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The validity of simplifying gaming simulations

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ABSTRACT

Simplifications of the real world affect the validity and reliability of gaming simulations. This challenges the application of gaming simulations as an instrument for experiential learning, reflective practices and data collection. This study investigates the effects of simplification on extracting tacit knowledge from human behavior by answering the research question: Can tacit knowledge in a simplified design of a gaming simulation be transferred without compromising the validity and reliability corresponding to the real-world complexity? By applying a participatory design a gaming simulation is tested as an instrument to extract tacit knowledge. To test and evaluate the validity of this application, simulation sessions have been performed with experts from the field. In simplifying reality, participants' participation emphasized that the most accurate representation of reality is a prerequisite for capturing tacit knowledge. This in turn contributes again to the validity of the simulation design. The results show that simplification of the real world didn't affect participants' perspective on the use of the gaming simulation as an experiential tool to enable learning processes or create awareness. And that a simplified simulation design, is still valid in addressing the real-world complexity, with minimization of the level of abstraction and maximization of the truthfulness.

1. Introduction

Simplifying real-world complexity is at the heart of gaming simulation models. Each model includes a selection of elements simplifying or reducing what is simulated (Peters, Vissers, & Heijne, 1998). Developing simplified gaming simulations is often addressed as a dilemma (Barlow, 2009; Goosen, Jensen, & Wells, 2001). Complex or simple gaming simulation designs are seen as a balance between time and efforts (Faria, Hutchinson, Wellington, & Gold, 2009; Van Der Zee, Holkenborg, & Robinson, 2012). Another dilemma is the question whether simplifications of the real world affect the validity and reliability of gaming simulations positively or negatively (Lee, Yi, & Malkawi, 2011; Tako, Tsioptsias, & Robinson, 2020; Van Lankveld, Sehic, Lo, & Meijer, 2017). Despite the learning benefits of gaming simulations for real-world complexity, several studies point out that the simplification or segmentation of reality hampers learning processes of participants (Cannon, 1995; Goosen, Jensen, & Wells, 1999), especially when dynamic human behavior is included (Zimmermann, 2006). In a response several studies suggest a careful trade-off and evaluation of the simplified simulation and real-world characteristics (Blagus, Šubelj, & Bajec, 2014; Robinson, 2013).

A gaming simulation can purposefully be designed to transfer and increase understanding of specific knowledge (Greenblat, 1975; Lukosch, Bekebrede, Kurapati, & Lukosch, 2018). Transferring knowledge becomes even more complicated when it is tacit in nature (Polanyi, 2009). By simplifying real-world complexity in a gaming simulation combined with a participatory design, this study's aim is to investigate the effects of simplification on extracting tacit knowledge from human behavior. Simplification in this study is defined as complexity reduction by breaking down what is being simulated into understandable and manageable components to improve understanding by omitting unnecessary parts or details. The explored research question is: Can tacit knowledge in a simplified design of a gaming simulation be transferred without compromising the validity and reliability corresponding to the real-world complexity?

Peters et al. (1998) point out that reduction (selection of elements from reality), abstraction (lower detail-level than in reality), and symbolization are basic principles of every gaming simulation development process. There is a limit to the extent of reduction and abstraction. The transfer of knowledge is hampered when essential elements are absent,

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which is known as construct irrelevant variance (Messick, 1994; Mislevy et al., 2016). The same goes for the level of detail of the elements included. Absence of essential details threatens validity (Messick, 1994; Mislevy et al., 2016). Another study has shown that a sufficient level of details enabled participants to elicit their actions from reality (Dignan, 2011), and it enabled participants to reflect on the process experienced in a gaming simulation (Dignan, 2011; Van Lankveld et al., 2017). Simplification of complex models increases the understanding of systems and time-dependent behavior (Salt, 1993; Saysel & Barlas, 2006). Likewise, reduction of model complexity contributes to the understanding of the gaming simulation output and analysis of the results by creating transparency about actions and consequences (Brooks & Tobias, 2000; van der Zee, 2017). Transparency of skillful actions and consequences contributes to the transfer of knowledge (Kolb, 2014). Creating transparency and increasing understanding are especially relevant for explicating tacit knowledge and skills (Polanyi, 2009).

Apart from reality, there are other formal and explicit specifications that affect complexity, two of which are addressed in the following sections: stakeholder participation and gaming simulation design. The participatory design allows for multiple actors to be involved. The larger the number of involved actors, the larger the number of interactions or processes in a social or technical system (e.g. gaming simulation), the more complex what is simulated (Lukosch et al., 2018; Mayer, 2009). The complexity of the gaming simulation design is relevant for participants' interpretation of the design and their ability to identify with what is simulated (Raghothama & Meijer, 2018). The more complex the gaming simulation design the more difficult the analysis and development of the game simulation model, and of its outcomes (Klabbers, 2018).

1.1. Participatory design

A participatory design has been applied to develop the simulation process collectively and to collect and appraise data together with participants. Participant participation in the development of the simulation allowed for elicitation and exploration of tacit knowledge and invisible practices of participants. The acquisition of tacit embodied knowledge and the actions undertaken in different practical situations in reality often form the basis for skillful acting and professional knowing (Argyris, 1999, pp. 123–140; Giunipero, Dawley, & Anthony, 1999). Sharing experiences is a method to explicate and transfer tacit knowledge (Nonaka & Takeuchi, 2007; Polanyi, 2012). The participatory design facilitated the gaming simulation development and the sharing of experiences. Two conditions are necessary to fulfil, to explicate participants tacit knowledge.

a) Expertise. Studies into expert performance show that the explicit professional reasoning was often built on underlying tacit knowledge (Nee, 2004; Patel, Arocha, & Kaufman, 1999; Patel, Kaufman, & Kannampallil, 2019).
b) Commitment of individual participants. Participants' commitment is essential in explicating tacit knowledge (Gourlay, 2006; Polanyi, 2009; Wagner & Sternberg, 1987).

Ad a) Emphasizing the ineffability of tacit knowledge and individual embodiment, several studies indicate that tacit knowledge can only be displayed by what people do (Nonaka & Takeuchi, 2007; Tsoukas, 2005). Participants' expertise by experience is therefore a basic requirement to explicate tacit knowledge.

Ad b) Commitment ensures active participation (Robertson & Simonsen, 2013), increases task involvement and immersion (Garris, Ahlers, & Driskell, 2002), and fosters learning effects due to increased cognitive engagement (Hannafin & Hooper, 1993). Commitment is positively affected by the organization of an instruction, participants' role fulfilment, feedback on progress towards the aim of the gaming simulation and mirroring reality (Bills, 2009; Garris et al., 2002; Kriz, 2003; Mayer, 2009).

To simulate the replication of a realistic trading environment in which participants can act professionally, the explication of tacit knowledge from experts by experience is required (Polanyi, 2009). Their involvement in this specific context plays an important role in the gaming simulation development process (Gourlay, 2006; Polanyi, 2009; Wagner & Sternberg, 1987), especially for knowledge-sharing (Teixeira, Tenório, Pinto, Matta, & da Cruz Urpia, 2023). The instruction given to participants, role play, and feedback mechanisms are included in the design of the gaming simulation and discussed in section 2.

1.2. Validity and reliability

This study bridges the science of analytical science and gaming simulation modelling by addressing validity and reliability from both perspectives (Klabbers, 2018). Whether simplified gaming simulations are a successful tool to enable the elicitation of tacit knowledge, depends on the degree of validity and the representation of the real world it simulates (Bekebrede, Lo, & Lukosch, 2015; Peters et al., 1998). The degree of validity is relevant to assessing the strength of evidence, especially when a simulation is used as a research instrument. The different types of validity and the reliability included in this study are presented in Appendix A (table A.1). The concepts of validity and reliability are relevant in assessing whether the results are similar to participants' reality. These aspects relate to the validity and reliability of the gaming simulation modelling (Raghothama & Meijer, 2018). In analytical science the validity and reliability relate to the accuracy and truthfulness of data and measurements. Where reliability refers to its consistency (over time) and repeatability, the validity represents a measurement that accurately represents the concept it intends to measure. The validity and reliability in analytical science can be evaluated by a combination of quantitative and qualitative methods of analysis which are addressed in section 4.

1.3. Case study: modelling trade in horticulture

This study is part of a research project called SamenMarkt (Van Kooten, Nevejan, Brazier, Oey, & Hubers, 2018) which focuses on understanding trade in the Dutch horticultural sector. The importance of understanding the role tacit knowledge plays in competent professional performance has recently been recognized in a study that revealed that knowledge about trading is tacit in nature (Van Haaften, Lefter, Lukosch, van Kooten, & Brazier, 2021). This study continued the search for understanding trade in horticulture, by enabling participants to put their experience into practice (Bell, Kanar, & Kozlowski, 2008). While trading, participants used their tacit trade knowledge in a process of experimental and experiential learning and reflective practice (Dewey, 1986; Schön, 2017; Zhang, Grandits, Härenstam, Hauge, & Meijer, 2018). To this purpose the gaming simulation as described in section 2 was developed.

2. Gaming simulation development

The gaming simulation was developed around the process of trade. The process used to develop the gaming simulation is discussed in section 2.1. The relevant game elements of the gaming simulation are included in two game-stages: the pre-stage (role play, instruction), and the playing of the simulation (the process simulated, game options) in section 2.2. The rules and objectives for participants are discussed in section 2.3.

2.1. Development gaming simulation

To develop the gaming simulation two different methods were used. In both participants provided input to its development. How these methods relate to the development process is presented in Fig. 1.

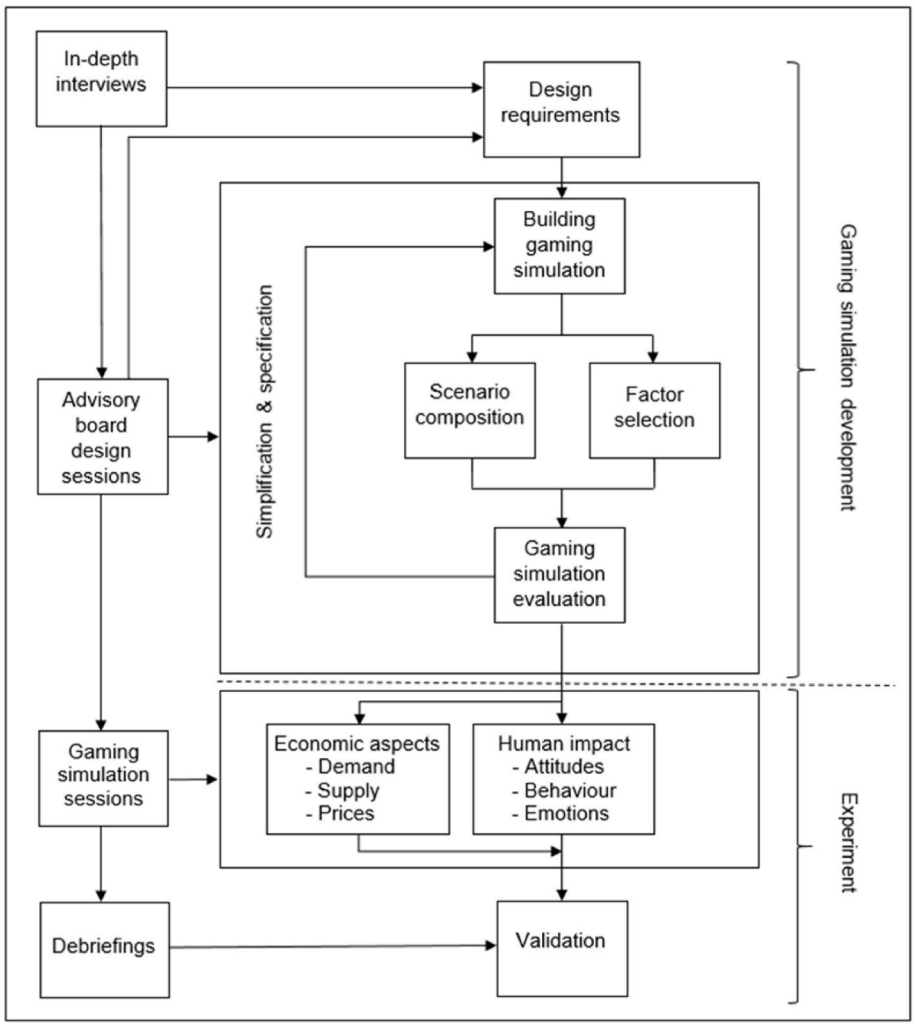

Fig. 1. Participatory development process gaming simulation.

Interviews with experts by experience created input for the relevant information each supply chain member needed for trading and for the factors that fostered or hampered trade. An overview of this information of the last prototype is displayed in Appendix B.

This information was processed in prototypes, and discussed with different experts by experience in Advisory Board design sessions. The prototype was evaluated as too complex due to multiple scenarios, multiple profiles for supply chain members and multiple factors that could change supply or demand. The data in this prototype have been evaluated as not realistic enough or incomplete. Advisory Board members and interviewees emphasized the importance of realistic and precise data. The prototype's complexity and unrealistic data could hamper the examination of cause (behavior in the trading process) and effect (consequences of actions) and consequently the explication of tacit knowledge. Based upon the feedback from Advisory Board design sessions the prototype was simplified to its current design, discussed in sections 2.2 and 2.3.

2.2. Game stages

Inherent to any simplification is the fulfilment of roles. Participants fulfilled the roles of cooperative and wholesaler in the online trading gaming simulation. The gaming simulation is divided into three different stages. In the first stage participants are confronted with the element of role-play. Participants have to make a choice about fulfilling the role of cooperative or wholesaler. After this participants followed an instruction round as depicted in Fig. 1. In the simulation both roles exchanged prices and volumes, with the objective to maximize profit.

In the second stage participants play the gaming simulation (see Fig. 2). In four different gaming simulation sessions traders participated in a virtual trade environment. During the play participants had for each role an attributed set of information. Each simulation session consisted of four rounds. The first and third round simulated the week market, followed by a second and fourth round of the daily market. Each round was limited with a time constraint of 7 minutes to simulate time pressure. To elicit trading behavior a trading process divided into actions was simulated. Apart from trading between cooperatives and wholesalers, participants could also trade with an external party which was not represented by one of the participants. Trading with the external party was limited to a fixed price and any amount up to a maximum volume set by the game leader. Trading with an external party was only available for a 3 minute interval, 2 minutes after a round had started.

The roles of cooperatives and wholesalers were supported by three categories of information. Firstly, information that displayed the progress participants made (volume supply, volume sold, volume to sell, average price). These values changed during the play as participants closed deals. Additionally, both roles were flanked with information which simulated the trading circumstances (market type and week number). Thirdly, the last five transactions (each accepted, declined or recalled) were visible during all rounds, to enable participants to adjust their trading. Wholesalers only had a fourth category of information at their disposal that represented the relationship between wholesalers and

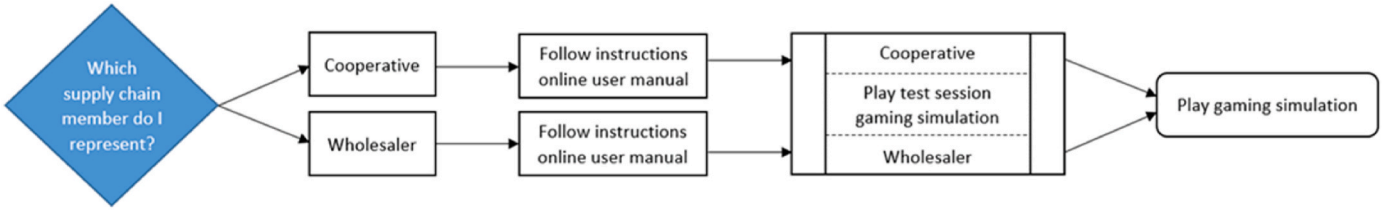

Fig. 2. Pre-stage: Instruction round.

retailers. This information (retail price, fixed costs and fine) remained fixed in the rounds that simulated the week market (round 1 and 3).

In interviews, interviewees distinguished the different critical moments in the negotiation process: sending, accepting and confirming an offer. The process to reach a deal was fixed (see Fig. 3), for each offer, each participant (sender and receiver of a bid) had two trade options at any time until a deal was concluded. Offers sent consisted of volume and price, after which the receiver had the option to accept or decline. Previously accepted offers were displayed separately. Before a deal was made the sender and receiver of an offer could recall the offer at any time, see Fig. 4. These different qualifications after sending an offer (recall, accept and decline) are marked with a colour in the gaming simulation, screenshots of the gaming simulation played are included in Appendix C.

The third stage evaluated how each participant fulfilled their role, given the conflicting objectives. The game element included in the third stage was the competition to win: gaining the highest profit representing a cooperative or wholesaler.

2.3. Rules of the gaming simulation

The rules and objectives of the gaming simulation are related to the game mechanic of trading a commodity (Järvinen, 2008). A competitive environment was simulated by providing individual goals for each participant and conflicting goals between to the roles of wholesaler and cooperative. The trading behavior shown is predominantly characterized by negotiations where participants reach an agreement or not, based on mutual interest. Actions of participants were assumed to be self-interested, maximizing the individual utility.

Participants individually fulfilled roles, each of which was given associated attributed information like volumes to sell or to buy, specific retail prices, etc. Modified between different rounds as described above. Participants were asked to negotiate contracts for the delivery of produce with players of the opposite role. Participants with the role of cooperative were instructed to obtain the highest trading price per sale and on average over all rounds played. Participants with the role of wholesalers were instructed to negotiate the lowest possible trading price for every deal. If wholesalers failed to buy produce for retailers, a fine for each kilogram was paid. Contrary to cooperatives, wholesalers incurred fixed costs (per kilogram), that were subtracted from their revenue to determine the profit made. The revenue of wholesalers was calculated as the difference between retail price and purchase price minus costs.

In the instruction round participants were explicitly notified that the volumes to sell or to buy were only prognoses of the definitive amount. After the weekly trade (round 1 and 3), the amount to trade for is made definitive by adjusting it with a random value. Participants had to account for this possible change during both the weekly and the daily trade. The volume to trade could change by either 0%, 5%, or 10%, positive or negative. Each percentage was equally likely to occur, with 0% twice as likely. In the evaluation stage the highest scores of participants in each role separately, were compared among each other. Untraded volume was erased. The best cooperative is the participant with the highest average unit price among all cooperatives, and the best wholesaler is the participant with the highest average profit per unit of produce among all wholesalers.

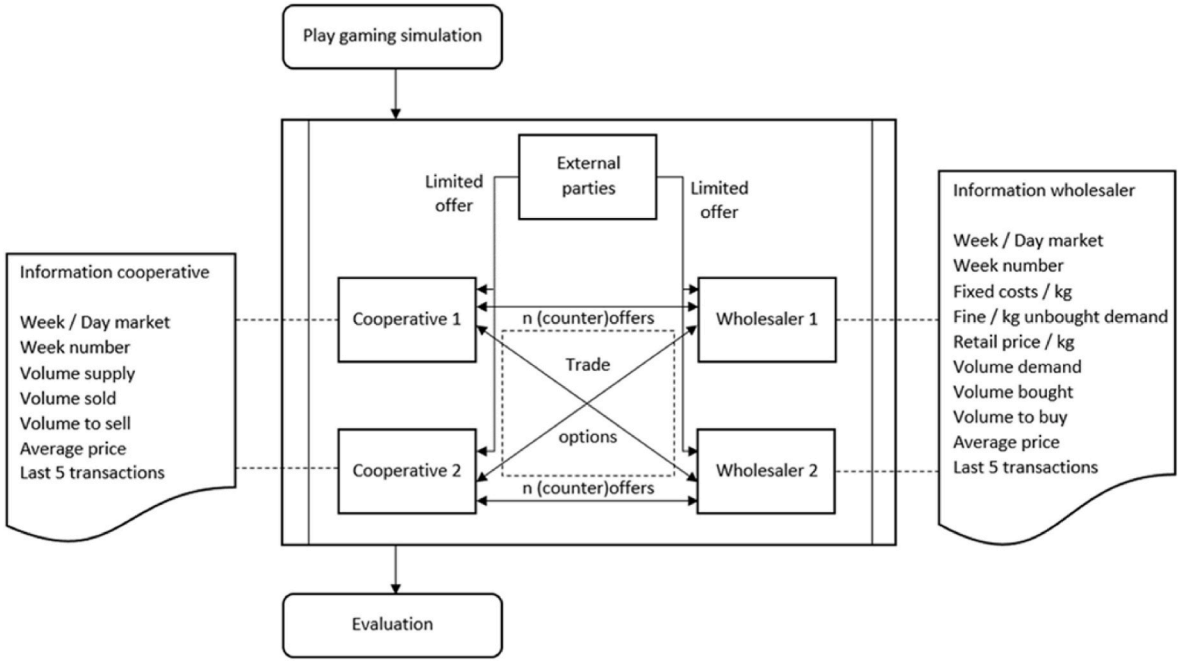

Fig. 3. Play of the gaming simulation.

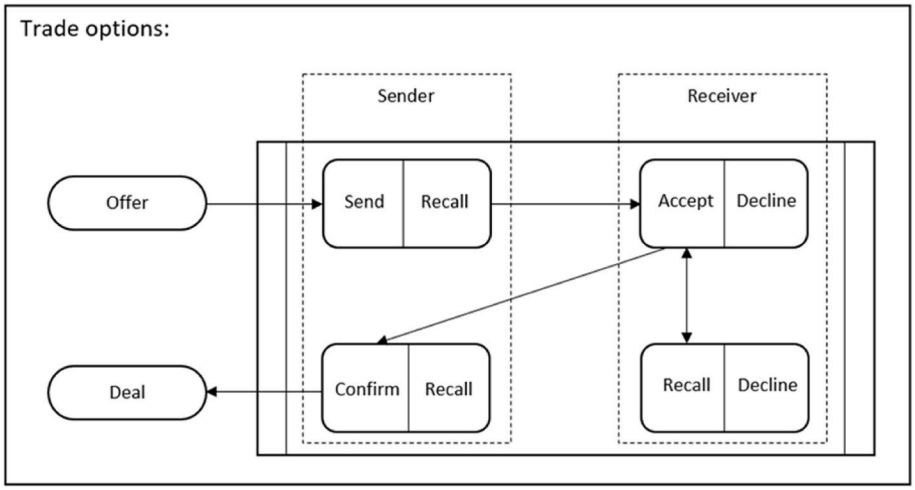

Fig. 4. Trade options in the gaming simulation.

3. Methods and participants

Together with in-depth interviews and Advisory Board design sessions, gaming simulation sessions were used to explicate participants' knowledge. Gaming simulation sessions were followed by debriefings in which participants' reflected on their actions and behavior. This section discusses the participants (section 3.1), the data collections from the methods applied (section 3.2) and how the data have been analyzed (section 3.3).

3.1. Participants

Interviewees in in-depth interviews (n = 26; all male) were conducted with 14 director-managers of growers who traded their fresh produce on the market themselves, six sellers employed at different cooperatives and six buyers employed at different wholesalers. These interviews were held to obtain information about the role, price and volume played in the negotiation process. Additional interviews (n = 15) were held until no new information was obtained with five employees of three cooperatives, one employed at an auction, one trading consultant, with three growers who traded directly with supermarkets and seven employees of three wholesalers.

Advisory Board members participated continually throughout the SamenMarkt process and their contribution was therefore identical to the previous studies (see section 1.3).

Participants in simulation sessions and debriefings (n = 18) traded tomatoes, peppers and cucumbers professionally on a daily basis and were employed by three wholesalers, one grower which traded products to retailers and two cooperatives. To avoid the Hawthorne effect, participants in the gaming simulation sessions were naive to the simulation itself and to its purpose (McCarney et al., 2007). The participants in each gaming simulation session were employed by one company (cooperative or wholesaler) or were invited to participate in the simulation session by this company. Participants reflected on their actions in the *debriefings* afterwards (Good & Su, 2011; Huss et al., 2008). All interviews and debriefings were conducted in physical presence and recorded with permission for which ethical approval was obtained from the Human Research Ethics Committee of the TU-Delft.

3.2. Data collection

Individual in-depth interviews Open-ended questions were used (Rossman & Rallis, 2017). Some broader topics were framed as questions to uncover participants' opinion or perspective (Adams, 2015). The topic categories related to participants' market position, cooperation, information exchange, pricing and participants' market vision. The topics and related questions can be found in Appendix D). The interviews were conducted by independent interviewers employed by the TU-Delft or Inholland University of Applied Sciences.

In *Advisory Board design sessions* the results from anonymized interviews were evaluated to explicate how a negotiation process leads to a deal. The Advisory Board provided feedback on prototype versions of the gaming simulation, composing the scenarios and selecting the relevant factors (de Wit, 2004).

Gaming simulation sessions were held with traders (sellers and buyers) of fresh produce. Given the confidential nature of trade information, gaming simulation sessions were held on-site at the participating companies. Employees of these companies (or from related companies) which traded fresh produce on a daily basis, participated in the gaming simulation sessions. Four gaming simulation sessions were played, three sessions with four participants and one session with six participants: 1 female, 17 male (females are hardly present in the field), of which 10 were occupied as cooperative and 8 as wholesaler.

Debriefings were organized directly after the simulation sessions to enable all participants to evaluate and reflect on their actions and to which extent their actions reflected reality (Van den Hoogen, Lo, Meijer, & Kriz, 2014, pp. 88–99). This evaluation and reflection is based on a combination of mental and social experiences (cognition, reflection, collaboration and affection) from the gaming simulation sessions (Chu, Ravana, Mok, & Chan, 2019).

3.3. Data analysis

The interviews were anonymously transcribed verbatim by the first author of this paper or by two independent transcribers employed by Inholland University of Applied Sciences using Elan version 5.8 (Sloetjes & Wittenburg, 2008). Transcripts were reviewed a second time by another transcriber. Transcripts were loaded into Atlas. ti (Atlas.ti, 2022), and deductively reviewed for instances in which participants discussed their experiences and tagged for additional coding (Charmaz, 2006). Differences in interpretations with transcriptions and with coding of the transcripts were discussed until an explicit reproduction of the conversation was clear.

Given the categorical nature of the data and the small sample size, Fisher's Exact test was used to determine relationships between the occupation of participants and the level of veracity of the simulated process (Field, 2013, pp. 686–690). Both two-sided and one-sided p-values are reported, as some studies define the p-value as twice the smallest of the one-sided p-values, with a maximum of 1 (Fay, 2010). To measure each dependence between two binary variables a φ test of

Cramer's V and uncertainty test were executed (Fisher, 1922). Descriptive statistics of the data (frequencies, mean and standard deviation/error) can be found in Table 1. Tests for confounding in the residuals with an outcome of more than 2 or less than −2, were considered to be significant (see Appendix E) (Sharpe, 2015). The larger any residual is the larger the contribution to the overall Fisher's Exact tests (Adetunji, Jemilohun, & Adaraniwon, 2015; Shan & Gerstenberger, 2017). To examine the presence of confounding variables Cochran's and Mantel-Haenszel statistics were calculated (Kuritz, Landis, & Koch, 1988; Upton, 2000). All statistical tests were performed with the software SPSS for Windows, version 26.0 (Corp, 2019).

4. Results

The development of the gaming simulation was based upon results from literature, interviews and Advisory Board design sessions. Two elements from the complex model of factors revealed in a previous study were selected to explore (reduction): price and volume. The interaction between those two elements has been described by rules as detailed as possible (precision contrary to abstraction).

Table 1
Descriptive statistics of participants' experiences.

Reflections from debriefings	n	yes	no	mean	Std	S.E.
1. The simulated scenario is similar to a trade scenario in real life	18	14	4	1.22	0.101	0.428
2. The data presented in the simulation is similar as data in reality	18	18	0			
3. The options in the trade model work similar as in reality	18	14	4	1.22	0.101	0.428
4. All trade options used in reality are present in the gaming simulation	18	15	3	1.17	0.090	0.383
5. All decision parameters used in reality are present in the gaming simulation	16	9	7	1.44	0.128	0.512
6. The representation of the data is sufficient for a realistic role fulfilment	17	16	1	1.06	0.059	0.243
7. The trade model in the simulation is sufficiently realistic for the role fulfilment	18	16	2	1.11	0.760	0.323
8. Information can be used in the same way as the information in reality	17	15	2	1.12	0.081	0.332
9. The information for the role of cooperative was complete	18	12	6	1.33	0.114	0.485
10. The information for the role of wholesaler was complete	18	18	0			
11. The experience in the simulation session felt like a normal working environment	18	10	8	1.44	0.121	0.485
12. The biddings appeared to be realistic	18	18	0			
13. The simulation contains the necessary functionalities to perform trade tasks in the gaming simulation	18	12	6	1.33	0.114	0.485
14. This simulation can be a precursor for a digital trading platform	18	10	8	1.44	0.121	0.511
15. This simulation can be used to train employees	12	12	0			
16. The instruction round matched the simulated scenarios	18	14	4	1.22	0.101	0.428
17. The online instruction round supported the participants' understanding of the simulation	14	14	0			

4.1. Interviews

Interviewees very rarely answered questions directly but shared story-wise personal experiences from their trade practices, which enabled researchers to identify the decision moments in the trade process. Based upon these stories a prototype of the present gaming simulation in trading greenhouse vegetables was created by researchers and presented to the Advisory Board. The first prototype was based upon four different scenarios. Each scenario differed in climate data (outside weather conditions and forecast, average greenhouse temperature), excess supply or demand on the world market, promotional activities of retailers and the extent in which the forecast of supply differed from the actual supply. Realistic data on prices, traded volumes, forecasts and the changes these data make over time were collected from additional interviews for greenhouse vegetables.

4.2. Advisory board design sessions

The Advisory Board evaluated how these decision moments were embedded in the gaming simulation, by testing two prototype versions of the gaming simulation. In the first prototype, information was simplified to the basic trade process in which the essential characteristics were included in detail. The essential characteristics are displayed in Fig. 3. In the second prototype the Advisory Board adjusted the data from fictitious to real data. Experts in the Advisory Board qualified fictitious data as an insult to participants from the field expecting them to feel tricked and disrespected. Additionally the rules of the gaming simulation were affirmed or challenged by content experts in Advisory Board design sessions. The rules were refined by identifying the characteristics of performances in prototype versions of the gaming simulation and were changed when the prototype differed meaningfully from the experience from content experts.

4.3. Debriefings

The debriefings were transcribed and coded. Participants' opinions on statements were analyzed quantitatively, and qualitatively evaluated by participants. There were no significant differences between the opinions of participants who fulfilled the role of cooperative or those that fulfilled the role of wholesaler (see table E2). The occupation of cooperative or wholesaler however, significantly influences opinions and has been analyzed in detail.

In four different simulation sessions, wholesalers and cooperatives from different companies participated in the gaming simulation and reflected upon their experiences in debriefings. Each sessions was held at an individual company, where participants could fulfil the roles of wholesaler and cooperative, regardless whether they were occupied as wholesaler or cooperative. The topics and corresponding descriptive statistics are presented in Table 1. In the debriefings participants reflected on the veracity of the trading process, the extent to which it mirrored their daily life and the functioning of the gaming simulation itself.

The responses of participants in the debriefings can broadly be categorized into mimicking reality (level of abstraction) and the performance of the gaming simulation (level of reduction). Statements (S) 1–8 reflected on the perceived reality-level of participants. Three or four participants (all employed as wholesaler) responded negatively to S.1, S.3 and S.4. Participants in initial denial of the validity of these statements showed a change of heart during a debriefing session from "it is a game and not realistic at all", to "it is realistic but you know it's a game, so the tension is game tension", ending with "it is too simple to come close to reality, the whole people management is missing and in reality you know when you make a wrong decision it hurts your wallet". Participants who responded positively (S.1, S.3, S.4) mentioned that all data (week numbers, prices, deviations in volume) and scenarios were realistically embedded, making it possible to act in accordance with their

daily profession. Asked which decision parameter (S.5) was missing participants responded that they could not convince the other party to close the deal based on personal interaction, missing the use and influence of speech and (positive) feelings and missing the option to award someone the deal (S.5). There was no doubt that the data in the simulation were real (S.2), nor that it were sufficient for a realistic role fulfilment (S.6, S.7). Although all participants in advance expected it to be unrealistic, 16 of the 18 participants explicitly stated that they could act as in reality.

Participants' discussion in the debriefing of the level of abstraction is represented by statements 9 to 17. Asked whether the information displayed was complete (S.9, S.10), the majority of participants employed as wholesalers appraised the information for the role of cooperative as incomplete, opposite to the information for the role of wholesaler. Participants employed as cooperative however, appraised information for the role of cooperative and wholesaler as complete. Wholesalers motivated their response by mentioning that they were not aware of the limited information position of cooperatives. About half of the respondents regarded the experience as a normal working environment (S.11). Eight participants mentioned the following elements to improve that experience (S.11, S13).

- Add two additional rounds: one week and one day market, to increase more pressure on the wholesalers side, when competition increases it will cause more pressure;
- Let participants decide how much volume is reserved for annual contracts;
- Use a minimum and maximum bid to avoid game-like behavior in under/over bidding;
- Build a difference in time length between rounds when the week and day market are simulated,

In discussing future opportunities (S.14), participants unanimously regarded this simulation useful to create awareness and understanding for educational purposes of teaching students and professionals, also in related fields (e.g. growers) (S.15, S.17). Although about half of the participants judged this simulation as insufficient to be the precursor of an online trading platform (S.14), all participants were convinced that online trading does not change tactical behavior of sellers and buyers. Four participants mentioned that the presentation of prices in the instruction round did not match with reality and neither with the simulated scenarios (S.16), generally the instruction round was regarded as useful for knowing where to find which information (S.17).

The outcome of the Fixed Effects test on whether differences in responses from participants were significant for occupation and roles, and the corresponding contingency table are presented in table E.1 and E.2 (Appendix E). The response on the statements was not influenced by the roles participants fulfilled. For some statements, it mattered whether the occupation was cooperative or wholesaler. Based upon participants' occupation, the disagreement with the statements S.3, S.4, S.9 and S.13 was statistically significant, which indicated that wholesalers had a different perspective on trade than cooperatives. For statement 3 and 4 the simulation mirrored the trade process, while wholesalers' in reality have a dual focus on trade and persuading trade partners. Wholesalers who fulfilled the role of cooperatives had a different expectation of the information, which was available. A multilevel Fixed Effects test indicated a significant difference between cooperatives and wholesalers fulfilling the role of cooperative ($p = 0.008$, 1-& 2-sided sign.). Contrary to wholesalers fulfilling the role of wholesaler ($p = 0.167$, 1-& 2-sided). Responses to statement 13 clearly indicated additional elements that could be introduced to increase the perception of reality.

A further analysis showed significantly strong associations (Cramers' V) at a 99% probability for statements 3, 9 and 13 and at a 95% probability for statement 4. Knowledge of participants' occupation could with 99% confidence contribute to reducing error in predicting the response to each statement with approximately 30–40%. The corresponding statistics of Cramers' V and the uncertainty coefficient are presented in table E.4. The test for conditional independence between occupation and the statements controlled for one or more confounding factors (see for statistical details table E.5). The statements 1, 5–8, 11, 14 and 16 had a p-value above 0.05, which indicated absence of evidence for any confounding factor. The p-value below 0.05, which indicated evidence of conditional independence for the statements 3, 4, 9, and 13, which means that there are one or more confounding factor(s) present. The outcome of the residuals also provides the possibility for confounding in the residuals of the same statements, see table E.3.

These results show that details increased the commitment of participants. Reduction of reality caused a limited experience on the available trade options (S.3, S.4, and S.13). Despite the reduction of reality, participants declared to have acted as in reality (S.11, S.12). The information and its representation, the process modelled and the decision parameters present were considered suitable for a realistic role fulfilment (S.1, S.2, S.5, S.6, S.7 and S.8). The results also indicate ex ante information asymmetry between cooperatives and wholesalers, which wholesalers were unaware of (S.9, S.10). A further application or development of this gaming simulation did have the potential for learning by experience or for a future online trading platform (S.15, S.16 and S.17).

5. Discussion

The development of gaming simulations to extract knowledge is limited in the literature and even more when it comes to tacit knowledge. However, that does not make the significance of gaming simulations to explicate tacit knowledge any less relevant. This section discusses that relevance from the perspective of model simplification (section 5.1), a specific context based upon theory (section 5.2) and its meaning for the acquisition of knowledge from the tacit domain (section 5.3).

5.1. Simplified models and validity

Studies discussing the simplification of models in gaming simulations in relation to the concept of validity are hardly present in literature (Peters et al., 1998). Insolubly bound up with developing (gaming) simulations is the simplification of reality, which is the foundation of any scientific model (Box, 1976). This raises the question why to practice or rely on simplifications when those models only represent parts of the truth and never the whole truth (Wit, Heuvel, & Romeijn, 2012). Firstly, part of the answer is given by participants stating, "We could still act as in reality", despite their notifications that the gaming simulation displayed a reduction of reality. Wenmackers and Vanpoucke (2012) define a good model as the balance between being useful but not too wrong, but with the annotation: how to be sure that the elements selected indeed apply to reality? This brings us to the second part of the answer: despite the reduction in reality, methodological aspects ensured that the selected elements resembled reality (ecological validity) and its reality-detailed level with precision (content validity). Experts responded with agreement on the selection of elements in Advisory Board design sessions. The presence of feedback loops enabled adjustments during the gaming simulation development process. The participatory design (internal validity) enabled the multiple sessions with experts by experience (reliability) to have a mutual evaluation of the selected elements in a collective 'reflection-in-action' (debriefings). The combination of different methods, the prior testing of prototypes and the multiple gaming simulation sessions contribute to internal and external validity.

Precision is enhanced by including game elements in the simulation like role-play and the competition to win. Some discuss that role-play with conflicting interests has a better predictive value than game theory (Green, 2002). Other studies argue that the combination of role-play and game theory increases the predictive value and also performs a

consistent trustworthy outcome (Bolton, 2002; Bolton & Kwasnica, 2002). The contest to win represented the conflicting interest of the roles and can be expressed in a probabilistic choice function which statistical measures survey its predictive validity (Chen, Hoyle, & Wassenaar, 2013). Other elements such as the quest for realism (in data, rules, actions, time pressure) increased the validity of the gaming simulation design.

5.2. Theory driven or context specific research

The segregation between gaming simulations developed for theory driven or domain specific research has been discussed in literature alongside the academic approach and the application of game design (Klabbers, 2003, 2018; Kriz & Hense, 2006). This gaming simulation bridges the difference between those fields by focusing on the instrumentality and methodological pluralism of the gaming simulation as well the contribution to analytical research. This gaming simulation can be explored as a tool to collect data in behavioral research, e.g. tactics and strategies in horticultural trade, especially since all participants declared they could act as in reality with all relevant decision parameters and necessary information present. The results show the possibility of developing a simplified gaming simulation, which improves domain specific knowledge and at the same time can contribute to context independent knowledge. The results indicate the possible application of this gaming simulation in the field, to study the trading behavior, its actual tactics and sequentially applied strategies of participants. Trade in horticulture seemingly exemplifies the principal-agent dilemma, because of the conflict of interest between cooperatives and wholesalers and the occurrence of asymmetric information. Taking the presence of confounding in the covariates and residuals into account, further research into causal and economic relations between factors is one of the options.

5.3. Acquisition of knowledge from the tacit domain

The explication of tacit knowledge from skills requires the support of an organizational structure and environment (Sternberg et al., 2000). In this study the organizational structure and environment was set by the participatory design, private company sessions and gaming simulation design.

Participatory designs have in common that they enable participants to act. This empowers participants to express their experience and knowledge by means of actions, which matches with the concept that tacit knowledge is the necessary component of any action (Alvesson, Kärreman, & Swan, 2002; Tsoukas, 2005). In line with other studies, participants themselves realized that this design enabled and utilized experimental and experiential learning and reflective practices that could be explored in further research (Dewey, 1986; Schön, 2017; Zhang et al., 2018). Participatory research and design is known for its diversity, making it difficult to extrapolate the results from one case to another and to generalize the results (Beierle, 2010; Cornwall & Jewkes, 1995). Participants experience consciously or unconsciously "reflection-in-action" that affects their learning process while playing the gaming simulation (Klabbers, 2018). The simplified design with fixed rules and actions, does not distinguish explicated tacit knowledge that was raised from the reflection-in-action, which would have been explicated if all participants could adapt the design while being in action. Adaptation of the design while participating in the gaming simulation sessions was limited to the Advisory Board meetings. An earlier study where participants could adapt the design showed a similar outcome for the design process as in this study (Van Haaften et al., 2021). The combination with the modelling of gaming simulations makes this method sensitive to contextual adaptations, which matches with the personal and context-based nature of tacit knowledge (Nonaka & Takeuchi, 2007). The focus on the process itself, more than on the context, resulted in the appraisal by participants that this simulation is sector-wide useful for learning purposes and gathering trade knowledge. The participation of multiple players, avoids a discussion on the characterization of tacit knowledge as individual (Nonaka & Takeuchi, 2007), or also collective knowledge (Baumard, 1999).

Private company sessions were held on-site, where the participants in each session were all employed by the same cooperative or wholesaler, or were nominated by the company to participate. In addition to the competitive sensitivity, this also decreased the level of risk and uncertainty for participants regarding any exposed trade knowledge displayed from the actions in the gaming simulation. This is in line with other business oriented research in which trusted relationships between participants were critical to the exchange of tacit knowledge (Foos, Schum, & Rothenberg, 2006; Holste & Fields, 2010). This however comes with the limitation that there are unexploited sources of tacit knowledge. Although trade relations are submissive to price and volume when trading a commodity, intangibles (beliefs, culture, emotions, social norms) from reality might have played a role in the decisions participants made, while trading in the gaming simulation sessions (Klabbers, 2018; Polanyi, 2009). Familiarity with the environment in which the gaming simulation sessions are played ensures a higher reliability of the results. Research on designing knowledge and learning concepts demonstrates better outcomes in environments that support and foster the natural complexity of the content and are executed and instructed in participants' real-world context (Faulkner, 1994; Vincenti, 1990). The authenticity that comes with these natural environments increases engagement and collaboration (Kearsley & Shneiderman, 1998), and validate the generalizability of the outcomes. This emphasizes the relevance for mirroring real world processes or situations set by a structural approach in order to extract tacit knowledge (K. S. Johannessen, 1988).

Gaming simulations provide an organized environment where experts by experience can act or play. Tacit knowledge can be characterized by insight, beliefs, mental models, skills, practical intelligence and know-how (McAdam, Mason, & McCrory, 2007). The latter three can be empirically investigated and rationalized with gaming simulations (J.-A. Johannessen, Olaisen, & Olsen, 2001). The founders of statistical inference (including R.A. Fisher) emphasized that their methods only are valid in the absence of any prior knowledge (Jeffreys, 1998), which in the context of tacit knowledge creates insight into the level of probabilities. Confounding can be approached from a statistical perspective, testing the degree of variability not taken into account by measuring it or eliminating it (Berrett, Wang, Barber, & Samworth, 2020). Interesting is that the statistical results for the majority of statements indicated absence of evidence for any confounding factor. Gaming simulations moreover, enable the examination of causality and corresponding causal confounding relations (Zeigler, 2019). When gaming simulations represent reality plausibly and meet the conditions to intervene for counterfactuals, the possibility arises to uncover causal relationships given a set of information (v) participants have and the actions they perform (x) ($P(v) \mid do(x)$) (Bareinboim & Pearl, 2016). This means that the reduction of reality is inherent in the capture of tacit knowledge, as well as the most accurate representation of reality.

6. Conclusion

This study shows that a simplified design of a gaming simulation can represent real world processes without compromising the validity corresponding to the real-world complexity. The results indicate that the applied level of abstraction together with the variance in truthfulness should be minimized. The results also show that simplification of the real world did not affect participants' perspective on the use of the gaming simulation as an experiential tool to enable learning processes or create awareness.

The design was based upon the actual experience of experts from the field, through interviews and Advisory Board design sessions. This resulted in gaming simulation sessions where experts by experience

could interact realistically in the process simulated. Although these processes are tacitly performed by participants in the real world, the separate repeated simulation sessions at different companies resulted in a consistent outcome ensuring the reliability and generalizability (external validity) of this gaming simulation.

The results also indicate the suitability of this gaming simulation as a research tool to collect further data. The attention to precision and detail from participants for the simulated process contributed to the internal validity and reliability. The participation in a simulated process creates sequentiality between action and consequence, which opens possibilities for examining causal relations between participants' behavior and factors included in the gaming simulation design.

CRediT authorship contribution statement

M.A. van Haaften: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Validation, Writing – original draft, Visualization. **I. Lefter:** Supervision, Validation, Visualization, Writing – review & editing. **O. van Kooten:** Conceptualization, Supervision, Validation, Writing – review & editing, Investigation. **F.M. Brazier:** Conceptualization, Investigation, Supervision, Validation, Visualization, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The authors declare the following financial interests: M.A. van Haaften received financial support for this work from the Dutch Research Council (Nederlandse Organisatie voor Wetenschappelijk Onderzoek), specifically the Doctoral Grant for Teachers program.

Data availability

An overview of the data can be found in the appendices which are attached as supplementary material for online publication.

Appendix A. Accountability of validity types and reliability

Table A.1
Accountability of validity types and reliability in the gaming simulation design

VALIDITY CONCEPT	DESCRIPTION	RESEARCH DESIGN ELEMENT	APPLIED IN SIMULATION DEVELOPMENT
CONSTRUCT VALIDITY	Total aggregation of evidence based upon other validity types to support the interpretation of what a simulation reflects (Cronbach & Meehl, 1955; Polit & Beck, 2008)	Include feedback loops in the research design (Adams, 2015; Parshall & Guille, 2015).	See section 2.1 (Fig. 1) for feedback loops.
CONTENT VALIDITY	'The systematic examination of the content to determine whether the simulation represents the domain (Anastasi & Urbina, 1997, p. 114)	Calculate and evaluate the content validity ratio (Lawshe, 1975; Wilson, Pan, & Schumsky, 2012)* Statistical and qualitative evaluation of domain expert opinions (Sadeghi et al., 2022).	See section 3.3 and 4.3 for the qualitative and quantitative analysis and results.
PREDICTIVE VALIDITY	Predictive validity determines to which degree operationalisation provides accurate future outcomes (Lo & Meijer, 2014)	Create rules that resemble the rules of what is simulated as closely and accurately as possible (Dormans, 2011) Role-play results in accurate predictions or forecasts (Bolton, 2002; Green, 2002)	The simplified design was based upon a high level of precision. The outcome is shown in section 4.3. Role-play is discussed in section 2.2. The rules of the gaming simulation are discussed in section 2.3.
INTERNAL VALIDITY	The extent to which the gaming simulation generates accurate and unambiguous conclusions from the results (De Vaus, 2010) The results support a claim about cause and effect (Shadish, Cook, & Campbell, 2002)	Simulation-based assessment based on participants' actions (Mislevy et al., 2016) Triangulation of research methods (Sari & Bogdan, 1992). Address rival explanations (Stainton, Johnson, & Borodzicz, 2010). Participants field experience is used in an applicable situation or process (Toulmin, 2003).	Participants by experience provided input for the simulated process. An overview of the different methods is presented in Fig. 1. Rival explanations are discussed in section 5. Participants by experience participated in every research method, see section 3.
EXTERNAL VALIDITY	The extent to which results from this study are generalizable beyond this study (De Vaus, 2010; Feinstein & Cannon, 2002).	Examining multiple cases for replication (Stainton et al., 2010)	Multiple gaming simulation sessions were held at different companies.
ECOLOGICAL VALIDITY	The extent to which what is simulated predicts similar outcomes in the real-world (Brunswik & Kamiya, 1953)	Consensus of experts regarding the content (Clauser, Margolis, & Clauser, 2016) Participatory design (Spinuzzi, 2005)	The consensus of experts by experience is evaluated and analyzed in section 4. The applied participatory design is discussed in see section 1.1 and 3.1.
RELIABILITY	The reliability of a gaming simulation is concerned with a consistent outcome after running repeated simulations (Berchtold, 2016).	Minimize error and bias of participants and researchers to obtain equal results when measurements (gaming simulation sessions) are repeated (Green, 2002).	Table 1 provides an overview of how consistent the outcomes are among the different simulation sessions.

Legenda: * Given the data it was not possible to calculate Content Validity Ratio (CVR) in all cases and therefore not applied in this study, but included for the sake of completeness.

Appendix B. Prototype gaming simulation

The goal of the prototype was similar as the present gaming simulation: explicating knowledge from behavior and skills. The prototype of the gaming simulation was based upon different scenario's (S), possible events (E), profiles of supply chain members (P) and the creation of the yield forecast (F). In the prototype gaming simulation session (s) the behavior of each individual (i) participant could be described as $\prod_{i}^{s}(S,E,P,F)$. These different elements are individually discussed in the following eponymous sections.

Scenario's

Five different scenario's had been composed, in which data of exogenous variables was displayed. An overview is presented in Fig. 1. These variables were expected to influence price and volume. Experts by experience in Advisory Board meetings appraised these scenario's as unrealistic and unnecessarily offending. The combination of week numbers and temperatures did not match reality. Likewise the sun hours, the distribution between week market and day market, domestic supply and demand in the Netherlands, which numbers were evaluated to be too low. Both, the supermarket price and international market price, were assessed to be too high. Playing a simulation with these scenario's triggered resistance from Advisory Board members, who judged it as impossible to work with.

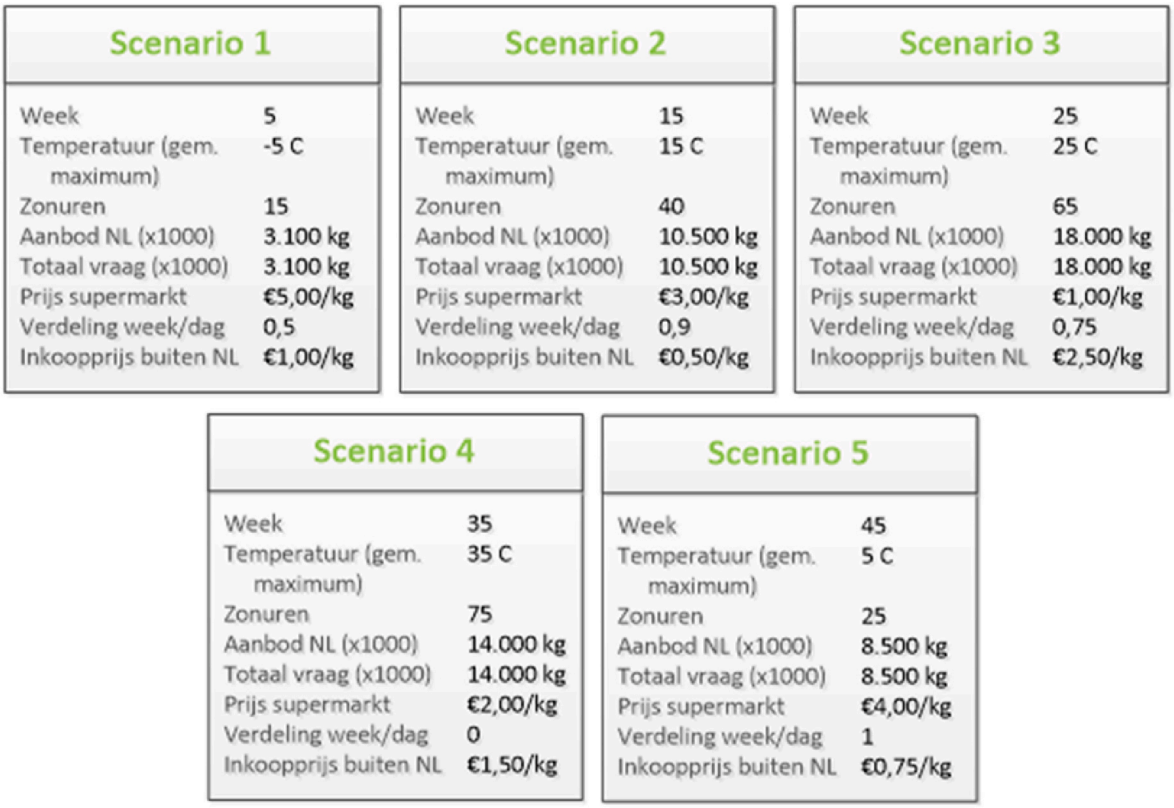

Fig. B.1. Overview of different scenario's.

Events

The occurrence of an occasional and unexpected event created uncertainty regarding the data associated with this event (Wasserkrug, 2009). The occurrence of these events caused an unexpected change in the trade factors price and volume. In the prototype, only one of these events could happen randomly at an individual player. Six different events were included, causing a change in cost price, increase in international market supply, production-enhancing inventions, new product market combinations, pressure from pests or diseases, increase in international market demand (celebration of public holiday's). These six different occasional events are shown in Fig. B.2. According to experts by experience in Advisory Board meetings, the occurrence of events was accounted for in the volume that growers supplied to cooperatives. The volume to be supplied to cooperatives was Including these events would suggests participants' understood that this influenced the yield and consequently supply. In the Advisory Board meeting it became clear that wholesalers and retailers had no notion of how these factors affect the yield and also supply. Events were therefore left out in the final gaming simulation.

Fig. B.2. Display of different events included in the prototype.

Profiles of supply chain members

For each supply chain member different profiles were compiled. Participants who fulfilled the role of growers could choose from different profiles. Each profile included the production area, yield per square meter, whether the crop makes use of lamps to add artificial light to the level of natural sunlight (assimilation lightning), when the crop will be ended, the percentage of secondary quality, cost price and the income per kilogram last year. The included information in each profile does influence the supply a grower communicates with a cooperative. However about 90% of all growers don't trade directly with wholesalers, except when their nurseries are very large (>50 ha). Growers deliver their volume to cooperatives to trade. Grower profiles were therefore not included in the final gaming simulation.

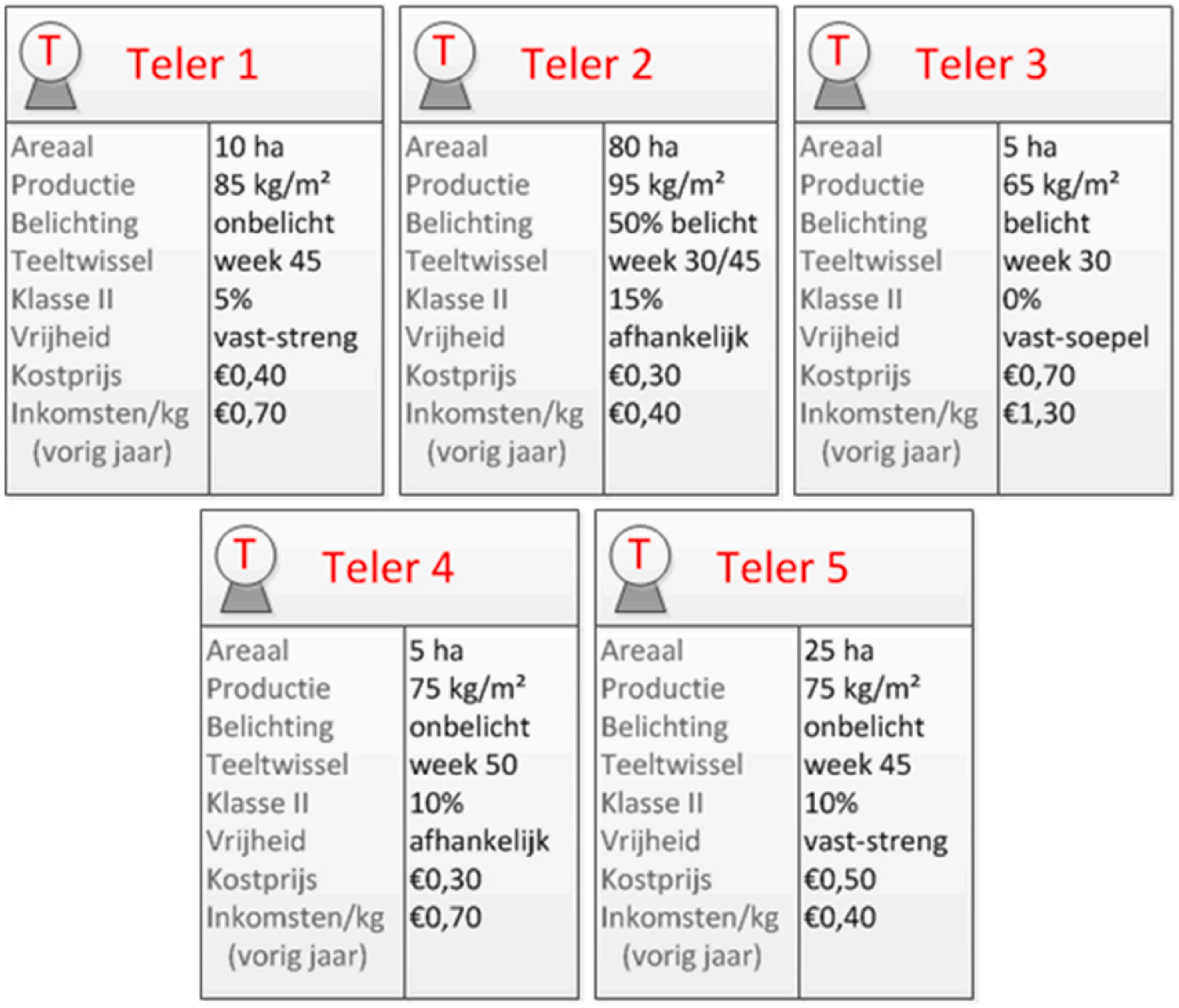

Fig. B.3. Grower profiles in the prototype gaming simulation.

Participants from the Advisory Board who fulfilled the role of cooperative had the choice from four different profiles. Each profile came with the characteristics of the supply offered to trade, its quality, the number of growers and corresponding production area and the extent to which co-operatives could act independently from their growers. Cooperatives are owned by a collection of growers. In the Advisory Board meetings and from interviews it became clear that production area and number of affiliated growers, did not make a difference with regard to trade. In the end only the production volume that growers deliver to the cooperative, is what sellers use in trading with wholesalers. Like in the previous study Advisory Board members and interviewees stated that consensus on the quality of the goods between cooperative and wholesaler exists, before the actual negotiations take place (Van Haaften et al., 2021). Quality aspects are therefore left out in the final gaming simulation design. The Advisory Board appraised a sellers freedom to act not to be relevant in trading. When it comes to trading someone has to get the highest price.

Fig. B.4. Profiles of cooperatives.

For wholesalers there were also four different profiles made. The capacity symbolized the volume to trade and its corresponding quality level is mentioned. Additionally the number of affiliated cooperatives wholesalers regularly trade with is mentioned and how strong the connection between wholesaler and cooperative is (low/regular/high). The available information was appraised by members of the Advisory Board as incomplete, while the strength of business ties and quality were regarded as irrelevant and both were left out in the final gaming simulation. Wholesalers match demand from retailers and supply from cooperatives. The difference between purchasing price and selling price, minus the fixed costs is the profit they make. In order to fulfil the demand of retailers, wholesalers make appointments on the volume to be delivered and the price they get. If wholesalers don't deliver, retailers will impose a fine per kilogram that not has been delivered. In the final gaming simulation the fine, fixed costs and retail price were added.

Fig. B.5. Profiles of wholesalers.

The four profiles of retailers differed in the strength of their relationship with wholesalers on a scale of low-medium-high. A similar threefold scale was used to express how strict delivery specifics (quality, time per week) and a delivery obligation were retained (strict-middle-flexible). The majority of retail organizations have purchasing centralized, although some retail organizations have purchasing organized on a regional level. Last comes the business formula retail organizations apply: discount or full-service. Retailers tell wholesalers which volume they need and which price is paid for delivering this volume. When wholesalers agree to this, the price, volume and frequency is laid down in an agreement. Negotiation is largely absent between retailers and wholesalers. For this reason the profile of retailers has been left out in the final gaming simulation.

Fig. B.6. Profiles of retailers.

Yield forecasts

Growers estimated their yields and communicated their expected yields with cooperatives as the supply they expect to deliver. The difference between yield and supply varied between 10% and 50%. Growers and Cooperatives could change the difference by a percentage. In the final gaming simulation the Advisory Board advised strongly to drop this factor and choose for a fixed deviation of 10%.

Appendix C. Trading options in gaming simulation

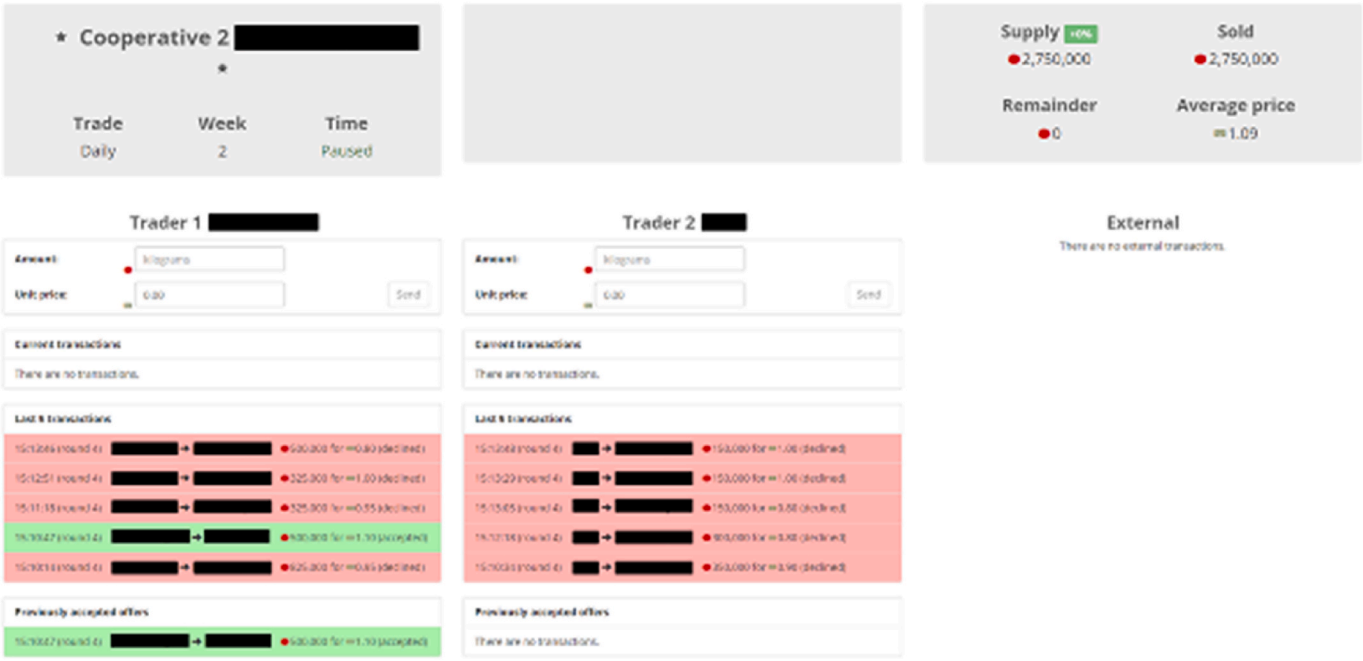

Fig. C.1. Trading options for cooperatives in gaming simulation.

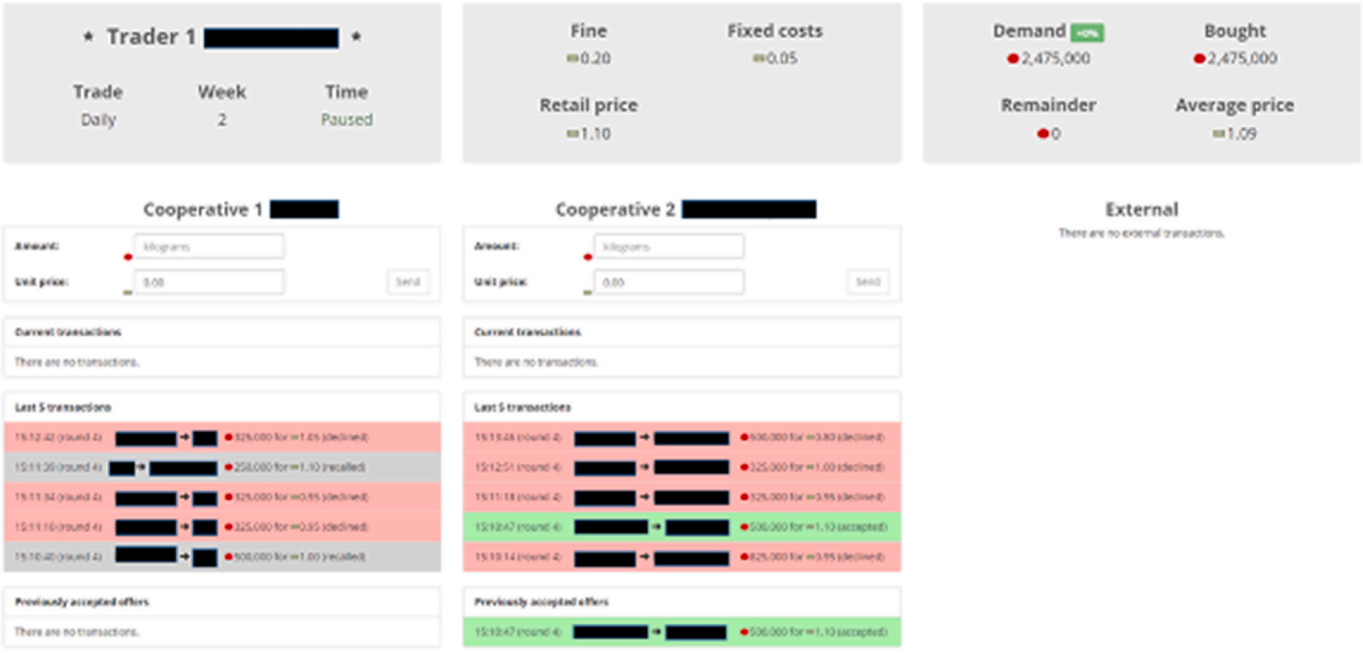

Fig. C.2. Trading options for wholesalers in gaming simulation.

Appendix D. Structure in-depth open interviews

Introduction

For the SamenMarkt-project, we are mapping out the market and supply chain of greenhouse vegetables like tomatoes, peppers, cucumbers, etc. To investigate what exactly happens in trade from the grower to the retailer. The project was set up jointly by Inholland University of Applied Sciences, TU-Delft and the Wageningen University as a research project. For this interview we are interested in the market and trade in the supply chain, and the incentives. To understand why things go the way they do.

Questions

Can you describe your position in the supply chain compared to other companies?

- Points of interest: number of players, size of players, size of produced volume, size of traded volume, influence of player on competitors or colleagues and vice versa, influence of players on the market structure
  Can you describe how trade is organized in the supply chain?
- Points of interest: goods, money and information, how transparent is the market and the supply chain and why

  What role does information/supply & demand/prices play in negotiating a deal.

- which information is necessary to determine the price, which public, market or competitive information is involved, etc.
  Can you explain how companies in the supply chain do cooperate and why?
- Points of interest: formal or informal contact, long term/short term contacts, variable/fixed business relations, differences in contract types, etc.?
  Can you explain how prices are established from bidding to agreement?
- Points of interest: when are prices concluded, for what period are prices determined, how does this differ between companies, etc.

  What is your vision on the markets' future?
  Feedback on how to get that future realized?

Appendix E. Outcome of the statistical tests

1. Frequency table of statements crossed with participants occupation

Table E.1
Occurrences of statements x occupation

Statement	Role:	Occupation			
		Cooperative		Wholesaler	
		#	%	#	%
1. The simulated scenario is similar to a trade scenario in real life	*Yes*	7	70.0	7	87.5
	No	3	30.0	1	12.5
2. The data presented in the simulation is similar as data in reality	*Yes*	10	100.0	8	100.0
	No	0	0	0	0
3. The options in the trade model work similar as in reality	*Yes*	10	100.0	4	50.0
	No	0	0	4	50.0
4. All trade options used in reality are present in the gaming simulation	*Yes*	10	100.0	5	62.5
	No	0	0	3	37.5
5. All decision parameters used in reality are present in the gaming simulation	*Yes*	5	55.6	4	57.1
	No	4	44.4	3	42.9
6. The representation of the data is sufficient for a realistic role fulfilment	*Yes*	10	100.0	6	85.7
	No	0	0	1	14.3
7. The trade model in the simulation is sufficiently realistic for the role fulfilment	*Yes*	8	80.0	8	100.0
	No	2	20.0	0	0
8. Information can be used in the same way as the information in reality	*Yes*	9	100.0	6	75.0
	No	0	0	2	25.0
9. The information for the role of cooperative was complete	*Yes*	10	100.0	2	25.0
	No	0	0	6	75.0
10. The information for the role of wholesaler was complete	*Yes*	10	100.0	8	100.0
	No	0	0	0	0
11. The experience in the simulation session felt like a normal working environment	*Yes*	5	50.0	5	62.5
	No	5	50.0	3	37.5
12. The biddings appeared to be realistic	*Yes*	10	100.0	8	100.0
	No	0	0	0	0
13. The simulation contains the necessary functionalities to perform trade tasks in the gaming simulation	*Yes*	4	40.0	8	100.0
	No	6	60.0	0	0
14. This simulation can be a precursor for a digital trading platform	*Yes*	6	60.0	4	50.0
	No	4	40.0	4	50.0
15. This simulation can be used to train employees	*Yes*	4	100.0	8	100.0
	No	0	0	0	0
16. The instruction round matched the simulated scenarios	*Yes*	9	90.0	5	62.5
	No	1	10.0	3	37.5
17. The online instruction round supported the participants' understanding of the simulation	*Yes*	6	100.0	8	100.0
	No	0	0	0	0

2. Results of the Fisher's Exact test

The results of the Fisher's Exact test are presented with a one and two sided significance for occupation x statement and role x statement. Significant outcomes are marked with an asterisk.

Table E.2
Statistical analysis of the relation between occupation and statement

Fisher's Exact test (cooperative/wholesaler)	Occupation		Role	
Statement	sign. 2-sided	sign. 1-sided	sign. 2-sided	sign. 1-sided
1. The simulated scenario is similar to a trade scenario in real life	0.588	0.382	1.000	0.712
3. The options in the trade model work similar as in reality	0.023	0.023*	1.000	0.712
4. All trade options used in reality are present in the gaming simulation	0.069	0.069**	1.000	0.500
5. All decision parameters used in reality are present in the gaming simulation	1.000	0.581	1.000	0.601
6. The representation of the data is sufficient for a realistic role fulfilment	0.412	0.412	1.000	0.529
7. The trade model in the simulation is sufficiently realistic for the role fulfilment	0.477	0.294	1.000	0.765
8. Information can be used in the same way as the information in reality	0.206	0.206	0.206	0.206
9. The information for the role of cooperative was complete	0.002	0.002*	0.620	0.310
11. The experience in the simulation session felt like a normal working environment	0.664	0.480	1.000	0.681
13. The simulation contains the necessary functionalities to perform trade tasks in the gaming simulation	0.013	0.011*	1.000	0.690
14. This simulation can be precursor for a digital trading platform	1.000	0.520	0.637	0.319
16. The instruction round matched the simulated scenarios	0.275	0.206	0.576	0.288

* significant at 95% confidence interval, ** significant at 90% confidence interval.

3. Standardized and adjusted residuals for each statement x occupation

There are no residuals calculated for the statements 2, 10, 12, 15 and 17, because the outcome was unanimous. The statements 3, 4, 9 and 13 are marked with an asterisk to indicate a significant outcome, which means that the possibility of confounding in the residuals is present.

Table E.3
Residual analyses of the statements x occupation

		Occupation			
Statement	Residual:	Cooperative		Wholesaler	
		Yes	No	Yes	No
1. The simulated scenario is similar to a trade scenario in real life	*Standardized*	−0.3	0.5	0.3	−0.6
	Adjusted	−0.9	0.9	0.9	−0.9
3. The options in the trade model work similar as in reality	*Standardized*	0.8	−1.5	−0.9	1.7
	*Adjusted**	2.5	−2.5	−2.5	2.5
4. All trade options used in reality are present in the gaming simulation	*Standardized*	0.6	−1.3	−0.6	1.4
	*Adjusted**	2.1	−2.1	−2.1	2.1
5. All decision parameters used in reality are present in the gaming simulation	*Standardized*	0	0	0	0
	Adjusted	−0.1	0.1	0.1	−0.1
6. The representation of the data is sufficient for a realistic role fulfilment	*Standardized*	0.2	−0.8	−0.2	0.9
	Adjusted	1.2	−1.2	−1.2	1.2
7. The trade model in the simulation is sufficiently realistic for the role fulfilment	*Standardized*	−0.3	0.8	0.3	−0.9
	Adjusted	−1.3	1.3	1.3	−1.3
8. Information can be used in the same way as the information in reality	*Standardized*	0.4	−1.0	−0.4	1.1
	Adjusted	1.6	−1.6	−1.6	1.6
9. The information for the role of cooperative was complete	*Standardized*	1.3	−1.8	−1.4	2.0
	*Adjusted**	3.4	−3.4	−3.4	3.4
11. The experience in the simulation session felt like a normal working environment	*Standardized*	−0.2	0.3	0.3	−0.3
	Adjusted	−0.5	0.5	0.5	−0.5
13. The simulation contains the necessary functionalities to perform trade tasks in the gaming simulation	*Standardized*	−1.0	1.5	1.2	−1.6
	*Adjusted**	−2.7	2.7	2.7	−2.7
14. This simulation can be a precursor for a digital trading platform	*Standardized*	0.2	−0.2	−0.2	0.2
	Adjusted	0.4	−0.4	−0.4	0.4
16. The instruction round matched the simulated scenarios	*Standardized*	0.4	−0.8	−0.5	0.9
	Adjusted	1.4	−1.4	−1.4	1.4

4. Association between Occupation and perceived reduction/abstraction

Statistical estimations showed a strong association (Cramers' V) of 59.8% for statement 3, 79.1% for statement 9 and 63.2% for statement 13 with a 99% probability, and an association of 50% for statement 4 with 95% probability. The uncertainty coefficient indicated that knowing a participant's occupation reduces error in predicting the response to each statement of 36.4% for statement 3, 27.5% for statement 4, 58.4% for statement 9 and 39.7% for statement 13, all at a 99% confidence interval.

Table E.4
Association and conditional independence between occupation and statement

	Cramer's V		Uncertainty coefficient	
Statement	value	p-value	value	p-value

(*continued on next page*)

Table E.4 (*continued*)

	Cramer's V		Uncertainty coefficient	
Statement	value	p-value	value	p-value
3. The options in the trade model work similar as in reality	0.598	0.011	0.364	0.005
4. All trade options used in reality are present in the gaming simulation	0.500	0.034	0.275	0.018
9. The information for the role of cooperative was complete	0.791	0.001	0.584	0.000
13. The simulation contains the necessary functionalities to perform trade tasks in the gaming simulation	0.632	0.007	0.397	0.002

5. Test for conditional independence

Table E.5
Testing for absence or presence of confounding variables

Tests of conditional independence:	Cochran's		Mantel-Haenszel	
Statement	Chi^2	p-value	Chi^2	p-value
1. The simulated scenario is similar to a trade scenario in real life	0.788	0.375	0.095	0.758
3. The options in the trade model work similar as in reality	6.429	0.011	3.647	0.056
4. All trade options used in reality are present in the gaming simulation	4.500	0.034	2.083	0.149
5. All decision parameters used in reality are present in the gaming simulation	0.004	0.949	0.185	0.667
6. The representation data is sufficient for a realistic role fulfilment	1.518	0.218	0.032	0.858
7. The trade model in the simulation is sufficiently realistic for the role fulfilment	1.800	0.180	0.325	0.568
8. Information can be used in the same way as the information in reality	2.550	0.110	0.669	0.414
9. The information for the role of cooperative was complete	11.250	0.001	7.677	0.006
11. The experience in the simulation session felt like a normal working environment	0.281	0.596	0.003	0.959
13. The simulation contains the necessary functionalities to perform trade tasks in the gaming simulation	7.200	0.007	4.489	0.034
14. This simulation can be a precursor for a digital trading platform	0.180	0.671	0.003	0.959
16. The trial session matched the simulated scenarios	1.945	0.163	0.641	0.423

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