred in their experiments, in particular when stakes were high. So, for deceit to occur, at least two conditions have to be satisfied: motive (substantial advantage for the deceiver) and opportunity (lack of information on the part of the deceived).

As Boles et al. found, the conditions of motive and opportunity are not sufficient for deceit. The decision to deceive depended on interpersonal interactions and the player's satisfaction about the behavior of the other party. They report that "*the bargainers were little like those depicted by rational economic models*" [5] and that "*responders may react emotionally and reject profitable offers in the present when they realize that they have been deceived in the past*" [5].

Role-playing research into cheating on service guarantees by consumers reported by Wirtz and Kum [15] confirms that people are not inclined to seize any opportunity to cheat. Their research also confirms that potential material gain is a condition for cheating, but they found no evidence that people who cheat let their decision depend on the expected amount of payout or the ease of the opportunity to cheat. They report cheating to be related to personality of players (morality, Machiavellianism and self-monitoring). Two factors found to decrease cheating were satisfaction about the deal and the expectation of repeated dealing with the supplier in the future. Wirtz and Kum [15] suggest that a sense of loyalty and trust may reduce cheating. They also refer to Hwang and Burgers [16] who take an economics approach and argue that the high cost of the loss of a trusted partner is an inhibitor of opportunism. Both views indicate that a high-trust relation inhibits deceit.

In the research discussed above, four factors that influence deceit are found: opportunity, expected payout, player's personal traits and values, and player's trust relationship with their counterpart. Steinel and De Dreu [17] conclude on the basis of experiments with the Information Provision Game that, due to greed and maybe to fear of exploitation, individuals are less honest when they experience their counterpart to be competitive rather than cooperative, and that this tendency is stronger for prosocial than for selfish individuals. The importance of the relationship and the

behavior of the counterpart is confirmed by Olekalns and Smith [18] who contrast two models of ethical decision making: *fair trade* (my counterpart trusts me, so I will cooperate) and *opportunistic betrayal* (my counterpart trusts me, so I can easily defect). In experiments with Australian undergraduate students they found strong support for *fair trade* as the prevailing model. However, Wirtz and Kum [15] found that individuals scoring high on Machiavellianism in the personality test, were more easily tempted to seize an opportunity to cheat and actually followed what Olekalns and Smith [18] called the *opportunistic betrayal* model.

A general conclusion of the work cited so far in this section is that deceit is less likely to occur when trade partners show trust in each other, even when rational strategies to win the game would suggest cheating. As the purpose of the multi-agent simulation reported in this paper is to represent actual human behavior rather than to apply deception as a strategy to win a game, we cannot employ rational models like the ones proposed by Castelfranchi et al. [19] and Ward and Hexmoor [20].

In the simulation a supplier's decision to deceive business partner b is modeled as a Bernoulli variable with probability of deceit

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

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 business partner b: m_b=1 if the supplier expects an extra profit from deceit; m_b=0 otherwise, for instance if the customer negotiated a guarantee and the supplier expects the customer to trace the delivery;
- d_b represents on the interval [0, 1] seller's threshold for deceit toward business partner 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 toward the seller, i.e., seller's trust that the customer will accept deliveries without tracing; details on d_b and the influence of cultural background are discussed in Section 3.

For the purpose of the simulation, Klein Woolthuis et al.'s [2] narrow definition of trust is adopted. A customer's trust in a particular supplier is defined as the customer's estimate of the probability that the supplier will cooperate and deliver according to contract, even if the supplier has the motive and the opportunity to defect. However, this does not imply that an agent's decision to have a delivery traced can be modeled as a Bernoulli variable with $p(\text{trace})=q(1-c)(1-t_b)$ where $q(1-c)$ represent opportunity as in equation (1) and t_b represents trust in business partner b. Additional factors like power and group relationships with the supplier and the agent's cultural background also have their effect on the decision to trace. The effects of relationships and cultural background on the tracing decision are discussed in Section 3.

Trust and distrust develop during social interactions. Visual and auditory contact is relevant to develop trust and detect deceit in human interactions [21]. The multi-agent simulation does not support these effects. The only sources of information that can be

taken into account 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. The possibility that a supplier carries out a trace is disregarded here. Customers can decide to trace a delivery and this can have its effects on mutual trust. First, if the result of tracing reveals deceit, the customer's trust in the seller will be reduced. Second, to some extent the fine and the reputational damage resulting from revealed deceit will reinforce the supplier's honesty. However, reinforced honesty will decay to its original level in the course of time. Third, the supplier delivering truthfully may be offended by tracing and the relation may be damaged. For this reason, customers may exercise restraint to trace. Tracing by a customer will always reduce the supplier's belief about customer's benevolence. So, 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.

Formal models for representing the development of trust were analyzed by Jonker and Treur [22]. They distinguish six types of trust dynamics: blindly positive, blindly negative, slow positive – fast negative, balanced slow, balanced fast, and slow negative – fast positive. The most realistic type of dynamics for trust in 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 (e.g., Boles et al. [5] report that deceit leads to emotional reactions and consequences beyond what is in their own interest; Steinel and De Dreu [17] refer to "*punitive sentiment*" towards deceivers).

The trust dynamics are modeled as follows. After the n'th experience a consumer's trust in business partner b is updated according to belief update factors u_+ and u_-:

$$\begin{array}{ll} t_{b,n} = t_{b,n-1} + u_+(1 - t_{b,n-1}) & \text{if } n^{\text{th}} \text{ experience is positive ,} \\ t_{b,n} = (1-u_-)\, t_{b,n-1} & \text{if } n^{\text{th}} \text{ experience is negative ,} \\ t_{b,n} = t_{b,n-1} & \text{if } n^{\text{th}} \text{ experience is neither positive nor negative ,} \end{array} \qquad (\mathbf{2})$$

with $0 < u_+ < u_- < 1$, where $t_{b,n} = 1$ represents complete trust and $t_{b,n} = 0$ represents complete distrust in b; 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 $v_{b',n}$ about a partner's benevolence is updated similarly:

$$\begin{array}{ll} v_{b',n} = v_{b',n-1} + u_+(1 - v_{b',n-1}) & \text{if } n^{\text{th}} \text{ experience is positive ,} \\ v_{b',n} = (1-u_-)\, v_{b',n-1} & \text{if } n^{\text{th}} \text{ experience is negative ,} \\ v_{b',n} = v_{b',n-1} & \text{if } n^{\text{th}} \text{ experience is neither positive nor negative ,} \end{array} \qquad (\mathbf{3})$$

For the supplier a successful negotiation counts as a positive experience. However, tracing always counts as a negative experience for a supplier, whether it reveals deceit or not, because it is interpreted as distrust.

An effect of revealed deceit on the supplier's part is that supplier's current honesty h_k (a personal trait, representing the inclination to deliver truthfully) is reinforced to 1, representing maximal honesty in the supplier's cultural background. h_k will subsequently decay to a base value h' on each interaction, whether it is successful or not, with a decay factor f.

$$h_k = h' + f(h_{k-1} - h'), \text{ with } 0 < h' < 1 \text{ and } 0 < f < 1. \quad (\mathbf{4})$$

with $0 < h' < 1$ and $0 < f < 1$.

3 Deceit and Trust across Cultures

The preceding section introduced models for deceit, trust and belief update in a process of trade. The roles of deceit and trust are known to be different across cultures [6, 7]. Therefore, a multi-agent simulation of international trade that models the effects of deceit and trust should include the effects of culture. This section proposes an approach to model the effects of culture on the parameters and variables introduced in the previous section (deceit threshold, inclination to trace, and positive and negative trust update factors), based on G. Hofstede's dimensions of culture [8]. First culture and Hofstede's dimensions and their effects on deceit and tracing are discussed.

Table 1. Hofstede's dimensions of culture [8]

Dimension	Definition
Power Distance	"*The extent to which the less powerful members of institutions and organizations within a country expect and accept that power is distributed unequally*" [8], p. 98
Uncertainty Avoidance	"*The extent to which the members of a culture feel threatened by uncertain or unknown situations*" [8], p. 161
Individualism and Collectivism	"*Individualism stands for a society in which the ties between individuals are loose: Everyone is expected to look after him/herself and her/his immediate family only. Collectivism stands for a society in which people from birth onward are integrated into strong, cohesive in-groups, which throughout people's lifetime continue to protect them in exchange for unquestioning loyalty*" [8], p. 255
Masculinity and Femininity	"*Masculinity stands for a society in which social gender roles are clearly distinct: Men are assumed to be assertive, tough, and focused on material success; women are supposed to be more modest, tender and concerned with the quality of life. Femininity stands for a society in which gender roles overlap: Both men and women are supposed to be modest, tender and concerned with the quality of life.*" [8], p. 297
Long- Versus Short-Term Orientation	"*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*" [8], p. 359

Hofstede describes culture as "*the collective programming of the mind that distinguishes the members of one group or category of people from another*" [8], p. 9. This implies that culture is not an attribute of individual people, unlike personality characteristics. It is an attribute of a group that manifests itself through the behaviors of its members. For a trading situation, culture of the trader will manifest 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 transactions, 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 situation and the desired situation.

G. Hofstede [8] identified five dimensions to compare national cultures (Table 1). For the dimensions, indices are available for many countries in the world. The indices are usually named PDI, UAI, IDV, MAS, and LTO. For the multi-agent model, we scale the indices to the interval [0, 1] and refer to the scaled indices as PDI^*, UAI^*, IDV^*, MAS^*, and LTO^*. E.g., IDV^* refers to the degree of individualism and $1\text{-}IDV^*$ to the degree of collectivism, both in the range [0, 1].

G.J. Hofstede et al. [9, 10, 11, 12, 13] modeled the influence on trade processes of each of the five dimensions separately. However, single dimensions do not fully represent the differentiation of human behavior. A realistic simulation must take the simultaneous effect of all dimensions into account. The purpose of the present paper is to develop a first version of integrated models for deceit, trust and belief update. The remaining part of this section summarizes the effects of individual dimensions as described in [9, 10, 11, 12, 13].

Power Distance. [9] On the dimension of power distance, egalitarian societies are on the one extreme (small power distance), hierarchical societies on the other (large power distance). In hierarchical societies, status and position in the societal hierarchy are the main issue in relations. Trust is only relevant among partners that have equal status. The lower ranked have no choice but to show trust in the higher ranked, whatever belief about their trustworthiness they may have. The higher ranked have no reason to distrust the lower ranked, because they assume that deceit of a higher ranked would not even be considered. With respect to deceit, the higher ranked do not have to fear for repercussions when trading with lower ranked, so the decision, whether to defect or not, merely depends on their morality. The lower ranked on the other hand will not easily consider to defect. They will usually cooperate when trading with higher ranked and will only defect if in need.

For egalitarian traders, decisions to deceive and to trust are not influenced by status difference. Trust is equally important in every relation, regardless of partner's status. However, showing distrust may be harmful to relations, so there may be other incentives for benevolent behavior.

Uncertainty Avoidance. [10] Uncertainty avoidance must not be confused with risk avoidance. People in uncertainty avoiding societies accept risks they are familiar with,

but they fear the unknown. They are willing to take risks in order to reduce uncertainty about things they are not familiar with, or to eliminate them.

Uncertainty avoiding traders fear and distrust strangers. They follow the rules when dealing with familiar relations, but easily deceive strangers. A foreign partner will be distrusted until sufficient evidence for the contrary has been found. 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 may finally 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.

In this simulation it has been hypothesized that the tracing agency is always trusted. This is a deliberate simplification. In uncertainty avoiding societies, institutions in general and government in particular tend to be distrusted.

Individualism and Collectivism. [11] In individualistic societies, people have a personal identity and are responsible for their personal actions and view a business partner as an individual. In collectivistic societies, a person's identity is primarily given by group memberships (such as extended family, village, and clubs) and relations. People from collectivistic societies feel responsible for their in-group and prefer to trade with their in-group. Serious negotiations with out-group business partners must be preceded by some form of familiarization. In collectivistic societies harmony must be preserved, so the threshold for showing distrust by tracing is high. Tracing is also less likely because the idea of calling in outsiders to perform the tracing runs counter to a collectivistic way of thinking.

In collectivistic societies trust and deceit are based on group memberships and norms. People from collectivistic societies primarily trust in-group members and distrust out-group members. After a long-lasting relation, outsiders may be trusted as in-group members. Deceiving an out-group partner is acceptable if it serves in-group interests. In individualistic societies opportunistic behavior and trust are based on personal interests, personal values, and interpersonal relations.

Masculinity and Femininity. [12] On the masculine extreme of the dimension are competitive, performance-oriented societies; on the other are cooperation-oriented societies. A stereotypical trader with a feminine, cooperation-oriented cultural background is interested in the relationship. Building trust is important. In principle, the cooperation-oriented trader does not trace, since in his mind this would constitute ostentation of distrust. If conned, then the cooperation-oriented trader will avoid the conman if possible, or give him one more chance.

Trust is irrelevant in extremely performance-oriented, masculine societies. A performance-oriented trader sticks to the contract of the deal, and deceives the trade partner to the limits of the contract without any compunction. As a consequence, the performance- oriented trader sees no problems in dealing again with a trader that conned him in the past: "It's all in the game". The performance-oriented trader always traces the goods after buying, since he expects the possibility of deception. The trader

learns from mistakes to make sure that new contracts will not lead to new and uncomfortable surprises on his side.

Long- Versus Short-Term Orientation. [13] Traders from long-term oriented societies value their relations. They value a deal not only by the financial pay off, but also by the relational gains. They are inclined to invest in relations by behaving truthfully and by trusting their partners. They value their business relations by the prospect of future business. They have no respect for others that put their relations at stake for some short-term profit. If they turn out to be deceived by a business partner they will not easily forgive the deceiver.

People from short-term oriented cultures find it hard to understand the sacrifice of the long-term oriented. The short-term oriented tend to grab a chance for an easy profit and are willing to put their relations at stake for it, especially if they are in need to fulfil other social obligations, like showing off for family members. They calculate the bottom line of the transaction. Their threshold to deceive or to distrust depends on the value they attach to the relation in their social life. They can understand that a business partner may be tempted to defect if a profitable opportunity occurs, and they have trouble understanding that people from long-term oriented cultures cannot.

4 Integrated Computational Model

Hofstede et al. [9, 10, 11, 12, 13] proposed formal models of the effects of each of the dimensions of culture on trade processes, including effects on deceit threshold, inclination to trace, and positive and negative trust update factors. The models are based on expert knowledge, gained with a classical knowledge acquisition approach. This section presents an approach to integrate the knowledge about individual dimensions into a model of the joint effect of the dimensions on deceit and trust.

The expert knowledge is formulated as "cultural factors" having an increasing or decreasing effect on the strength or occurrence of behaviors along one of the dimensions of culture. Apart from the dimensions of culture, the behaviors can be influenced by attributes of the relation with the business partner. Examples of such relational attributes are status differences and ingroup relations. This kind of relational attributes have different relevance in different cultures.

The expert knowledge about the effects of cultural factors is expressed as effects on parameters or variables of the agents' decision models. The dimensions of culture provide a linear ordering of cultures with respect to the strength or frequency of phenomena associated with the dimensions. Therefore, we model the effect of a cultural factor as either no effect at all or as strictly monotonic, i.e. increasing or decreasing. As long as no further evidence is available, we assume the most simple monotonic relation: a linear relation between a cultural factor and the effective value of a parameter or variable. Table 2 summarizes the effects of cultural factors that were identified as relevant for the present simulation. The effects are grouped by dimension. In some cases the effects of the cultural dimensions stand alone; in other cases the effects depend on attributes of the relation with the business partner.

Table 2. Effects of Hofstede's dimensions of culture and relational characteristics on deceit and trust parameters (+ indicates increasing effect; - indicates decreasing effect)

Dimension index	Culture and relational characteristics	Cultural factor to be taken into account	Effect on			
			deceit threshold	inclination to trace	negative update factor	positive update factor
PDI	Large power distance	PDI^*				
	- with higher ranked partn.	$\max\{0,PDI^*(s_b-s_a)\}$	+	–		
	- with lower ranked partn.	$\max\{0,PDI^*(s_a-s_b)\}$		–		
	Small power distance	$1-PDI^*$				
UAI	Uncertainty avoiding	UAI^*			+	–
	- with stranger	$UAI^*\cdot D_{ab}$	–	+		
	Uncertainty tolerant	$1-UAI^*$				
IDV	Individualistic	IDV^*				
	Collectivistic	$(1-IDV^*)$			+	
	- with in-group partner	$(1-IDV^*)(1-D_{ab})$		–		
	- with out-group partner	$(1-IDV^*)D_{ab}$	–			
MAS	Masculine (competitive)	MAS^*	–	+	–	
	Feminine (cooperative)	$1-MAS^*$		–		
LTO	Long-term oriented	LTO^*	+	–	+	
	Short-term oriented	$(1-LTO^*)$				
	- with well-respected part.	$(1-LTO^*)s_b$	+	–		
	- with other partners	$(1-LTO^*)(1-s_b)$	–			

The types of cultural factors in Table 2 are:

- a normalized index I^* of one of the dimensions, as a characterization of a culture;
- $(1-I^*)$, as the characterization of the opposite culture on that dimensions;
- an index I^* or $(1-I^*)$ multiplied with a relational characteristic, such as agent a's group distance D_{ab} with business partner b or status difference s_a-s_b.

D_{ab} and s_a and s_b are reals on the interval [0, 1], as are the normalized dimension indices; so, the value of every cultural factor is a real on the interval [0, 1].

4.1 The Decision to Deceive on Delivery

In the preceding sections a model is developed of factors that influence the agents' decision to cooperate or to defect. In the agent model the decision whether to deceive or to deliver truthfully is modeled as a Bernoulli variable, taking the probability according to equation (1) into account.

$$p(\text{truthful delivery}) = 1 - p(\text{deceit}) . \quad (5)$$

This decision is taken in the delivery phase of the transaction, after a contract has been negotiated.

The opportunity to deceive depends on contract attributes q (quality) and c (certification required). If q=0 or c=1, there is no opportunity to deceive and the agent delivers truthfully: p(deceit)=0 and p(truthful delivery)=1 if q=0 or c=1. Otherwise, the motive and the deceit threshold are relevant.

The motive to deceive is present if the value difference between high quality and low quality exceeds the cost of the estimated risk of deceit. The motive depends on:

- Δy , value difference between high and low quality,
- v_b , the agent's belief about the partner b's benevolence (interpreted as the subjective probability that b will not put the delivery to the test),
- r, the amount of the fine in case deceit would be revealed;
- $g \cdot y$, where g=1 if the contract entails a guarantee, g=0 if not, and y, the value to be restituted in case of a guarantee).

The motive to deceive b is computed as:

$$\begin{aligned} &m_b = 1 \text{ if } \Delta y > (1 - v_b)(r + gy) \ ; \\ &m_b = 0 \text{ otherwise } . \end{aligned} \qquad \textbf{(6)}$$

It follows from (1) that p(deceit)=0 and p(truthful delivery)=1 if m_b=0. If motive and opportunity are present, the decision is affected by the agent's current honesty h_k and its belief about the quality relation with the customer b. We assume that the deceit threshold toward agent b has $\max(h_k, v_b)$ as a basis:

$$d_b' = \max(h_k, v_b) \qquad \textbf{(7)}$$

The actual deceit threshold equals basic value d_b' modified by increasing cultural effect $e^{d+}{}_b$ in the direction of 1; by decreasing effect $e^{d-}{}_b$ in the direction of 0:

$$d_b = d_b' + (1 - d_b')\, e^{d+}{}_b - d_b'\, e^{d-}{}_b \ , \qquad \textbf{(8)}$$

The joint increasing effect $e^{d+}{}_b$ is modeled as a weak disjunction of all increasing factors from Table 2; The joint decreasing effect $e^{d-}{}_b$ is modeled as a weak disjunction of all decreasing factors from Table 2:

$$e^{d+}{}_b = \max \{\mathrm{PDI}^*(s_b - s_a), \mathrm{LTO}^*, (1 - \mathrm{LTO}^*)s_b\} \ ; \qquad \textbf{(9a)}$$

$$e^{d-}{}_b = \max \{\mathrm{UAI}^* D_{ab}, (1 - \mathrm{IDV}^*)D_{ab}, \mathrm{MAS}^*, (1 - \mathrm{LTO}^*)(1 - s_b)\} \ . \qquad \textbf{(9b)}$$

In the present model, if opportunity and motive for deceit are present, the probability that an agent acts truthfully equals the culturally adapted deceit threshold d_b according to equations (8) and (9); the probability that an agent defects under these conditions equals $1 - d_b$. If motive or opportunity are absent, the agents will always deliver truthfully.

4.2 The Decision to Trust or Trace Deliveries

According to Castelfranchi and Falcone [23] "*Trust is the mental counter-part of delegation*". The mental aspect of trust in the present agent model is the experience-based belief about a business partner b's trustworthiness t_b. The delegation aspect of trust is in the act of trusting: to delegate the responsibility to deliver high quality to b, without safeguard that b will actually do so.

Across cultures different norms exist for the showing of trust or distrust. The probability that an agent will show trust is not necessarily equal to its subjective, experience-based belief t_b about the probability that b will act truthfully. In the present model, believed trustworthiness is the basis for the act of trusting, but the actual act of trusting does not necessarily correspond with it.

The decision to trust a delivery from business partner b or to trace is based on the estimated trustworthiness t_b. An agent's belief t_b about b's trustworthiness can be interpreted as a subjective probability that b will not deceive. $(1 - t_b)$ is the agent's distrust in b, or the subjective probability that b will defect. So, the basis for the inclination w_b' to trace b's delivery is:

$$w_b' = (1 - t_b) \,, \tag{10}$$

which is adapted by culture, similar to equation (8):

$$w_b = w_b' + (1 - w_b')\, e^{w+}{}_b - w_b'\, e^{w-}{}_b \,, \tag{11}$$

where

$$e^{w+}{}_b = \max\{\mathrm{UAI}^* D_{ab}, \mathrm{MAS}^*\} \,; \tag{12a}$$

$$e^{w-}{}_b = \max\{\mathrm{PDI}^* |s_a - s_b|, (1-\mathrm{IDV}^*)(1-D_{ab}), 1-\mathrm{MAS}^*, \mathrm{LTO}^*, (1-\mathrm{LTO}^*)s_b\} \,. \tag{12b}$$

The culture-dependent probabilities that agent a will trace or trust b's delivery are:

$$p(\mathrm{trace}) = q\,(1 - c)\, w_b \,; \tag{13a}$$

$$p(\mathrm{trust}) = 1 - w_b \,. \tag{13b}$$

4.3 Belief Update Factors

The values of the belief update factors to be applied in equations (2) and (3) for positive and negative experience, u_+ and u_-, respectively, are agent parameters that do not depend on the partner. They may be modeled as global parameters u_+' and u_-', respectively. In the latter case, the global values are culturally adapted as follows, in analogy with the preceding subsections.

u_+' is influenced by only a single factor according to Table 2. The value is reduced in societies with high uncertainty avoidance:

$$u_+ = u_+' - u_+' \, \mathrm{UAI}^* . \tag{14}$$

u_-' is influenced by more factors, under the constraint that $u_- > u_+$:

$$u_- = u_-' + (1 - u_-') \, e^{u-+} - (u_-' - u_+') \, e^{u--} , \tag{15}$$

where

$$e^{u-+} = \max \{\mathrm{UAI}^*, \text{1-IDV}^*, \mathrm{LTO}^*\} ; \tag{16a}$$

$$e^{u--} = \mathrm{MAS}^* . \tag{16b}$$

5 Testing the implementation

The model described in the preceding sections is implemented in a multi-agent model in Cormas[1]. The decision functions and plans are implemented as methods in the software agents. The agents can communicate through the Cormas synchronized message system. They can exchange messages to communicate or to transfer the ownership of commodities. Each commodity has slots for

- real quality, not visible for the trading agents;
- stated quality, visible and modifiable by the agents; a commodity is initialized with stated equal to real quality, but may be modified during the simulation;
- traced quality, visible for the trading agents, but only modifiable by the tracing agent; it is initially empty.

In the simulation there is a tracing agent to which the trading agents may, at the cost of a fee, send a commodity for inspection (the stated quality slot may deceitfully be modified by a supplier). Upon request, the tracing agent sets traced equal to real quality, returns the commodity, informs the suppliers that their product has been traced, and, in case of deceit, traces deceivers to punish them with a fine. A product that has the traced value set, can be seen as certified. A supplier can have a product certified before selling it, to increase the value. The amount of the tracing fee increases with each transaction in the history of a commodity, so certification in advance is cheaper than tracing by the customer.

The agents have access to a central directory with references to all agents and the tracing agent. The agents have labels for status and group membership. Labels are visible for all other agents. In some cultures group distance and status difference with trade partners are very relevant. The agents use the label information to estimate these parameters. Experience gained while trading, using the update mechanism described

[1] http://cormas.cirad.fr/

by equations (2) and (3), results in beliefs about trustworthiness and benevolence for each partner. Agents propose to negotiate to potential partners and they may accept or ignore negotiation proposals.

Partner selection is based on the model of Weisbuch et al. [24]. This model is based on a nonlinear probability of selecting a particular partner according to experience of profitability of previous deals – which we call fairness belief – and an agent-specific loyalty parameter. The loyalty parameter determines the relevance of the fairness belief for partner selection. The fairness belief is updated through a mechanism like the ones describes by equations (2) and (3). The cultural adaptation of Weisbuch et al.'s model for the application in the simulation is described in [25].

In the process of negotiation, the agents exchange proposals with the following attributes:

- identifying attributes: sender; receiver; time; is it a first bid, reply to a previous bid or acceptance of a bid;
- price;
- quality;
- an indicator if is the commodity is to be certified in advance by the supplier;
- an indicator of a money-back guarantee in case deceit be revealed in future tracing.

The negotiation process is based on work by Jonker and Treur [26]. Their negotiation architecture is based on a multi-attribute utility function. In the present implementation the utility function is a linear combination of an economic value term, a quality preference term and a risk attitude term. The relative weights of quality preference and risk avoidance determine the agent's trade strategy and are culture-dependent. The other parameters modeled to depend on culture are the agents' willingness to make concessions, the step size of concessions, impatience, and the remaining utility gap that is acceptable between own and partners proposal. The agents' culturally adapted negotiation model is described in detail in [27].

A negotiation may end with a contract, or it may fail, because one of the agents quits. In the latter case the agents select a partner, to try and start new negotiations with. In case of a contract, the processes of trust and deceit modeled in the present paper come into effect.

To test the implementation of the model, simulations were run in the environment described above. Eight supplier agents and eight customer agents could trade repeatedly, approximately 30-40 times per run, resulting in approximately 240-320 deals per run. The negotiation process was limited to result in q=1, c=0, and g=0, so the agents were forced to decide on trust and deceit. They could only negotiate about price, and let negotiations fail in case of distrust.

A series of runs were made, with "synthetic" cultures: the culture dimensions were set to 0.5, except one dimension, which was set to 0.1 or 0.9 in order to represent a cultural extreme. For instance, in the first run, PDI^*=0.9, UAI^*=0.5, IDV^*=0.5, MAS^*=0.5, and LTO^*=0.5; in the second run, PDI^*=0.1, UAI^*=0.5, IDV^*=0.5, MAS^*=0.5, and LTO^*=0.5. In all runs, the agents were divided into two groups of four suppliers and four customers with equal labels, having group distance D_{ab}=0 in the ingroup and group distance $D_{ab'}$=1 with members of the other group. Status was mixed: four agents had status 0.1, four agents 0.4, four agents 0.6, and four agents status 0.9, divided equally over ingroups of suppliers and customers. A summary of the results is presented in Fig. 3.

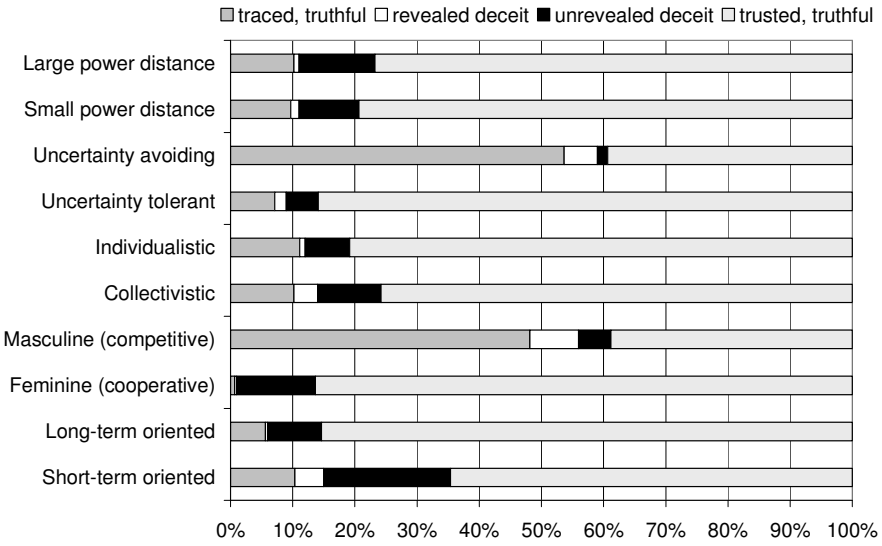

Fig 3. Results of simulations in societies with synthetic cultures; in the synthetic cultures all scaled cultural dimensions have index 0.5, except one, which has either 0.1 or 0.9

The first variable displayed in Fig. 3 displays the percentage of transactions that were traced and turned out to be truthful. Together with the second variable (traces that revealed deceit) it is a measure for the level of distrust that is shown. High values occur in the uncertainty avoiding and masculine societies. In the masculine society this results directly from the increased inclination to trace, equation (12), which reduces the relevance of the mental aspect of trust. In the uncertainty avoiding society, the high tracing ration results mainly from low trust: trust cannot develop because of the adapted positive belief update, equation (14). In addition, equation (12) has its effect on tracing frequency on deals with strangers.

The second variable in Fig. 3 indicates deceit revealed in traces, i.e. the confirmed distrust. There no obvious relation with the tracing frequency. In the societies where a considerable amount of the transactions is traced and distrust is frequently confirmed (the collectivistic and short-term oriented societies), this does not lead to even more tracing by the influence of equation (8), while the tracing ratio in the uncertainty avoiding society remains high, even if distrust is less frequently confirmed.

The third variable displays the frequency of unrevealed deceit. The high deceit frequency in the short-term oriented societies stems from the combination of the opportunity offered to higher ranked through equation (12b) - a low inclination to trace higher ranked – and the reduced deceit threshold toward lower ranked through equation (9b) – the opportunity is gratefully seized. This dimension is the only one where such a mutually reinforcing effect on deceit occurs in the equations. On the other dimensions, deceit frequency is lower and there is no obvious relation with the frequency of tracing (first column) across cultures. This is realistic.

In the masculine society the deceit frequency remains high while most of the deceit is revealed. This suggests that the competitive orientation is correctly implemented. In

the feminine society, deceit is rarely revealed, but it does not occur more frequently than in the masculine society. This suggests that the cooperative orientation is also correctly implemented. In the short-term oriented society, the wrong partners are traced: the percentage revealed is lower than the actual percentage of deceit, in spite of the rather high tracing frequency.

The results presented in Fig. 3 give confidence that the model can differentiate trade behavior across the Hofstede's dimensions of culture in a way that is qualitatively realistic.

The remaining part of this section discusses an example on the basis of experiments with the Trust And Tracing game, the human gaming simulation that the present model represents. Meijer et al. [28] report, among others, gaming simulations with the Trust And Tracing game with business school students in The Netherlands and in the USA. They report that the American students showed more eager to win, traded higher quality, seized opportunities to cheat, and expected their opponents to do so too, so they traced more frequently. Furthermore they report that in the USA a greater fraction of high quality transactions was certified, i.e. traced up-front by the supplier, using the tracing report as a quality certificate. The reason for this is that in the game as it was played, the tracing fee for suppliers was lower than it was for customers. The players discovered that with a high tracing probability, it was efficient to have the suppliers trace in advance.

If the difference between USA and Dutch games may be attributed to culture, which seems plausible, they must be reproduced by the present multi-agent model. Fig. 4 represents the cultural indices for The Netherlands and the USA. The main difference is in the MAS index. The values of the indices are [8]:

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

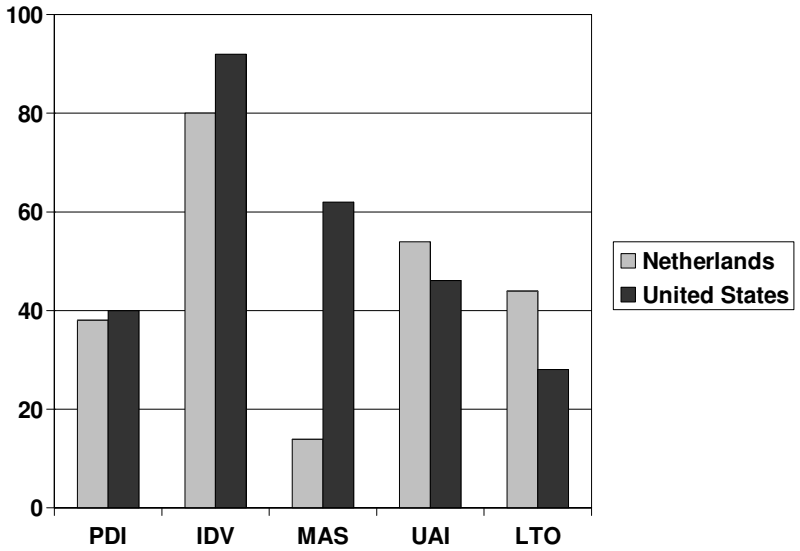

Fig. 4. The cultures of The Netherlands and the USA compared (data source: [8])

From the work of Meijer et al. [28] the following hypotheses can be formulated to be tested against simulation results:

1. The quality ratio (top quality transactions/all transactions) is higher in USA than in the Netherlands
2. The certification ratio (certified transactions/top quality transactions) is higher in USA than in the Netherlands
3. The defection ratio (untruthful deliveries/uncertified top quality transactions) is higher in USA than in the Netherlands
4. The tracing ratio (traces/uncertified top quality transactions) is higher in USA than in the Netherlands

For this purpose, simulations were run. As parameter values are unknown the following procedure was followed. For 1000 simulation runs, parameter sets were drawn at random from the joint space of parameters defined in the present paper (update factors u_+' and u_-', minimal honesty h_k, and honesty decay factor f, group distance D_{ab}, and status s_a and s_b) and parameters defined in the partner selection and negotiation models [25, 27]. All parameters were drawn independently from a uniform distribution on [0, 1], with some exceptions: u_+' was drawn from [0, u_-'], β (loyalty parameter in partner selection) from [0.5, 1.5], and the utility weight factors for quality and risk in the negotiation process were both drawn from [0, 0.2]. With these parameters agents were homogeneously configured, for a run where all agents had USA parameter settings and a run where all agents had Dutch parameter settings. So, in a single run, all agents had equal parameter settings, and for each setting, results for the USA and The Netherlands can be compared in pairs.

For each of the 1000 parameter sets, a simulation was run for each country. Each run had a length of 100 time steps, which practically limits the average number of transactions to a maximum about 20 per agent. To allow for partner selection, runs were configured for 8 suppliers and 8 customers, homogeneously parameterized. Negotiation was restricted to g=0 (no guarantees), with free choice between basic quality and top quality, and free choice of certification. Agents had the choice to deliver truthfully or untruthfully (equation 5) and to trust or to trace (equations 13).
Because of the wide range of parameters, many runs ended with zero or very few transactions. From the 1000 pairs of runs, the runs were selected that had a joint sum of at least 40 transactions per pair. Beneath this limit, many runs occur with zero transaction for one or both of the countries. The selection resulted in 317 run pairs.

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. According to the negotiation model reported in [27], customers do not take a differentiation of certification cost between themselves and suppliers into account. This difference was an important factor in the human gaming simulations in the USA. Therefore, the negotiation model from [27] was modified to take tracing fee difference and probability to trace into account. The original equation for customers' risk evaluation according to [27] was

$$r_c = (1 - c)(1 - t_b)q \ . \qquad \textbf{(17)}$$

The modified equation is

$$r_c = (1 - c)(1 - t_b)q + p(\text{trace})\phi_c \,, \qquad \textbf{(18)}$$

with p(trace) according to equation (13a) and ϕ_c representing customers' tracing fee.

This model adaptation is an example of the cyclic research approach proposed by Tykhonov et al. [3]. Their proposed approach entails stepwise refinement of models by alternating human gaming and multi-agent simulation.

The simulation was repeated after replacing equation (17) with equation (18) and setting the tracing fee equal to 0.2 for suppliers and 0.3 for customers. This resulted in 310 run pairs with a sum per pair of at least 40 transactions. Table 3 summarizes the results. Differences are significant for all variables, with $p < 0.001$ according to the Sign test. Histograms of differences are included in the Appendix.

Table 3. Test data for 310 run pairs for USA and NL with randomly generated parameter sets

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

[a] Test statistic, effective sample size, and two-sided probability level for Sign test

The simulation results confirm the hypotheses 1 through 4. However, some care must be taken. The hypotheses are formulated as stylized facts. The results reproduce these stylized facts, but cannot be interpreted to represent actual values for Dutch or American behaviors, as the model has not been tuned to actual data. Nevertheless, the tests give confidence that the model has been implemented correctly and can show cultural differentiation of deceit and trust in trade.

6 Conclusion

Culture is known to have its effects on honesty in trade, and on trust as a mechanism to compensate for the inevitable incompleteness of contracts. Occurrence of deceit, and mechanisms and institutions to reduce it, vary considerably across the world. For research into these mechanisms, multi-agent simulations can be a useful tool.

In intelligent agent research, much attention has been paid to trust. Little research has been published about the simulation of deceit. Publications such as [19] and [20] modeled deceit as a rational strategy to gain advantage in competitive situations. 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 [6]. The extent to which these feelings prevail is different across cultures [6]. 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 [5, 15, 17]. Once deceived, people react to an extent that goes beyond rationality [5], especially when they are prosocial rather than selfish [17]. In

human decision making a model based on *fair trade* prevails over a model of *opportunistic betrayal* [18]. In addition to psychological factors, evolutionary reasons [4] or rational economic motives [16] can be given for the human inclination to cooperative behavior.

This paper contributes by introducing an agent model of deceit and placing it in a cultural context. It takes human deceptive behavior as a point of departure. Building on the work of [9, 10, 11, 12, 13] that modeled single dimensions of culture, this paper proposes an integrated model of culture's effects on deceit and trust. Example results have been generated that verify the implementation and illustrate that cultural effects can be generated. However, for realistic experiments, the model has to be tuned to and calibrated by observations and results of experiments, for instance to simulate effects like the ones reported by Triandis et al. [6] from human experiments on deceit across cultures. Before such experiments can be performed, the integration of this model with culturally adapted models for partner selection and negotiation, based on [25] and [27], has to be tested and tuned in more detail. The integration task and experiments remain for future research.

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Appendix

Fig. 5 presents histograms of the (non-zero) differences reported in Table 3 between results of paired runs for simulated cultures of the USA and The Netherlands: in the top row the difference of the total number of successful transactions per run and the difference of the quality ratio; in the second row the certification ratio and the defection ratio; in the bottom row the tracing ratio.

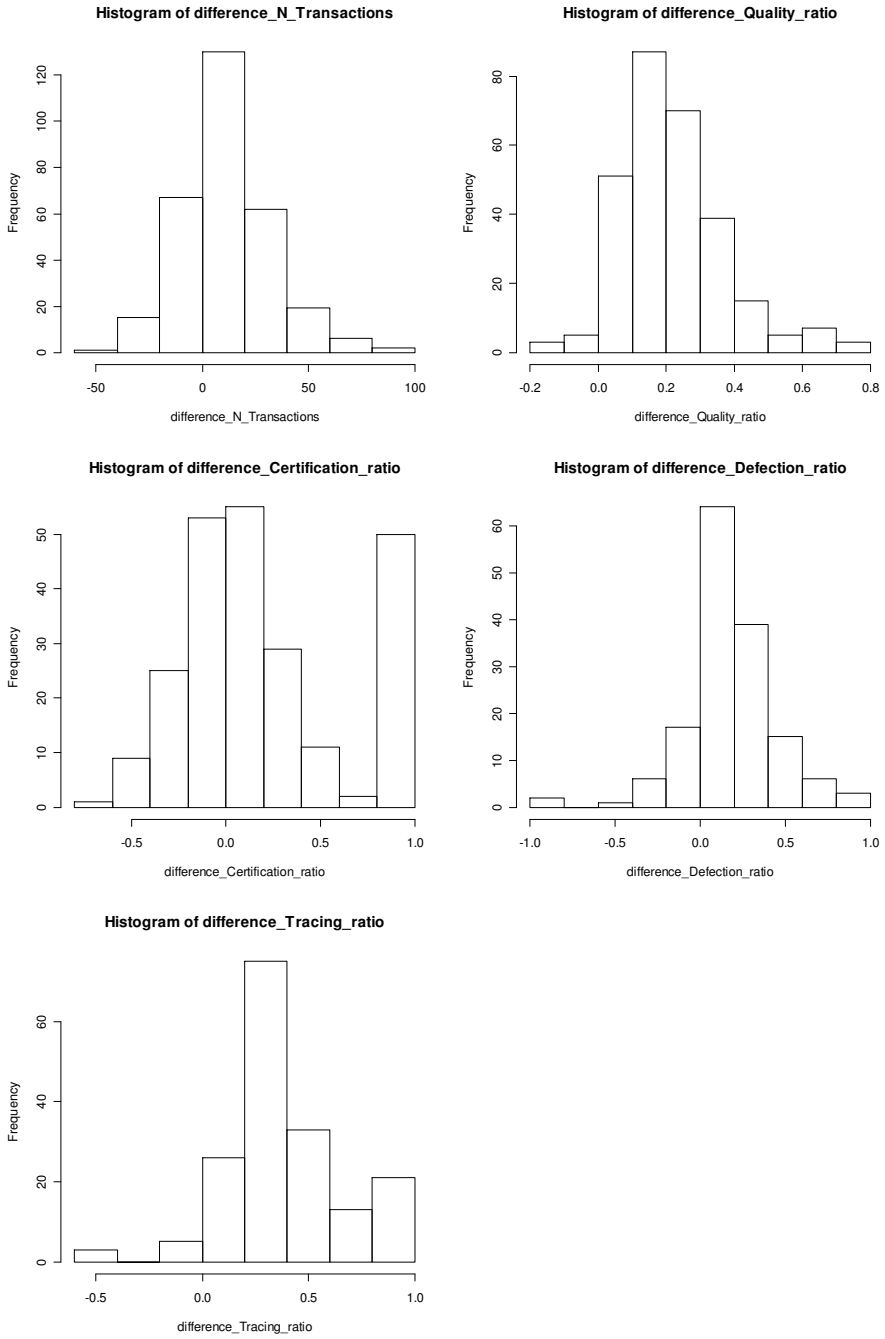

Fig. 5. Differences between tested variables of run pairs for the USA and The Netherlands.