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Enhancing digital transformation towards virtual supply chains: a simulation game for Dutch floriculture

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ABSTRACT

Supply chains are increasingly being virtualized in response to globalization and emerging market challenges. Virtualization requires technical innovation using IoT technologies such as smart sensors, and it allows to transmit quality information across the chain. Associated organizational innovation is complex, especially in SME-dominated supply chains, and relies upon intensive knowledge exchange, discussions and negotiation. However, the development of solutions to address socio-institutional barriers to virtual supply chains has been under-researched up to now. This study analyses barriers to virtualization faced in SME-dominated supply chains, that is, the Dutch floriculture. The second step is developing a solution to core barriers in the form of a dedicated simulation game, the 'Virtual Flower Chain'. Design and experiences are shown. The barriers that the game addresses are a sector-wide lack of cooperation, consumer focus, and sense of urgency, as well as a limited understanding of virtualization. The validation through game sessions shows that 87% of the participants gained more insights about the benefits of virtualization technologies and the willingness to collaborate, rather than blaming others, increased to 89% after the game. Game participants achieved more awareness of their position in a larger system, rather than as an isolated business.

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Virtualization; supply chain management; digital transformation; Internet of things; floriculture; simulation games

1. Introduction

In today's turbulent business environment, supply chains have to be competitive and dynamic, through continuous technological, structural, institutional and organizational changes (Beer et al. 2005; Tennant and Fernie 2013). These changes require new attitudes and innovative strategies, as well as the reconsideration of businesses̀ methods of operation (Shahzard et al. 2012). Supply chains in which larger numbers of smaller companies, without a hegemonic partner, deal with living produce are particularly affected.

In this context, Internet of Things (IoT) technologies represent a major technological development, as they allow to gather data from physical elements and analyse, control and interact with devices, equipment, and people. As a consequence of this technological development, supply chains are increasingly being virtualized (Ho, Au, and Newton 2003; Verdouw, Beulens, and van der Vorst 2013; Ivanov and Dolgui 2020). Virtualization can be defined as the digital representation of historical, present and future states of a physical object (Verdouw et al. 2015). Virtualization allows more efficient logistics by decoupling physical flows from information aspects of supply chain operations (Clarke 1998; Van der Vorst et al. 2016).

A shift to virtualization requires technical as well as organizational innovation. Until now, the focus has very much been on enabling IoT technologies, such as smart sensors, cloud computing and artificial intelligence, but virtualization can have a large organizational impact on business processes and supply chain collaboration as well (Chen et al. 2014). While technology is maturing fast, innovation seems to be delayed by organizational barriers (Van Kranenburg and Bassi 2012; Hsu and Lin 2018; Brous, Janssen, and Herder 2020). Overcoming these requires a fundamental change of business strategies, business processes, firm capabilities, products and services, and key inter-firm relationships (Bharadwaj et al. 2013; Falkenreck and Wagner 2017). Moreover, it requires socio-institutional change: the definition of new roles and agreements, the change in communication among different stakeholders as well as their workflow schemes and skills (Piccoli 2012; Eastwood, Klerkx, and Nettle 2017).

The picture that emerges, somewhat counterintuitively, is that in order for technical innovation to happen in a sector with small enterprises, instilling technical knowledge may not be enough. It is widely argued in literature that a digital transformation is needed, which is especially hindered by organizational and behavioural barriers (Bowersox, Closs, and Drayer 2005; Fitzgerald et al. 2014; Büyüközkan and Göçer 2018;

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Agrawal, Narain, and Ullah 2019). This is where the research gap is situated. This is the case of the Dutch floriculture sector, to be introduced in detail later. To find out which change is needed, a careful diagnosis of socio-institutional issues is needed that involves a wide range of stakeholders, since they are the people facing the incentives that block the change. Subsequently, targeted organizational learning tools can be designed, to facilitate the required changes.

For this reason, the present paper proposes simulation gaming to address the socio-institutional barriers for digital transformation towards virtual supply chains. Simulation games are a powerful tool to support organizational learning, as they offer an experimental setting to simulate the innovation process through practice in a risk-free environment (Saenz and Cano 2009). This can be done for instance by reflecting on the various processes that lead to organizational change, such as negotiation, dealing with conflicts, decision-making, and project planning. Additionally, they allow individuals and groups to participate in active dynamic interaction with a common challenge that they have to manage (Saenz and Cano 2009; Hofstede et al. 2010). Finally, they can be used to trigger knowledge exchange, to stimulate discussions about shared problems (Salvini, van Paassen, et al. 2016) and to achieve a joint understanding of system dynamics (Boissau and Castella 2003; Etienne 2003; Salvini, Ligtenberg, et al. 2016).

Simulation games have been used to support learning in a wide range of fields, from quality (Wang 2004) to supply chain management (Knoppen and Saenz 2007), trust and transparency in supply chains (Meijer et al. 2006), and process re-engineering (Smeds and Riis 1998; Thoben et al 2017). They serve to strengthen cooperation with chain partners, to improve communication and to trigger discussions about a strategic plan for a common benefit. According to the best of our knowledge, research is still missing about the effectiveness of games in addressing barriers of virtualization in supply chains.

This article focuses on the development and assessment of a simulation game, the 'Virtual chain game', as a tool to support organizational learning towards virtualization in supply chains. We address two questions: (i) Which barriers are keeping supply chain stakeholders from implementing virtualisation? (ii) How does the 'Virtual chain game' address these barriers? We explore this in the particular context of floricultural supply chains, with a case study in the Netherlands. The article begins by introducing virtualization of floricultural supply chains. It then introduces the methods used to identify the barriers and it describes the logic behind the game design and evaluation. The subsequent section focuses on the results, while the final sections discuss the key findings and draw conclusions.

2. Virtualization in floricultural supply chains

2.1. Digital supply chains

Supply Chain Management (SCM) originated in the 1980s as an inventory management approach that optimises the physical flow from primary producers to end customers as one integrated system with a shared objective (Cooper and Ellram 1993; Christopher 1998). SCM literature stressed the need for collaboration among successive actors in the supply chain to better satisfy consumer demand at lower costs (Lambert, Cooper, and Pagh 1998; Van der Vorst 2000).

A driving force behind SCM is the recognition of sub-optimization if each organization targets to optimize its own performance rather than coordinating its objectives and business processes with other supply chain participants (Mentzer et al. 2001; Arshinder and Deshmukh 2008). Information technology is a key enabler of supply chain coordination since it allows to share information timely and to adapt planning and control systems accordingly (Lee and Whang 2000; Prajogo and Olhager 2012; Marinagi, Trivellas, and Sakas 2014).

Recent digital technologies such as Cloud Computing, Internet of Things, Big Data, Blockchain and Machine Learning have significantly advanced the ways in which supply chain processes can be managed. As a result, digital supply chains (DSC) emerge that are smart, value-driven, and efficient enabled by novel technological and analytical approaches and resulting in new forms of revenue and business value (Büyüközkan and Göçer 2018; Seyedghorban et al. 2020; Coronado Mondragon, Coronado Mondragon, and Coronado 2020). However, despite the potential benefits and available technologies, supply chain digitization is way from deploying its full potential (Büyüközkan and Göçer 2018; Hartley and Sawaya 2019). A major reason is that moving towards digital supply chains is not primarily a technical implementation, but it requires a digital transformation that reinvents the way of business to capture the full potential of information technology across the total supply chain (Bowersox, Closs, and Drayer 2005). A digital transformation is a profound socio-technical change of key business operations that affects products and processes, as well as organizational structures and management concepts (Bernard 2011; Matt, Hess, and Benlian 2015; Vial 2019). As a consequence, especially organizational and behavioural barriers hinder digital transformations (Fitzgerald et al. 2014). The lack of urgency towards digitization is a major hurdle for digital supply chains (Fitzgerald et al. 2014, Agrawal, Narain, and Ullah 2019). Kotter (2008) argues that people tend to be content with the status quo and any successful change process starts with creating a sense of pressing importance. Other important barriers in supply chains are a lack of awareness, reluctance to share information, and a lack of required digital skills, a lack of industry specific guidelines and high implementation and running cost (Büyüközkan and Göçer 2018; Agrawal, Narain, and Ullah 2019).

2.2. Virtual supply chains

Virtual supply chains were introduced in the late 1990s as an agile alternative to static pipelines that efficiently push products to the marketplace (Rayport and Sviokla 1995; Chandrashekar and Schary 1999; Christopher 2000). These virtual supply chains are extended virtual organizations, that is, dynamic networks of independent companies with complementary resources (Chandrashekar and Schary 1999; Gunasekaran and Ngai 2004). Nowadays virtual supply chains are increasingly integrated with their physical product flow. In such virtual supply chains, planning, monitoring, adjustment and optimization of logistic processes can be carried out remotely via the Internet based on virtual objects (Ho, Au, and Newton 2003; Verdouw, Beulens, and van der Vorst 2013; Ivanov and Dolgui 2020). This allows for the decoupling of physical flows and information aspects of supply chain operations, which can change supply chain management in unprecedented ways (Clarke 1998; Van der Vorst et al. 2016).

In virtual supply chains, physical entities such as products and resources are accompanied by a rich, globally accessible virtual counterpart that links all relevant information of the related physical object such as current and historical information on that object's physical properties, origin, ownership, and sensory context (Welbourne et al. 2009). This perspective relies heavily on Internet of Things (IoT) technologies. The IoT is a web of smart connected objects that are context-sensitive and can be identified, sensed and controlled remotely by using sensors and actuators (Atzori, Iera, and Morabito 2010; Kortuem et al. 2010). In the IoT, physical entities become context-aware and they can sense, communicate, act, and interact (Sundmaeker et al. 2010). IoT-based systems in supply chains build on traceability systems that provide the information to track the location of certain objects (e.g. product, box, pallet, truck) and trace its history.However, IoT goes beyond tracking locations utilising sensors, wireless networks and (cloud) data management technologies to monitor the dynamic properties of the objects in (near) real time. In supply chains of perishables like food and flowers, this may include the monitoring of ambient conditions (e.g. temperature, ethylene and humidity), microbiological information and other quality parameters (Jedermann et al. 2014). In addition to sensors, objects may be equipped with Internet-connected actuators that can remotely operate objects such as coolers and lights in trucks or warehouses (Verdouw et al. 2016).

The implementation of virtual supply chains requires a digital transformation, which can be hampered by various challenges such as distinguishing between reliable and false data, dealing with threats to privacy and security (Del Vecchio et al. 2018) and data ownership (Ng and Wakenshaw 2017). Hence, virtualization can have a negative impact on business-to-business relationships, even in mature and trustful buyer-seller relationships (Falkenreck and Wagner 2017). In business relationships, social bonds are generated according to the norms of the industry and cultural environment. Virtualisation may require a rearrangement of these norms, through adaptive actions that allow individuals to collectively make economic decisions about future exchanges (Medlin 2004).

2. 3. Virtualization in floriculture

Floriculture is a challenging domain from a supply chain management perspective. It is characterised by high uncertainty in both demand and supply (Verdouw 2010). Demand uncertainty is high because of weather-dependent sales, changing customer behaviour and increasing global competition, among others. This results in high variability of supply capabilities and demand requirements in terms of volume, time, service levels, quality and other product characteristics (Van der Vorst, Bloemhof, and Keizer 2012). Supply uncertainty is high because living, perishable plants are involved, and chains are vulnerable to several factors that have an impact on flower quality. Quality decay of floricultural products is mainly determined by the duration of logistics operations (like transport, storage or processing) in combination with the temperature under which the operations are executed (Van der Vorst, Van Kooten, and Luning 2011; Rong, Akkerman, and Grunow 2011; Trienekens, van der Vorst, and Verdouw 2014). Virtualization is a promising approach to meet the above-mentioned challenges. It allows taking corrective action in time, for example by changing ambient conditions that might result in quality decay. Virtual objects make it possible to reproduce the historical state and to simulate the future state of the product. The simulation of future states is possible thanks to quality decay models, which among others predict flower vase life. Estimation of vase life and information on product quality decay can be used to reduce waste. For instance, providing an estimate of remaining vase life (Grunow and Piramuthu 2013) allows optimizing stock rotation systems like 'first expired first out' (Jedermann et al. 2014). Hence through virtualized quality-driven logistics, processes are monitored continuously in the chain and adjusted based on real-time information about product quality (Van der Vorst, Van Kooten, and Luning 2011). Moreover, virtualization allows to shorten supply chains by skipping intermediaries such as centralised logistics hubs (Verdouw, Beulens, and van der Vorst 2013; De Keizer et al. 2015). This implies that the travel distance is reduced and hence the logistics are more efficient and environmentally friendly. Finally, virtualisation allows for transparency of production data, which is increasingly required by consumers.

3. Materials and methods

3.1. The Dutch floriculture and DaVinc3i

The research was carried out in the Dutch floricultural sector. Figure 1 provides an overview of its main actors:

- Producers: in 2019, there were in total 1782 Dutch growers of flowers and pot plants with an average production area of 2,15 hectares (Wageningen Economic Research, 2020);
- Logistic service providers including transporters: mainly road freight within Europe and air freight for international transport of flowers. Sea and rail transportation is still very limited but growing;
- Hubs: one large auction (Royal FloraHolland), formed from a merger and a relatively small one (Plantion), and

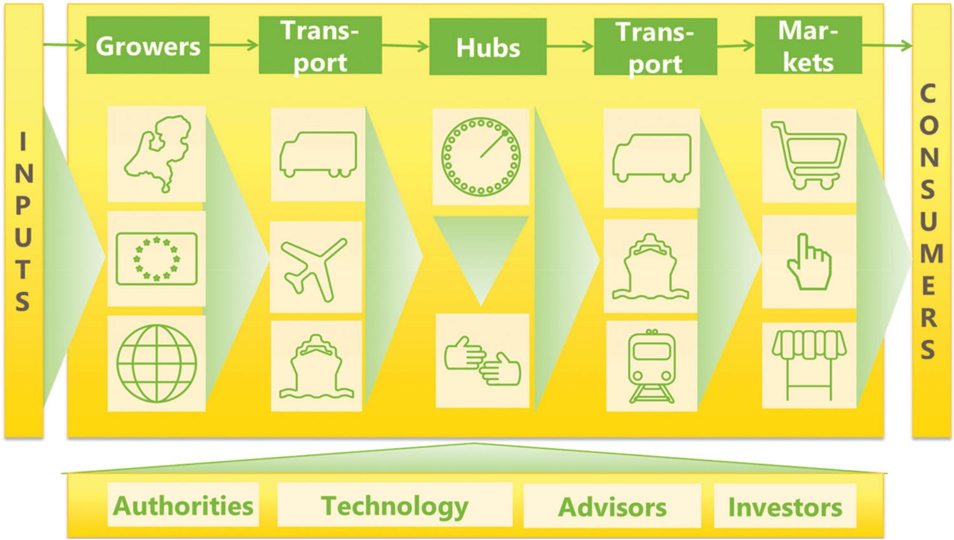

Figure 1. Supply chain structure of the Dutch floriculture (simplified).

about 1200 traders, that can be split up into three groups: wholesalers, exporters and importers.

- Market: different outlet channels in national and international marketplaces, especially: (i) florists and street trade, (ii) retailers, including garden and Do-It-Yourself (DIY) centres, and (iii) eCommerce platforms.
- Indirect actors such as authorities, for example, phytosanitary inspectors, technology providers, e.g. greenhouse systems and software vendor, advisors and investors including banks.

This study was as part of the DaVinc3i community project in close interaction with the involved business partners, or community members. In total, 109 companies participated in the community, of which 15% growers, 12% logistic service providers, 2% retailers, 17% hub companies, 6% authorities, 10% tech companies, 17% advisors, 3% investors, 6% sector organisations and 12% other organizations such as researchers and journalists. The DaVinc3i community project started in May 2016 as the continuation of the DaVinc3i project (2010–2015). This precursor project was about technical innovation needed for virtualization. At its conclusion in 2015 it emerged that, despite the availability of technologies for virtualisation, despite high expertise levels on flower treatment, and despite ubiquitous optimisation and automation of the internal operations of horticultural firms, there is still a need for disseminating knowledge about quality-driven logistics across the production chain in the Dutch horticultural sector. DaVinc3i Community aimed to bring about actual change in the sector towards virtualised, quality controlled, logistics.

3.2. Simulation gaming

Simulation gaming has been dubbed the 'language of the future' for its ability to make stakeholders engage with possible changes. Simulation games are increasingly being adopted by companies as a participatory approach to facilitate organizational learning and innovation. They provide an experimental setting that represents the complexity of a real-world system (Anderies et al. 2011). Simulation games that correspond to a real-world case are generally aimed to trigger imagination and exploration of participants (Vieira Pak and Castillo Brieva 2010; Villamor and van Noordwijk 2011). This type of game is often played with participants who are real stakeholders in the given context to remind them of their own situation (De Caluwé, Hofstede, and Peters 2008; Meadows 2001; Salvini, van Paassen, et al. 2016). This allows them to trigger knowledge exchange, stimulate discussions about shared problems and achieve a joint understanding of system dynamics (Battini et al. 2009, Hofstede et al. 2010). Additionally, they can be an effective method to experiment with different scenarios, observing behavioural responses of participants within a specific context (Bousquet et al. 1999). As such, simulation games contribute to the understanding of complex systems and facilitate negotiation processes (Vieira Pak and Castillo Brieva 2010).

3.3. Research methodology

As explained in section 3.1, the problem faced was that despite high levels of automation and optimisation inside firms, quality information was not shared across them; in line with literature findings mentioned in the introduction, this was diagnosed to be an organisation innovation problem. To address it, the study comprises three main phases (Figure 2). The first phase, problem analysis, consisted of semi-structured interviews and a workshop, aimed at identifying the barriers to, and opportunities for, virtualisation in the Dutch floricultural sector. Interview questions were constructed using a system analysis methodology (Wieczorek and Hekkert 2012). Eligible interviewees had to be active in the floricultural sector, since they have first-hand experience, and are those able to take action. The 15 interviewees were either members of the DaVinc3i Community or other people involved in virtualization of quality-controlled logistics: researchers, policy makers and representatives of various supply chain actors (producer, transporter or trader). The

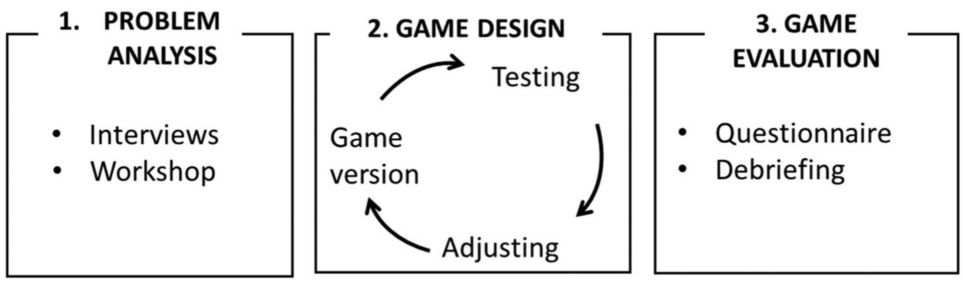

Figure 2. Schematic representation of the research methodology.

interviewees were identified through suggestions of project members and through snowballing. Their participation was voluntary; there is no other way to obtain participation of independent industry actors in this context. The identified barriers and opportunities were clustered into overarching themes and validated in a workshop with some of the interviewees and community members (seventeen participants). This exercise confirmed that the barriers were overwhelmingly socio-institutional rather than institutional. This pointed to communicative, motivational remedies, such as can be achieved in face to face contexts. The barriers identified in the interviews and the workshop were used to define the game requirements and objectives.

In the second phase, the game was designed based upon these requirements. The design phase was an iterative process consisting of three main steps: creating a game version, testing and adjusting. In the first step, a game version is created according to the game requirements. This is a creative process in which the essential components of the game are defined, to make it an interactive environment for experimental learning. Based on these goals, choices are made about game elements such as boards, cards and rules. The challenge is to represent the central issues at stake while keeping the game as simple as possible.

In the second step of game design the game is tested through game sessions in order to gather feedback in different aspects, such as assessing the game playability and finding redundancies and inconsistencies. Five test sessions were conducted: the first one in a community team meeting (nine participants), the second one in a workshop with the sector stakeholders (seventeen participants), the third one with colleagues from Wageningen UR (fifteen participants) and the last two sessions with university students of Supply Chain Management of Wageningen UR (for a total of thirty-six participants). The last step of the game design phase consists in adjusting the game based upon the feedback collected.

The third phase has evaluated how the game addressed the identified barriers. The evaluation comprised three game workshops with a total of 29 participants. Participants were chain stakeholders with different functions such as purchase, sale, quality control, marketing sustainability, commercial manager, logistics manager, business process manager, trainer, and human resources.

The game evaluation was done by asking participants to respond to a questionnaire before and after playing the game. The questionnaires consisted of the same set of questions, each corresponding to a barrier. Comparing the responses to the pre- and post-questionnaire allowed to measure the impact of the game on the mindset and perspective of the participants. Additionally, learning during the game was assessed through two debriefings, each at the end of a scenario. Questions asked were: (1) What happened during the game? (2) What did you learn? (3) Does the game reflect reality? These questions promoted group discussion and interaction about the link between the game and reality, and they supported further reflection.

The next sections will introduce the results of the research phases, i.e. analysis of the barriers (section 4), game design (section 5) and game evaluation (section 6).

4. Problem analysis

4.1. Definition of the barriers

The system analysis interviews gave insight into the main systemic barriers to virtualisation of the Dutch floricultural sector. As can be seen in Figure 3, these barriers are interrelated.

The interviewees described the floricultural sector as characterised by a traditional nature. They meant this in a positive sense. The craftsmanship of the Dutch floriculture sector, developed in family enterprises through dedication and hard work, has been a key success factor, and is exemplary today. Now that craft-related standards are so high across the sector, other aspects of business are becoming more limiting. The sector is still focussed on craftsmanship, making it very supply-driven, and there still is a predominance of family-owned business. These three attributes (craftsmanship, supply-driven, family enterprises) are now considered traditional in the sector. As a consequence, particularly family owned and smaller businesses have a relatively low level of planning and control regarding supply chain processes. Although growers can be very innovative regarding their product and the related production process, family owned businesses tend to be focussed on the daily activities and operational problem solving, and on the quality of their own output product. As a result, a lot of these family owned and smaller businesses across the supply chain lack a structured planning and control of their business processes, are hardly integrated with partners in the chain, and do not have a long-term innovation and investment strategy.

The traditional nature of the sector is linked to a number of barriers. Firstly, due to the supply driven orientation of the sector, there is often a mismatch between demand and supply. There is a lack of focus on consumer needs, as

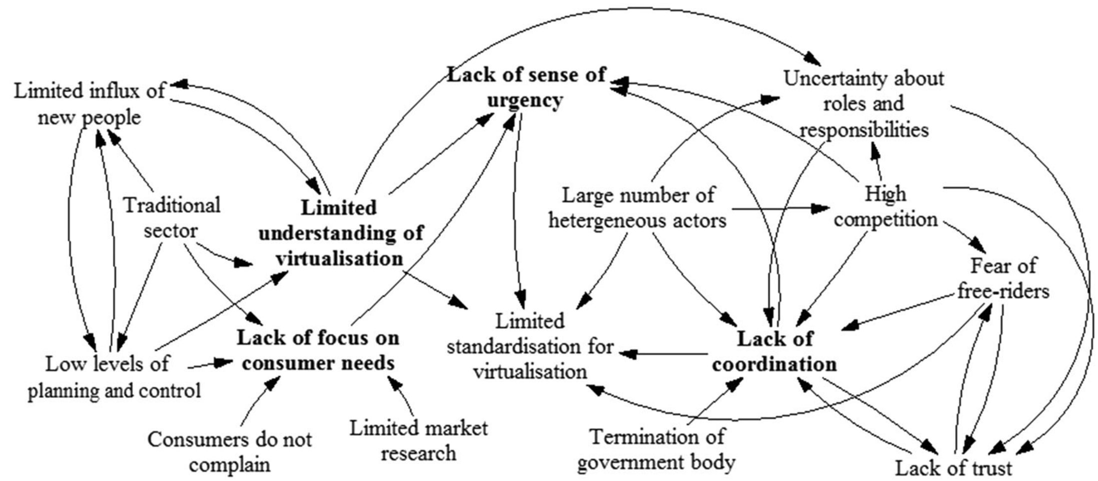

Figure 3. Overview of systemic barriers to virtualisation and links between them.

consumers can only buy what is offered to them. This is exacerbated by the long production process of flowers which cannot change as quickly as consumer needs. Additionally, according to two interviewees there is limited market research about consumer behaviour. This results in limited understanding of consumer needs. Another cause of a mismatch between demand and supply is that the floricultural sector so far seems to have been able to 'get away with it', as one interviewee put it, because consumers rarely complain about the flowers they buy. This is partly due to the fact that consumers are used to a short shelf life, but also due to a lack of consumer knowledge about the product.

Secondly, the traditional nature of the sector influences the limited influx of new people. The interviewees describe people in the Dutch flower sector as hard-working with early starts and long days. The interviewees also thought it was a difficult sector to enter when you are not 'born' into it'. This, in combination with the low level of virtualisation, makes it unappealing to young people – especially with digital skills – to work in.

Another barrier identified during the interviews is the limited understanding of virtualization. When asked what virtualisation means, a few interviewees responded that virtualisation is about using email instead of the telephone, and electronic auctioning. The majority of interviewees, however, defined virtualisation as sharing relevant data through platforms. The data shared would be about ambient factors that have an impact on product quality: temperature, light, ethylene and humidity. Some interviewees also mentioned that virtualisation enables the decoupling of product, information, and money flows. Regarding the status of implementing virtualisation some interviewees mentioned that an increasing number of businesses in the sector are currently using emerging technologies to tackle relatively simple issues, such as monitoring quality and analysing quality data. For instance, sensors added to transport trucks are currently paid for by traders, who place the sensors in the truck at the growers' when they fetch the plants, remove them at destination, and then put them away, only to consult them if there is a customer complaint. They are, however, merely used for legal liability, not yet for operational quality control. In general, the interviewees struggled to describe the full potential and opportunities of virtualisation in terms of both beneficial outcomes and implications for their supply chain processes.

A key characteristic of the Dutch flower sector is the large number of heterogeneous actors in all parts of the supply chain. This means that there are not only many supply chain roles, such as the producers, transporters, traders, auction, retailers, and consumers, but that actors in each of these roles differ in size, type of ownership, focus (national/international), and particular product. Additionally, there are several representative organizations, regulating bodies, service and technology providers, research organizations, etc. These various actors do not always understand one another's concerns and points of view. Moreover, they have different needs and requirements, as well as different views about the sector. The large number of heterogeneous actors goes along with a high competition among them. Most interviewees mentioned that business level interests are given priority over sector level interests.

In the same vein, the interviewees agreed that an important barrier is the lack of cooperation between all supply chain actors. Cooperation is limited due to both horizontal and vertical competition. While the representative organisations do take the role of 'spokesperson' and share knowledge and information with their members, this seems to be insufficient to enhance a mutual understanding. The cooperation is further troubled by forerunners that fear that others may free-ride on their pioneering of innovations. Another contributing factor to the lack of sector level cooperation is the termination of the government body 'Productschap Tuinbouw' (commodity board for horticulture) in 2015. This body used to play a coordinating role for the sector. Yet, a number of interviewees were aware that more sector level cooperation could lead to overcoming challenges like virtualization and thus create a higher individual benefit.

Interviews showed that due to the competition there is an uncertainty about roles and responsibilities: the boundaries of tasks and expertise of supply chain actors are increasingly blurring. The auction house is a prominent example. It was created as a market enabler between producers and

Table 1. Barriers to be addressed in the game.

Barrier	Game design
B1: Lack of focus on consumer needs	Game should increase understanding about the importance of flower quality from a consumer perspective
B2: Lack of sense of urgency	Game should raise awareness about future competition and increase the sense of urgency to keep flower quality
B3: Lack of cooperation	Game should encourage communication and a change of attitude to coordinate to keep flower quality
B4: Limited understanding of virtualisation	Game should increase knowledge and understanding about the benefits of IoT technologies

buyers. Today, however, physical products are increasingly going directly from the producer to the buyer. Such change causes friction and uncertainty about roles and responsibilities. According to the interviewees, this uncertainty could become even more problematic when supply chains virtualise. For instance, when flower quality can be monitored with IoT technologies, should the transporter be responsible for maintaining flower quality during transport, or is delivering the product at the right place at the right time the only responsibility of a transporter? One interviewee saw this as a business opportunity for transport: to expand and diversify the transport services.

As shown in Figure 3, a number of the above-mentioned barriers are closely linked to another barrier: the lack of trust among supply chain actors. In particular, the high level of competition is a barrier to trust. For example, when a competitive advantage is created by limited transparency, this in itself creates a lack of trust. This keeps vicious circles in existence. One interviewee said that the different stakeholders are often seeking to blame another party for what is going wrong at sector level, rather than considering their own role and contribution to a problem.

A further barrier is the lack of sense of urgency about the need for virtualisation. The sector seems to be unaware of the emerging challenges posed by globalisation and changing consumer requirements, which may have negative impact on their market position unless they innovate via for instance virtualisation.

The lack of sense of urgency about virtualization also is a key contributor to the limited standardization, which is crucial for achieving virtualization. Why standardize something that is not perceived as an issue? Currently, the sector is standardizing product and logistic codes that are included in digital messages. Virtualization requires more. From a technical point of view, virtualization requires standards regarding the technological infrastructure, such as sufficient Internet coverage, interoperability between software systems, and standards for using sensor data. Several interviewees also mentioned the importance of standardization for guaranteeing flower quality to which virtualization could contribute. Therefore, chain parties should agree on what quality is and how it is measured. This also has a practical implication about the format in which information and data about quality is shared: once it is clear what quality is, how to describe it and in which format? This also involves considering what you need to share, with whom, and when.

Interviewees identified that there are institutional and social reasons causing these technical challenges. Firstly, a few interviewees believed the standardization body is not pro-active enough in coordinating the standardization, and secondly some companies have already invested in their own ICT systems and are not eager to re-invest or adjust these.

4.2. Barriers addressed in the game

The criterion used to select the barriers to be addressed in the game was the amenability of the barrier to be addressed in the short run. For instance, a barrier such as 'traditional sector' is beyond the possibilities of a game, because it requires long-term change. Based upon this criterion we selected four barriers: Lack of cooperation, Lack of consumer focus, Lack of sense of urgency and Lack of understanding about virtualisation (Table 1).

5. Game design

5.1. Overview of the game

The 'Virtual chain game' is a board game on which two or more supply chains are competing within the flower market (Figure 4). It can be played by 4–16 participants and takes about 2–4 h. We chose to give it a form of a board game because this creates a visual, comprehensive picture of the chain for the players, and because it requires them to sit around a table and it supports discussions about the selected barriers among them.

Each chain consists of four players: a producer, two transporters and a wholesaler. Participants take the role of one of these stakeholders, who need to run their business activities by buying and selling flowers and by carrying out activities to reduce quality decay. All players get a role-specific board with investment options (Figures 5–7). The challenge is to deliver flowers to the shops with the highest income and reputation (represented in coins), that depend from shops satisfaction about the delivered flower quality (represented in tokens each worth a vase life day). Each participating chain has a black box filled with flower quality tokens that travel through the supply chain every round. At every turn a player needs to pick up an event card that might have an impact on flower quality. Based upon the investment made and the decisions on how to act to respond to the event described in the event cards, players need to remove a certain number of tokens from the black box. In total, 54 event cards are defined (18 cards per role, 9 for each scenario). Figure 8 shows some transporter examples.

5.2. Game protocol

Each game round consists of five phases.

In phase 1, the players make investments to keep vase life. Investments are specific per player role and are displayed in the personal board (see Figures 5–7).

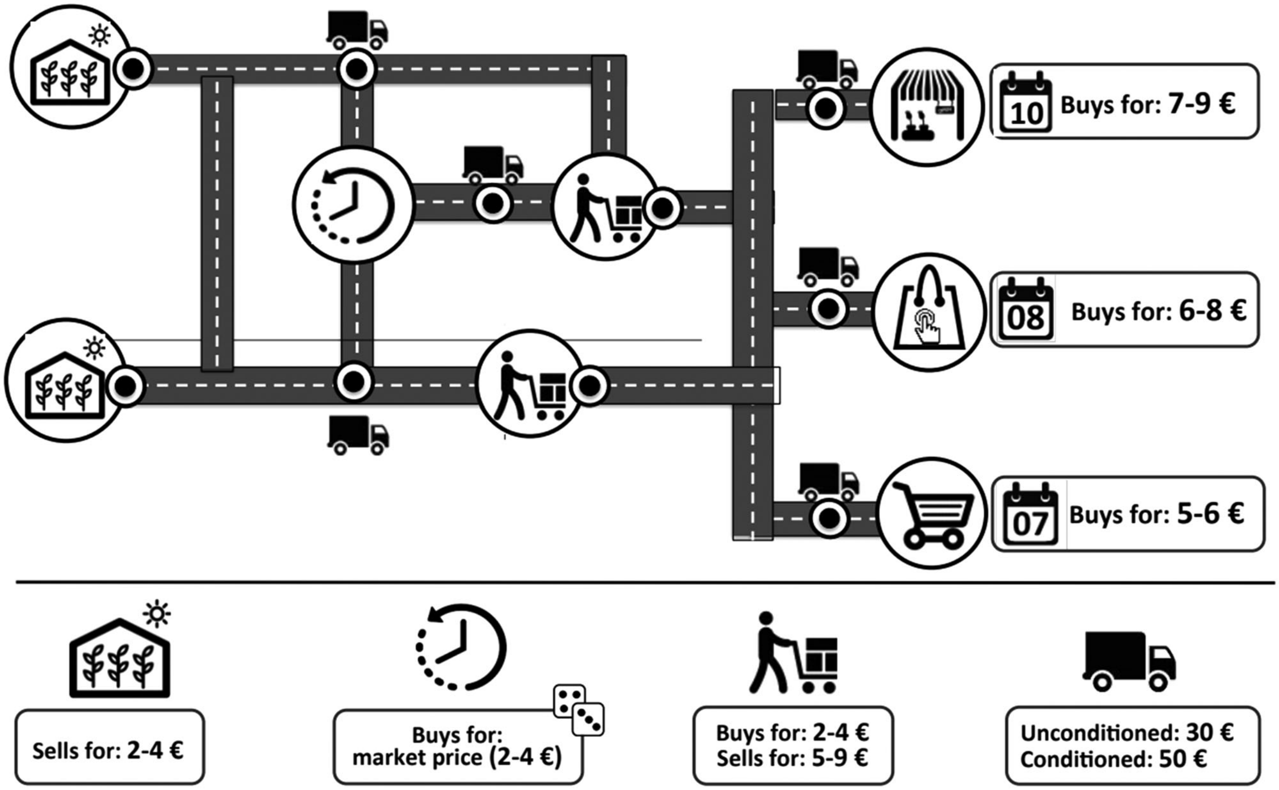

Figure 4. Game board representing (i) the different logistic routes: from the producer to the wholesaler (directly or through the auction), to three different shops (small flower shop, online shop and supermarket); (ii) the shelf life required by each shop and the offered price and (iii) the selling and buying price of the different actors. At every small circle the player has to pick up an event card.

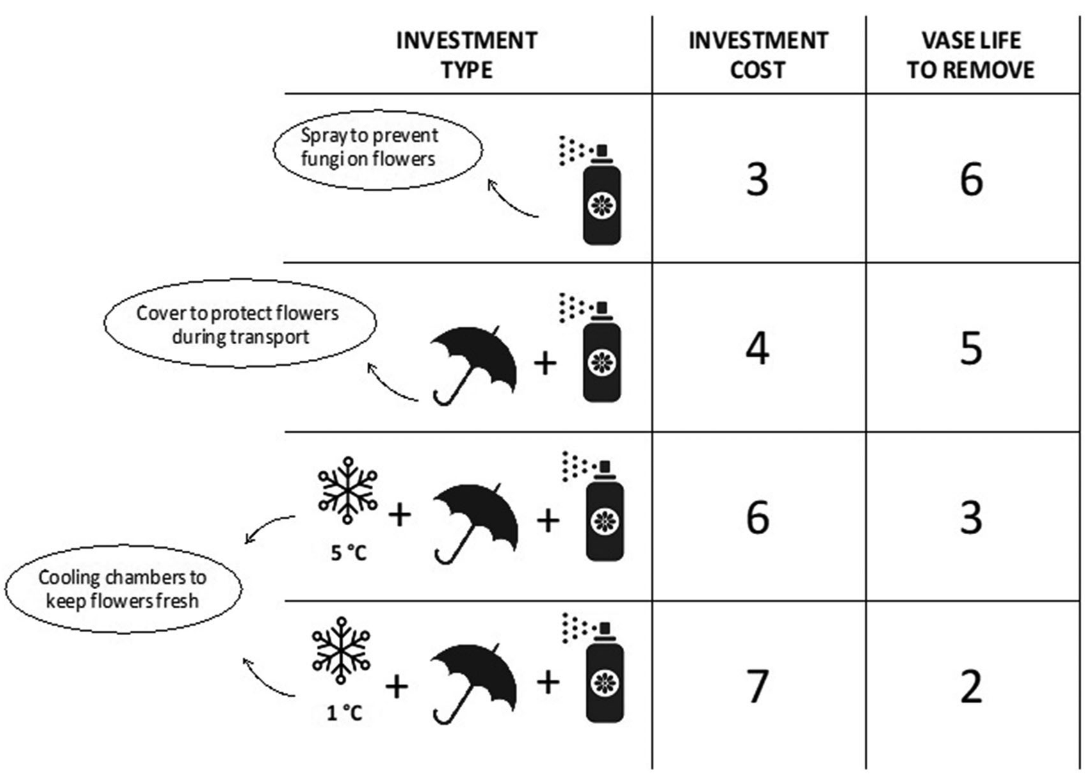

Figure 5. The producer board. The investment cost displays the cost per (set of) investment, while the vase life to remove indicates the corresponding number of tokens that should be removed from the black box.

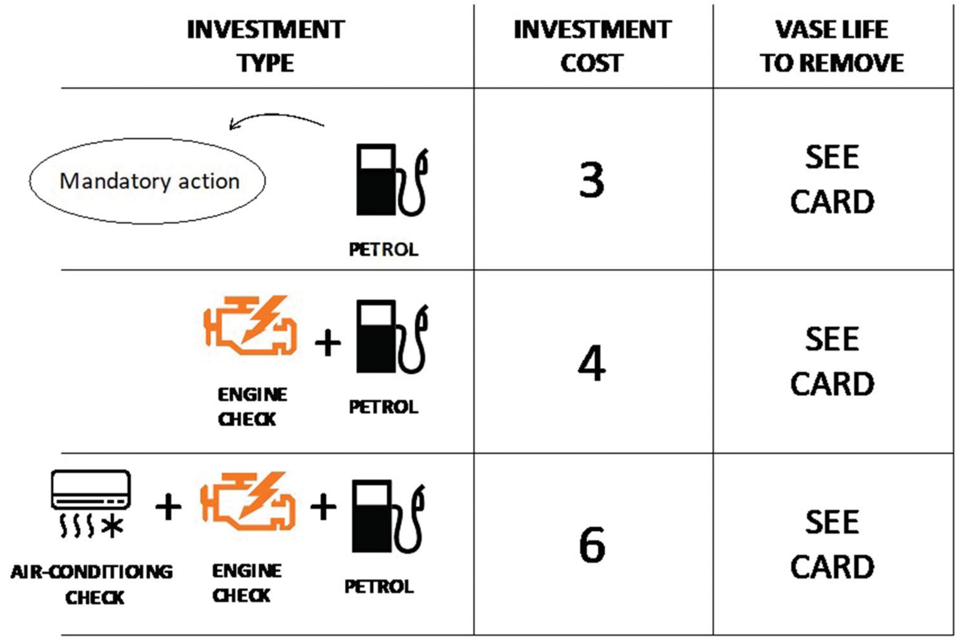

Figure 6. The transporter board. The investment cost displays the cost per (set of) investment, while the vase life to remove indicates the corresponding number of tokens that should be removed from the black box, determined by event cards.

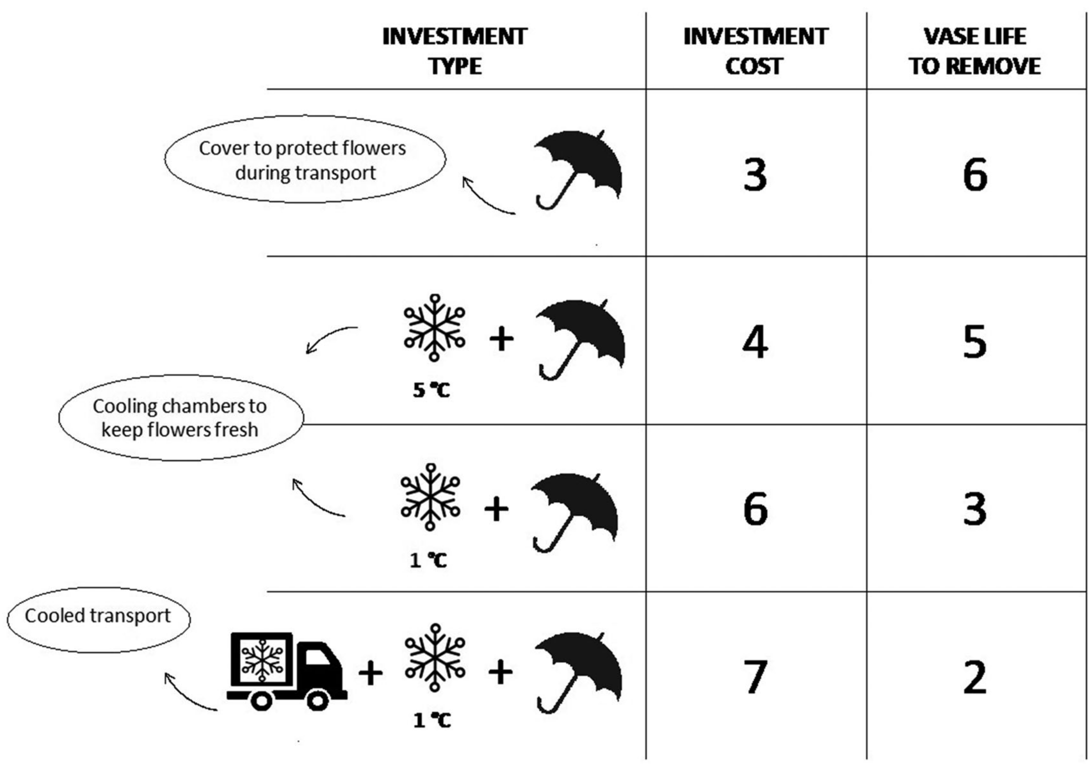

Figure 7. The transporter board. The investment cost displays the cost per (set of) investment, while the vase life to remove indicates the corresponding number of tokens that should be removed from the black box, determined by event cards.

In phase 2, event cards are picked that describe a certain issue that might result in a decline of the vase life. Figure 8 shows an example of some transporter cards.

In phase 3, the flower black box travels from the producer to the first transporter, to the wholesaler, to the second transporter and finally to the shops. Each player needs to remove tokens from the box once the box arrives in his/her hands. The number of tokens to be removed from the box is calculated based upon the investments made and the event cards chosen.

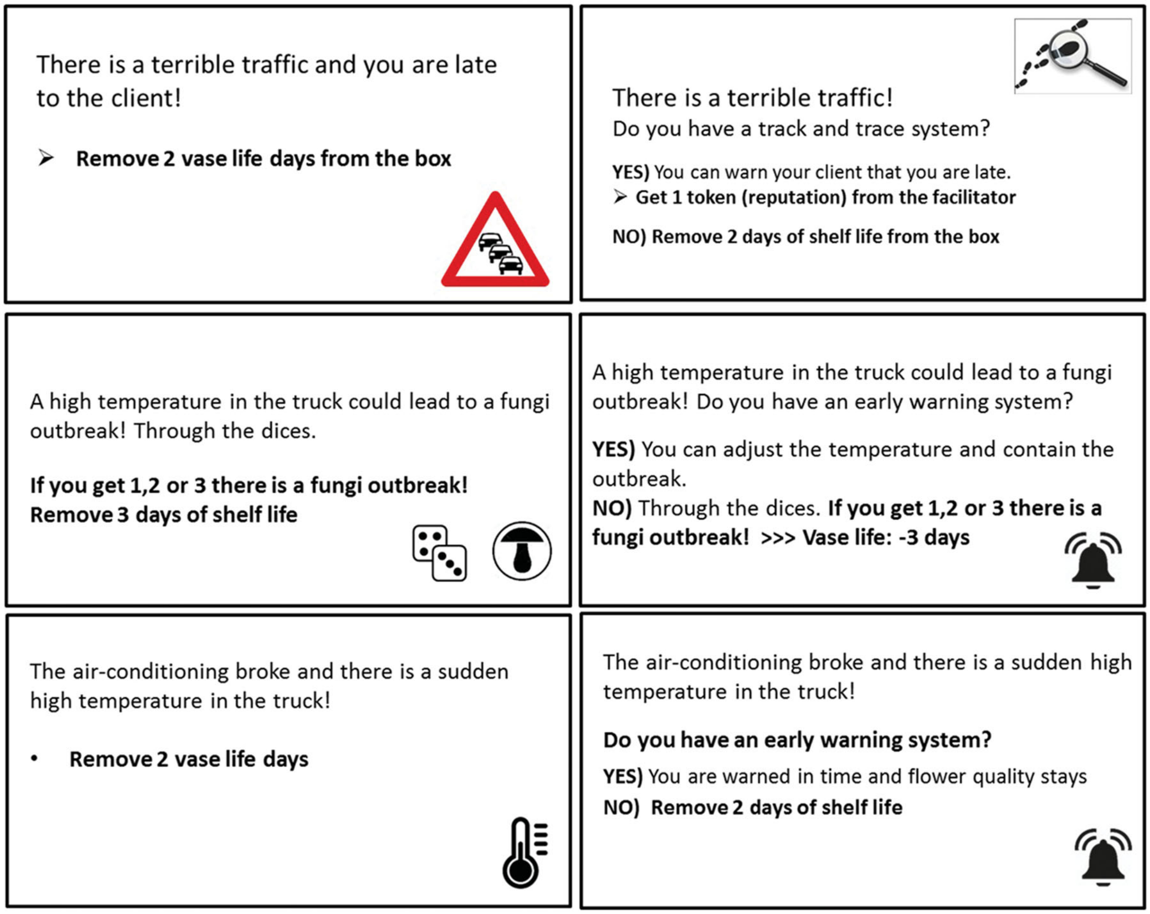

Figure 8. Some event card examples for the transporter role. The three cards left are used in the first scenario, the other cards right in the Figure are used in the second scenario.

In phase 4, the wholesalers choose the shop to which they would like to sell flowers: a (small) flower shop, a supermarket or an online shop (c.f. Figure 4). A flower shop requires a remaining vase life of at least 10 days, the supermarket 7 days and the online shop 5 days.

In the last phase, flowers arrive at the shop and the facilitator gives the income to all players. The flower black box is opened and the number of remaining vase life days is revealed. This number is the result of the investments and the decisions of all players of each round. If the number of tokens is lower than the required vase life days, the chain has to pay a penalty, while they get a bonus if it is higher.

5.3. Playing scenarios

A game run consists of two scenarios, each of which is played for three rounds. The first scenario represents the current situation, while in the second scenario players have the opportunity to invest in digital technologies that help reduce quality decay.

There are two types of technologies available (Figure 9). The first type of technologies includes: temperature sensors, track and trace system and stock management system. These technologies are beneficial for the single player regardless of their adoption by the rest of the players in the chain. The second type of technologies includes early warning system, data sharing system and quality decay models. These technologies can be purchased only if specific technologies of the first type are adopted.

5.4. Barriers addressed

The 'Virtual chain game' addresses the barriers as defined in Table 1 as follows.

The barrier 'lack of cooperation' is especially reflected in the flower quality box, the content of which is not visible, nor are the processes that lead to flower quality decay in the logistic processes. The higher the collaborative investments, the fewer tokens are removed from the box and the more income will be earned. As a result, supply chain collaboration really pays off in the game. To address the barrier 'lack of focus on consumer needs', the game was designed to increase awareness about the importance of consumer satisfaction for profitability. In particular, if flower quality is low when flowers arrive at the shop, all chain players need to pay a fine, which represents the loss of market competitiveness and reputation. On the contrary, if the flower quality is high, all players get a monetary reward. This reward is an indicator of the success and reputation of the stakeholders in that chain: by receiving high quality, end consumers are satisfied and hence the market demand from that chain

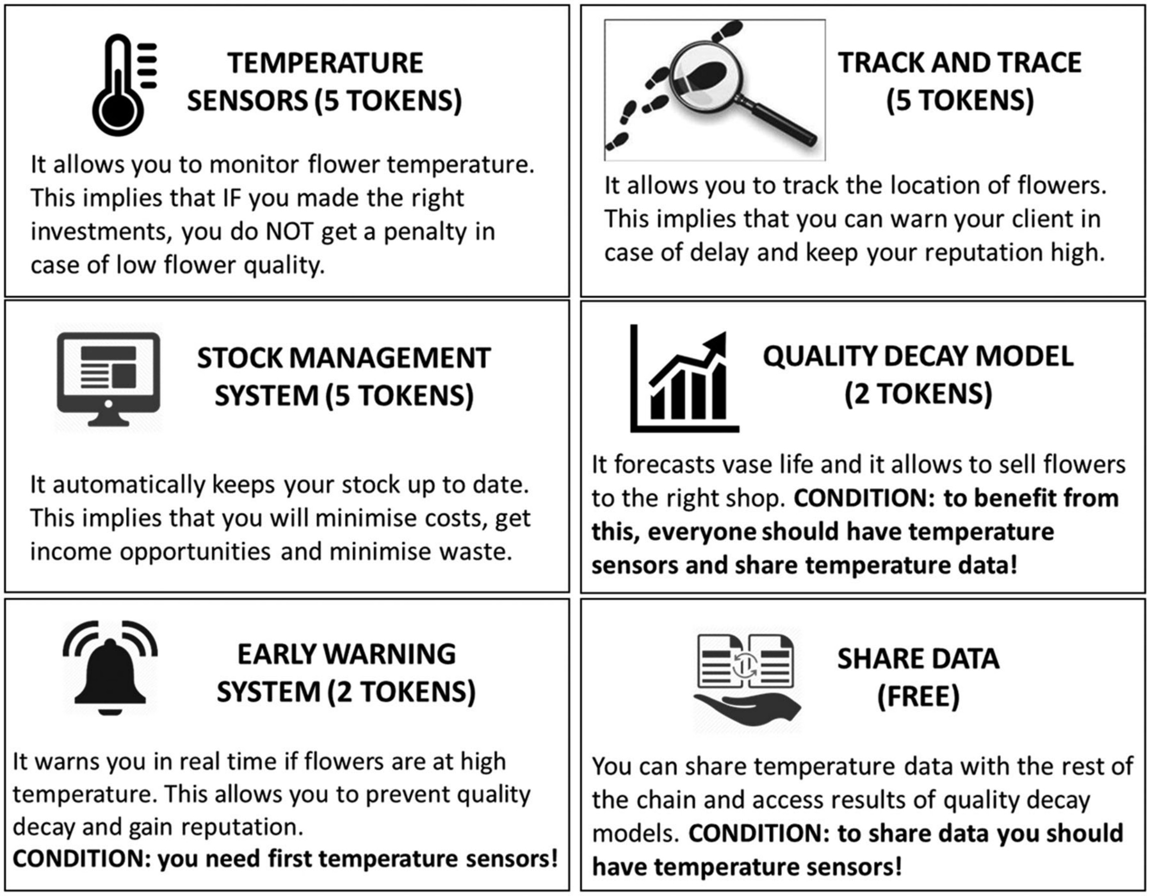

Figure 9. Available technology investment cards, including the associated price (in tokens) and benefits.

remains high. This game rule also addresses the barrier 'lack of sense of urgency': it introduces the possible future risk of losing market competition if flower quality is low and market competition increases.

The second scenario aims to address the barrier 'Limited understanding of virtualisation'. It introduces key enabling technologies and explains their benefits. Moreover, the interdependences and the resulting sequence of implementation are incorporated. As a consequence, players experience how virtualization can be realized and the gains it can bring.

6. Game evaluation

The comparison of the responses to the pre- and post-questionnaires allowed to evaluate the effectiveness of the game in supporting organizational learning to cope with the identified barriers. The following sections describe the results of this assessment, structured per barrier addressed.

6.1. Focus on consumer needs

Participants were asked how they think consumer satisfaction can influence their business. Results of the pre-questionnaire show that all participants were already aware of the impact of consumer satisfaction on market demand. Common statements include: 'no satisfied clients, no business', 'it's important to keep innovating and provide a good service', 'client satisfaction is key to success'. Despite this awareness, respondents are confident about keeping consumer satisfaction high and hence maintaining their market position. Common strategies mentioned to keep this position are innovation, development, marketing and continuous investments. Nevertheless, the post questionnaire shows that the game increased awareness about the role of consumers among 27% of the participants. Some participants commented about the importance to keep thinking what are the clients' needs and to continually innovate to satisfy them. Others highlighted the role of IoT in monitoring and preserving flower quality. These results suggest that the game made them more aware of the role of these technologies to guarantee a better vase life. Additionally, the game increased awareness about the growing competition derived from selling products online. This competition seems to represent an extra incentive to invest in activities to keep consumer satisfaction high.

6.2. Sense of urgency

Participants were asked to state perceived threats to their current market position. Additionally, they were asked to state their sense of urgency to address such threats using a scale from 1 (not urgent) to 10 (very urgent). Future threats to the market position mentioned in the pre-questionnaire include increased competition and creation of corporate growers. Some wholesalers mentioned as a threat the direct

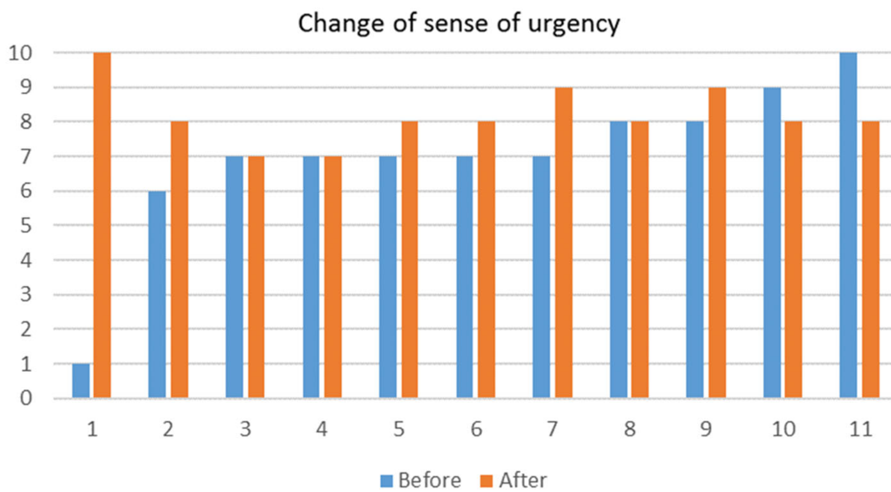

Figure 10. Change of sense of urgency to address threats to market position. The graph displays the responses from 11 participants: the remaining 18 participants did not respond. In blue the responses to the pre-questionnaire and in red to the post-questionnaire.

contact which some producers have with retailers, which would threaten their role in the supply chain. The same answers were given in the post-questionnaire.

Regarding the question about the sense of urgency, the participants who responded (11 out of 29) provided different answers (Figure 10). In the pre-questionnaire, one participant gave a very low urgency score (1), giving as motivation the high quality of their products. The same participant provided a high score (10) in the post-questionnaire, showing that the game provided insights about future threats in the market. Other seven participants provided quite high scores in the pre-questionnaire, ranging from score 7 to score 10. The main reason given for the high sense of urgency is the feeling that the sector needs to keep developing and giving a good service. For four of seven the sense of urgency increased after the game. For two participants, the sense of urgency slightly decreased after the game. Overall, these results suggest that the game was an eye opener for participants with low sense of urgency (up to score 7), and it prompted an even higher sense of urgency for participants whose sense of urgency was already high before the game. The game participants may have partially self-selected for a high pre-existing sense of urgency.

6.3. Supply chain cooperation

Participants were asked two questions to assess whether the game increased their willingness and motivation to collaborate with other chain stakeholders. Firstly, they were asked who is responsible to keep flower quality. This question was aimed to assess whether they are aware that quality decay is determined by everyone in the chain. Reponses to these questions vary (Table 2).

A rather high percentage (42%) of participants (category 1) responded that quality decay is determined by one or more stakeholders in the chain. In particular, in the first questionnaire, 13% replied that transporters are responsible for quality decay, while another 10% replied that both producers and transporters are responsible. Six per cent mentioned the producers as responsible, while another 3%

Table 2. Results of the pre and post questionnaire regarding the perception of who is responsible for quality decay.

Questionnaire before the game	*Questionnaire after the game*	Percentage	Total
Category 1			
The transporters	Everyone in the chain	13%	42%
The producers and transporters	Everyone in the chain	10%	
The producers	Everyone in the chain	6%	
Wholesalers and flower shops	Wholesaler and producer	3%	
No response	Everyone in the chain	10%	
Category 2			
Everyone in the chain	Everyone in the chain	58%	58%

pointed to the wholesalers and flower shops. Ten per cent of participants did not respond. This group of 42% pre-game respondents all mentioned in the post-questionnaire that everyone in the chain is responsible for quality decay. These results indicate that the game greatly increased their awareness of being part of a chain as a system, in which the decisions about flower quality maintenance made by each stakeholder have an impact on the whole. This awareness is the first step towards better cooperation to keep flower quality. The remaining 58% of the participants (category 2) was already aware of this and their opinion did not change after the game.

Secondly, participants were asked if they were currently collaborating with other supply chain parties to keep flower quality high (65% yes, 24% no, 11% blank) and whether they were willing to engage in such a collaboration in the future (24% no). After the game, these 24% had changed their mind. As a result, the willingness to collaborate (more) increased from 65% to 89%. These results show that the game increased awareness of the importance of collaboration to keep flower quality.

The remaining 65% were already collaborating before the game and mentioned that after the game they were even more willing to cooperate and coordinate with other chain stakeholders. Most of them added that the next steps towards a better cooperation would be to talk with chain stakeholders through for instance brainstorming sessions to see what could be the possibilities to collaborate. One added

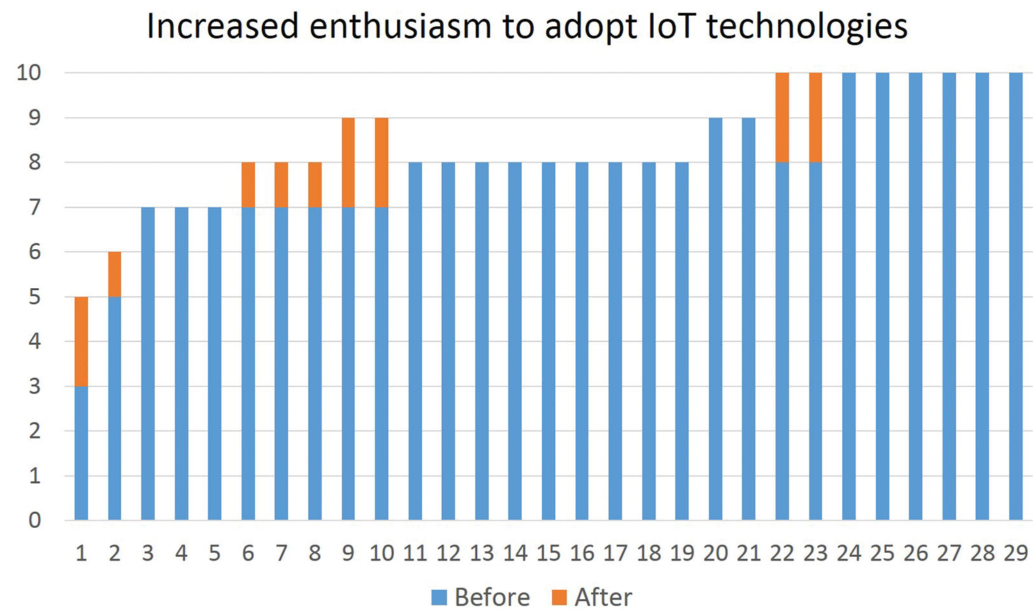

Figure 11. Impact of the game on the level of enthusiasm to adopt IoT technologies for chain virtualisation. The blue bars represent the scores provided in the questionnaire before the game (pre-questionnaire) and the orange bars represent the scores provided after the game.

that the creation of a platform for logistic control would be crucial to share data and maintain flower quality. In the debriefing, participants were asked what they learned during the game. Some responded that during the game they realized the importance that all stakeholders in the chain invest to maintain flower quality throughout the chain. Investments include for instance anti-fungi spray application by the producer, storage in refrigerated cells by wholesalers, and proper packaging during transport.

In fact, if only few invest, flower quality may decay in other chain segments, with negative consequences on the vase life and hence on the market position for everyone in the chain. Additionally, they noted that even if everyone invests, there are still events, described in the game in the event cards, that have an impact on flower quality. These events cannot be prevented in the first game scenario, as IoT technologies are not present yet. For instance, in case flowers wait to be picked up outside the building of the producer at high temperature, their quality may rapidly decrease. This can be prevented in the second scenario by IoT technologies such as temperature sensors and early warning systems, which allow to act in time to preserve flower quality.

6.4. Understanding of virtualization

Participants were asked about their current knowledge of IoT technologies use for chain virtualization. Additionally, they were asked about their enthusiasm to adopt such technologies, using a scale from 1 (not enthusiastic) to 10 (very enthusiastic). Comparing the responses to the pre- and post-questionnaire shows that the game triggered learning about IoT technologies and it increased the level of enthusiasm in adopting them (Figure 11). In particular, 87% of the participants stated that the game gave them more insights about some of the benefits of virtualisation technologies, while the remaining 13% already knew about the benefits of such technologies. Main benefits learned during the game include profitability, transparency and efficiency.

Figure 7 displays the impact of the game on the level of enthusiasm to adopt IoT technologies for chain virtualisation. It shows that 66% of the participants were already enthusiastic (score 8 to 10) before the game to adopt IoT technologies. In fact, they already knew that they would increase flower quality and income. Of them, two participants stated to be more enthusiastic about IoT technologies after the game. The main given reasons for the increased enthusiasm are enhanced transparency, the possibility to follow the product and to inform the consumer. Another group (10% of the participants) stated in the pre-questionnaire relatively low enthusiasm (scale 3 and 5) in adopting such technologies. The main reason of this is that they think not everyone in the chain will adopt them. This is in line with our findings about the lack of trust and cooperation within the supply chain. After the game these participants stated to be more enthusiastic as they realized that an increased income related to their adoption would probably trigger collaboration. Similarly, the remaining group of participants (24%) provided a score of 7 in the pre-questionnaire and most of them stated an increased enthusiasm after the game. Overall, these results show that enthusiasm to virtualise increased particularly for participants with a relatively low score before the game.

These results are in line with the results of the debriefing, in which participants stated that the game made them more aware of the benefits of IoT technologies to keep flower quality and improve the efficiency of the logistics. Some also noted the importance of every chain stakeholder adopting them. This is for instance the case of temperature sensors, which allow to measure temperature through the whole chain to guarantee continue monitoring. Nevertheless, they added that in reality it is difficult to bring all chain stakeholders on board, as individual commercial interest often prevails above chain interest.

7. Discussion

7.1. Contribution to practice

Our research demonstrated that the 'Virtual chain game' is a valuable tool for enhancing digital transformation towards virtual supply chains. This was achieved by addressing four selected barriers to virtualization: lack of focus on consumer needs, lack of sense of urgency, limited understanding of virtualization and lack of cooperation.

Regarding the lack of focus on consumer needs, the game increased awareness about the importance to preserve vase life to maintain consumer satisfaction and hence a competing market position. Additionally, it increased awareness about the growing competition derived from selling products online, such as via Amazon. This competition seems to represent an extra incentive to invest in IoT technologies to monitor and preserve flower quality.

Regarding sense of urgency, the game increased awareness about future possible market threats. Sense of urgency is a precondition to actually trigger virtualisation and in this respect the game was an eye opener about possible future scenarios. These results are in line with the literature, which shows that simulation games provide an experimental setting that triggers imagination and exploration of participants (Anderies et al. 2011; Vieira Pak and Castillo Brieva 2010).

Regarding the lack of understanding about virtualization, the game familiarized participants with the benefits of IoT technologies and allowed them to experience their benefits. Participants realized that investing in virtualization leads to increased transparency, efficiency and increased flower quality. Additionally, they learned that it leads to increased profit for the whole chain. Learning was likely especially strong because the game introduced these technologies not only in theory, during the explanation of the game rules, but also via game play, during which players experienced the positive impact of their adoption on their business strategies.

Finally, the game served as an exercise and a lesson to pay more attention to intra-chain cooperation. This was stimulated by the informal setting of the game, which supported communication and created a discussion platform that eased participants' interactions. Participants engaged in the game as an experimental environment and they explored the consequences of their business decisions on their income and reputation as a single company and more importantly as a chain. Moreover, participants reflected on how their decisions on flower quality impacted on the performance of the chain. Similar results were found by other authors that show the power of games to support knowledge exchange, stimulate discussions about shared problems (Vieira Pak and Castillo Brieva 2010) and achieve a joint understanding of system dynamics (Salvini, Ligtenberg, et al. 2016; Hofstede et al. 2010).

7.2. Contribution to theory

Literature has acknowledged that virtual supply chains need a digital transformation, which especially is hindered by organisational and behavioural barriers. However, studies on the implementation of virtual supply chains focus on the enabling technologies, such as IoT. Although conceptually addressed, the development of concrete solutions to address socio-institutional barriers has been under-researched up to now. To the best of our knowledge, this paper is the first that develops a simulation game for enhancing digital transformation towards virtual supply chains. Another main theoretical contribution is the constellation of barriers presented in Figure 3, and the attendant realization that when it comes to virtualization of a sector with small independent enterprises, and without a dominant partner (as e.g. the retailers in food), there are two levels of analysis. Problems at individual company level can differ fundamentally from those at sector level, and so can their solutions. The sector can simply not virtualise unless the independent companies across the chain standardize and collaborate.

7.3. Limitations

Some results of the game sessions seemed not to be in line with the system analysis interviews. First of all, while interviewees seemed to have a limited understanding about virtualisation, game participants appeared to have a good knowledge about the use of IoT technologies for virtualization and some even already adopted them for quality control. Secondly, while interviews suggested a low sense of urgency to virtualise, results of the pre-questionnaire suggest that game participant were aware of the importance to keep innovating to maintain chain competition. Thirdly, even if there is a general agreement about the high competition within the sector, some game participants mentioned being engaged in intra-chain collaboration. These discrepancies in the results could be explained by a selection bias of the game participants, whose positions already require a mindset prone to innovation and collaboration. Examples of these positions include marketing, quality control and innovation. These results suggest that in order for virtualization to actually occur it is crucial that a wider mass is willing to achieve the fundamental changes of business strategies, business processes and key inter-firm relationships necessary to achieve virtualization of supply chains. So, while the game has succeeded in mobilizing those who already have a notion about the relevance of the issue, drawing in the other entrepreneurs has so far proved beyond its power.

In fact, looking at Figure 3, one can wonder whether some of the barriers in the causal map have not been instrumental in keeping stakeholders from participating in game sessions so far. The game participants may turn out to be 'first movers', but there is still work to do.

7.4. Future research

The game was an important first step of a transformation towards virtual supply chains, as it increased awareness about the set of barriers represented in the game and it triggered willingness of participants to address them. Future research is needed to further evaluate and to extend the game.

First, the present research has evaluated the game in participatory and collaborative sessions with a total of 29 participants. The number of respondents needs to be increased for more statistical evidence. Furthermore, further research is needed to analyse the effects of the game in different adoption phases of the participants. For example, we expect that the increase of willingness to adopt IoT technologies will be larger for the early and late majority than for the innovators and early adopters (Rogers 1995), who mainly participated in this study. Moreover, the game was tested in the Dutch floriculture. Future studies could evaluate the applicability in other countries as well as in other supply chains of perishables.

Secondly, there are many research opportunities to extend and further develop the game. A next step would be to support more in-depth socio-institutional learning and engagement in actual collective action. This can be achieved through follow-up sessions aimed at discussing more in detail how intra-chain collaboration would actually take place. These sessions could take form of a series of more detailed simulation games or other types of workshops where IoT experts and chain parties think about possible collaboration scenarios. For this purpose, the functionalities for interaction and collaboration need to be extended.

Furthermore, for the purpose of the research, we have chosen for a board game to support the social interaction between players that are physically in the same room. However, among others due to the COVID-19 crisis, the technologies for digital interaction are advancing fast. An appealing question for follow-up research is if virtualization of the game itself can achieve the same quality of social interaction and similar effects as a board game.

Additionally, further research is needed to address other barriers which were not included in the game because they require a long term approach. For instance, the game could support trust building and help chain stakeholders to (re)define roles and responsibilities. Also, disruptive supply chains of new players, for example, start-ups and platforms like Amazon or Alibaba, can be included. Such scenarios use virtualization to by-pass current actors and to create shorter and more responsive routes from producers to consumers. We expect that this will strengthen the effect of a 'wake-up call' for existing supply chains, which would contribute lowering intra-chain competition and the fear of free riders. This would allow the Dutch floriculture sector to keep their current high position in face of globalisation and emerging market challenges.

8. Conclusions

8.1. Results

This paper analysed the barriers to virtualization of the Dutch floriculture sector based on interviews with industry experts and it describes the 'Virtual chain game', a simulation game designed to support digital transformation towards virtual supply chains. The main barriers addressed in the game included: lack of focus on consumer needs, lack of sense of urgency, limited understanding of virtualization and lack of cooperation. The game was developed through a participatory and collaborative method. It acted as an experimental platform that simulated the innovation process and enabled communication and reflection among players. Participants gained awareness of the processes that lead to flower quality decay and they shared their experiences and points of view about barriers to virtualisation. Additionally, they participated in active and dynamic interaction which helped achieving a joint understanding of logistic processes at the chain level. Hence, through the game and the joint reflection on the barriers, participants became more aware of the importance of thinking as a chain rather than as an individual business. This interaction allowed them to broaden their perspectives and think about possible future collaborations.

8.2. Managerial implications

These results suggest that the game represents a first important step to achieve organizational learning towards virtualization of supply chains. Nevertheless, the game could address only those virtualization barriers that can be tackled in a relatively short term. For organizational change to actually take place, follow-up sessions, and perhaps other measures, are necessary to address other important and underling barriers such as lack of trust and the low level of planning and control. These sessions should support trust building and decision making on different aspects, such as intra-chain collaboration and clarification of roles and responsibilities.

8.3. Theoretical implications

It might be presumed that high-tech firms populate high-tech sectors. This case study shows how small and medium-size enterprises all of which are technologically advanced and produce the highest quality products can still constitute a sector in which quality information is lacking. This multi-level nature, and the disparity between levels, is a salient finding. Our analysis and game contributed in making stakeholders aware of the importance of the sector level as a common resource.

Disclosure statement

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