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Door in Nigeria verse tomaten van boer tot retail te transporteren in plastic kratten in plaats van in traditionele rieten manden kunnen naoogstverliezen worden verminderd, zowel in kwantiteit als in kwaliteit. Met de Value Chain Laboratory-methode (VC-Lab) analyseren we het belang van vertrouwen tussen ketenpartijen, de risicohouding en sociale normen van de ketenactoren, een prijsbonus voor vervoer met kratten, de kosten en levensduur van kratten, en wie er investeert in kratten voor de acceptatie op lange termijn van deze plastic kratten. De prijs die een boer van de groothandel ontvangt, de risicohouding van de actoren en je houden aan de sociale norm waren de belangrijkste drijfveren voor het gebruik van plastic kratten op lange termijn.

Transporting fresh tomatoes from farmer to retailer in Nigeria in plastic crates instead of raffia baskets can substantially decrease post-harvest losses both in quantity and in quality. We apply the Value Chain Laboratory (VC-Lab) method to analyse the importance for the long-term acceptance of these plastic crates of trust in other chain actors, risk attitudes and social norms of chain actors, a price bonus for transporting tomatoes in crates, the costs and lifespan of crates, and who should invest in crates. The price a farmer receives from a wholesaler, risk attitudes of the actors, and social norms were the most important drivers for the long-term use of crates.

Key words: VC-Lab method, Agent-Based Model, Trust, Risk attitude, Social norm, Post-harvest losses, Tomato, Plastic crate, Nigeria

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Preface

During the transport of fresh tomato from farmer to retailer in Nigeria substantial post-harvest losses occur both in quantity and in quality. In a pilot project in five informal tomato value chains from the southwest regions to the urban centres of Lagos and Ibadan in Nigeria, plastic crates were introduced that replaced the traditional raffia baskets. Using plastic crates resulted in a lower weight loss and lower quality loss of the tomatoes during transport than using raffia baskets. After this intervention, the value chain participants were provided with the opportunity to purchase the crates and most farmers, wholesalers and a few retailers did. However, no further budgets were available for additional support of the participants and for scaling up the intervention to other tomato value chains. The CGIAR-A4NH Flagship Food Systems for Healthier Diets and the Dutch Ministry of Agriculture, Nature and Food Quality were interested to know how the behavioural factors mutual trust of actors in their trading partners, risk attitude of the actors and social norm of the actors (sticking to crates because other VC-actors trust you to use crates) influence the future uptake of plastic crates.

We applied the Value Chain Laboratory (VC-Lab) to analyse the importance of these behavioural factors for the sustained adoption of plastic crates to transport fresh tomatoes and for opportunities for upscaling in other tomato value chains. The VC-Lab consists of 1) Value Chain Analysis to provide information on the tomato value chain in Nigeria; 2) Value Chain Games to assess trust relationships between value chain actors, risk attitude and social norms; and 3) Agent-Based Model to simulate the impact of mutual trust, risk attitude and social norms on the long-term development of the use of crates. The most important factors for sustained adoption of crates to transport fresh tomatoes in Nigeria were the additional price a wholesaler pays to farmers to transport the tomatoes in crates instead of in baskets, the risk attitudes of the value chain actors and social norms of the value chain actors. Trust in other value chain actors, the price and lifespan of crates and whether farmers or wholesalers invest in crates only mildly influenced the long-term use of crates.

Gathering the necessary data through the Value Chain Analysis and the Value Chain Games that was used as input in the Agent-Based Model was a laborious activity, which we could not have done without the following people. We would like to thank the research team members that participated in the intervention in the tomato value chain in Nigeria: Johannes van der Waal, Luud Clercx (both AgroFair Projects B.V.), Milindi Sibomana (M.AGRO-SPEC Ltd.), Frits Blessing, Peace Eruore Quadt (both N-N-Solutions), Olalekan Emmanuel Akinwekomi and Thompson Ogunsanmi (both International Fertilizer Development Centre). And our thanks goes out to all tomato value participants that participated in the intervention.

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Summary

S.1 Key findings

The most important factors for the long-term success of the use of crates instead of baskets to transport fresh tomatoes in Nigeria were the additional price a wholesaler pays to farmers to transport the tomatoes in crates instead of in baskets, the risk attitudes of the value chain actors and social norms of the value chain actors. Trust in other value chain actors, the price and lifespan of crates and whether farmers or wholesalers invest in crates only mildly influenced the long-term use of crates. A 30% bonus on the price from wholesaler to farmer when using crates increased the number of farmers using crates after 30 seasons from 25% to 60% and decreased the loss of the best A-quality tomatoes by almost 50%. More risk averse actors are less inclined to keep using crates, because a crate requires a larger investment than a basket. A farmer with a low social norm factor cares less about whether others want to remain using crates, and thus switches to baskets quicker. Farmers with low levels of trust in the wholesaler switch from crates to baskets within a few seasons, whereas farmers with high levels of trust mostly remain using crates. The lifespan and the price of a crate had minor impact on the results, because of the relatively low investment costs of crates. Providing financial incentives for farmers to use plastic crates, developing mechanisms to reduce the risk for individual farmers and strengthening social norms of value chain actors working together in the value chain could help to improve the long-term use of plastic crates.

S.2 Background and methodology

During the transport of fresh tomato from farmer to retailer in Nigeria substantial post-harvest losses occur both in quantity and in quality. Replacing the traditional raffia baskets by plastic crates could reduce both the quantity and the quality losses. In December 2017 and July 2018 in five informal tomato value chains from the southwest regions to the urban centres of Lagos and Ibadan in Nigeria, plastic crates were introduced in a pilot project (Plaisier et al., 2019). The value chains consisted of farmers, transporters, dealers and retailers. Using plastic crates resulted in a lower weight loss and lower quality loss of the tomatoes during transport than using raffia baskets (Kok et al., 2019). After the intervention, the value chain participants were provided with the opportunity to purchase the crates and most farmers, wholesalers and a few retailers did. However, no further budgets were available for additional support of the participants and for scaling up the intervention to other tomato value chains.

The CGIAR-A4NH Flagship Food Systems for Healthier Diets and the Dutch Ministry of Agriculture, Nature and Food Quality were interested to know how the behavioural factors mutual trust of actors in their trading partners, risk attitude of the actors and social norm of the actors (sticking to crates because other VC-actors trust you to use crates) influence the future uptake of plastic crates.

We applied the Value Chain Laboratory (VC-Lab) to analyse the importance of these behavioural factors for the development of the use of plastic crates to transport fresh tomatoes beyond the pilot project period and for opportunities for upscaling in other tomato value chains. The VC-Lab consists of:

1. Value Chain Analysis (VCA) to provide information on the tomato value chain in Nigeria, such as production areas and volumes, post-harvest losses in quality and quantity, transport routes, modalities and routines, value chain actors and economics by literature search, field visits, a survey amongst and workshops with value chain actors;
2. Value Chain Games (VCG) to assess trust relationships between value chain actors, risk attitude and social norm measured with trust, risk and voluntary contribution mechanism games; and

3. Agent-Based Model (ABM) to simulate the impact of mutual trust, risk attitude and social norms on the long-term development of the use of crates in the tomato value chain in various scenarios.

The results of the ABM are generated with model simulation runs (3,000 runs per simulation), with each run representing a potential future development of the use of plastic crates. A typical simulation run in the ABM includes 130 farmers, 50 wholesalers and 60 retailers. At the beginning of a simulation run, all actors start with using crates. The span of a run is 30 harvest seasons, covering 15 years (two harvest seasons per year). At the beginning of each growing season in a run, each actor modelled in the ABM decides to keep using crates or to switch to using baskets to transport tomatoes. This decision is based on which provides him with the highest expected profit. It was assumed that actors don't switch back from baskets to crates once they have chosen baskets. The expected profit depends on the amount of tomatoes, the quality of the tomatoes, the price the actor is expected to receive and the costs the actor is expected to make. The amount and quality of tomatoes arriving at the customer depends on whether crates or baskets were used for transport. The expected price depends on the trust the actor has in the trading partner, with higher trust indicating a higher expected price. How the actor weighs expected revenues and costs depends on the risk attitude of the actor. In scenarios, we analysed the impact of different levels of trust between value chain actors, of social norms of the value chain actors, and of the risk attitudes of the value chain actors, as well as the impact of an additional price for tomatoes transported in crates, the costs of crates, the lifespan of crates and whether farmer or wholesalers invest in crates.

Samenvatting

S.1 Belangrijkste uitkomsten

De belangrijkste factoren voor een langtermijngebruik van kratten in plaats van rieten manden om verse tomaten door de keten te vervoeren in Nigeria zijn de prijsbonus die een boer van de groothandel ontvangt voor tomaten vervoerd in kratten, de risicohouding van de actoren en het voldoen aan de sociale normen. Vertrouwen in de andere ketenpartijen, de prijs en levensduur van een krat en of boeren of groothandelaren in kratten investeren hadden slechts een gering effect op het langtermijngebruik van kratten. Een bonus van 30% op de prijs van groothandelaar aan boer bij het gebruik van kratten verhoogde het percentage boeren dat kratten gebruikt na 30 seizoenen van 25% naar 60% en verminderde het verlies van tomaten van A-kwaliteit met bijna 50%. Meer risicomijdende actoren zijn minder geneigd kratten te blijven gebruiken, omdat een krat een grotere investering vereist dan een mand. Boeren met een lagere sociale norm laat zich minder leiden door of anderen kratten zouden willen blijven gebruiken en gaat dus sneller over naar manden. Boeren met een laag vertrouwen in hun opkoper schakelen binnen enkele seizoenen over van kratten naar manden, terwijl boeren met een hoog vertrouwensniveau meestal kratten blijven gebruiken. De levensduur en de prijs van een krat hadden een beperkte impact op de resultaten vanwege de relatief lage investeringskosten van kratten. Het creëren van financiële incentives voor boeren om kratten te gebruiken in plaats van manden, het ontwikkelen van mechanismen om het risico voor individuele boeren te verminderen en versterken van sociale normen van ketenactoren kunnen helpen het langetermijngebruik van plastic kratten te verhogen.

S.2 Achtergrond en methode

Tijdens het transport van verse tomaten van boer tot detailhandel in Nigeria zijn er aanzienlijke naoogstverliezen in zowel kwantiteit als kwaliteit. Het vervangen van de traditionele raffiamanden door plastic kratten zou zowel de kwantiteit als de kwaliteitsverliezen kunnen verminderen. In december 2017 en mei 2018 zijn in vijf informele tomatenketens in het zuidwesten van Nigeria plastic kratten geïntroduceerd in een proefproject (Plaisier et al., 2019). De ketens bestonden uit boeren, transporteurs, groothandelaren en retailers. Vervoer in plastic kratten leidde tot minder gewichtsverlies en kwaliteitsverlies dan vervoer in de traditionele rieten manden (Kok et al., 2019). Na het proefproject konden de deelnemers in het project de plastic kratten kopen, en de meeste boeren en groothandelaren en een paar retailers hebben dat inderdaad gedaan. Echter, er was geen budget beschikbaar voor verdere ondersteuning van deze deelnemers na afloop van het proef project en om de interventie op te schalen naar andere tomatenketens.

Het CGIAR-A4NH Flagship Food Systems for Healthier Diets en het ministerie van Landbouw, Natuur en Voedselkwaliteit waren geïnteresseerd hoe de gedragsfactoren onderlinge vertrouwen tussen ketenactoren, risicohouding van ketenactoren en sociale normen van ketenactoren (vasthouden aan kratten omdat anderen er op vertrouwen dat jij ook kratten blijft gebruiken) de toekomstige ontwikkeling van het gebruik van kratten kan beïnvloeden.

We hebben de methodologie van het Value Chain Laboratory (VC-Lab) toegepast om de invloed van deze gedragsfactoren te analyseren op de ontwikkeling van de interventie na de pilotprojectperiode en voor kansen voor opschaling in andere ketens. Het VC-Lab bestaat uit:

1. Value Chain Analyse (VCA) om informatie te verzamelen over de tomatenketen in Nigeria, zoals productiegebieden en -volumes, naoogstverliezen in kwantiteit en kwaliteit, transportroutes en -modaliteiten, ketenactoren en economisch kengetallen, via een literatuurstudie, veldwerk, een survey onder ketenactoren, en in workshops met een selectie van deze ketenactoren;

2. Value Chain Games om risicohouding en vertrouwensrelaties tussen ketenactoren te beoordelen via vertrouwensspellen, risicospellen en vrijwillige bijdrage spellen; en
3. Agent-Based Model (ABM) om de impact van onderling vertrouwen, risicohouding en sociale normen op het de langetermijnontwikkeling van het gebruik van kratten in de tomatenketen in verschillende scenario's te simuleren.

Resultaten van de ABM worden gegenereerd met simulatie runs, waarbij elke run een mogelijk ontwikkelingstraject van het gebruik van plastic kratten representeert (3.000 runs per simulatie). Een typische simulatierun in de ABM omvat 130 boeren, 50 groothandels en 60 retailers. Bij de start van een simulatierun gebruiken alle actoren plastic kratten. Elke simulatierun omvat 30 oogstseizoenen, dat overeenkomt met 15 jaar (twee oogstseizoenen per jaar). Bij het begin van elk groeiseizoen in een simulatierun besluit elke gemodelleerde actor om plastic kratten te blijven gebruiken voor het vervoer van tomaten of om te kiezen voor de traditionele rieten manden. Dit besluit is gebaseerd op welke van deze twee keuzes hem de hoogste verwachte winst geeft. Er is verondersteld dat actoren niet terug kunnen veranderen van manden naar kratten, als ze eenmaal voor manden hebben gekozen. De verwachte winst hangt af van de hoeveelheid tomaten, de kwaliteit van de tomaten, de prijs die de actor verwacht te ontvangen, en de kosten die de actor verwacht te maken. De hoeveelheid en de kwaliteit van tomaten die aankomen bij een klant hangen af van of er kratten of manden zijn gebruikt tijdens transport. De verwachte prijs hangt af van het vertrouwen dat de actor heeft in zijn handelspartner, met hoger vertrouwen leidend tot een hogere verwachte prijs. Hoe een actor verwachte baten en verwachte kosten afweegt hangt af van zijn risicohouding. In scenario's hebben we de impact van verschillende niveaus van vertrouwen tussen ketenpartijen, van sociale normen van ketenpartijen, en van risicohouding van ketenpartijen geanalyseerd evenals de impact van een prijsbonus voor tomaten vervoerd in kratten, de kosten van kratten, de levensduur van kratten en of boeren of groothandelaren in de kratten investeren.

1 Introduction

The urban areas in southern Nigeria are supplied with fresh vegetables by an intricate supply network linking urban consumers to producers in other parts of the country. Fresh tomatoes are one of the most important vegetables consumed and produced in Nigeria. Over 90% of consumers in the urban areas purchased tomatoes, of which over 90% purchased fresh tomatoes (Adeoye et al., 2016). From 2012 to 2014, the average annual production of tomatoes in Nigeria was estimated at over 2.0 million tonnes (FAOstat). Small holders, 30% by medium-sized farmers, and 10% by large farmers (Ugonna et al., 2015) produce about 60% of these tomatoes. Tomatoes are grown on seasonally irrigated flood plains in the north and in the south-west of Nigeria. Tomatoes are usually harvested ripe and transported to the urban areas by road. The distance between the areas of production and the urban areas are 100-200 km from the southwest and 800-1,200 km from the north. Travelling time could take up to several days including hold-ups. In combination with poor road conditions, unrefrigerated trucks and poor packaging, this results in substantial losses in quantity and quality. Ugonna et al. (2015) estimated the annual losses of tomatoes produced in Nigeria at 45% of production. Nigeria's Federal Ministry of Agriculture and Rural Development reported losses of tomatoes harvested but left unsold of more than 40% (FMARD, 2016). Olayemi et al. (2012) showed a reported average loss of 33%, although in this research it was not made explicit to which parts of the value chain these losses apply. Although uncertainty exists on the exact losses occurred during transport and storage, it is clear that these losses are substantial.

To reduce these post-harvest losses, an intervention was applied in several informal tomato value chains from the north to the urban centres of Lagos and Ibadan in Nigeria and from the south-west to the same urban centres. In this intervention, tomato value chain participants replaced the traditional raffia baskets for transporting the fresh tomatoes by reusable plastic crates (Plaisier et al., 2019). The value chains consisted of farmers, transporters, dealers and retailers. In the pilot projects, which were conducted in December 2017 and July 2018, the effects on post-harvest losses in quantity and in quality were measured. It was found that the plastic crates resulted in a lower weight loss and lower quality loss of the tomatoes during transport than raffia baskets (Kok et al., 2019). After the intervention, the value chain participants were provided with the opportunity to purchase the crates against a reduced price. Most farmers, wholesalers and a few retailers decided to buy the crates. However, no further budgets were available for additional support of the participants and for scaling up the intervention.

This intervention requires cooperation and coordinated actions between the value chain participants. The relationships between the participants and the behaviour influencing this relationship such as trust are important aspects for this. Next to the effectiveness of the plastic crates compared to the raffia baskets, the relationships between involved value chain participants is relevant for the intervention to succeed. However, as relationships need time to be built and can be easily disturbed, the period needed to develop the new relationships with the plastic crates exceeded the project period. Furthermore, the crates were only introduced in a small number of value chains. Important behavioural aspects that can be of influence on the acceptance and use of the crates are trust in the trading partners, the risk attitude of the actors, and the social norm of the actors. In this study, we apply the VC-Lab methodology to analyse the role of these behavioural aspects in the development of the use of plastic crates to transport fresh tomatoes beyond the project period and for opportunities for upscaling in other tomato value chains.

2 Literature

The VC-Lab methodology takes into account social capital concepts. Social capital in development programmes is an important contributor to poverty alleviation and development (Collier, 2002; Grootaert and van Bastelar, 2001; Isham, 2002). Uphoff (2000) identifies two different types of social capital: cognitive and structural. Cognitive social capital refers to common norms, values and beliefs and is also related to levels of trust and attitudes towards risk. It is therefore a subjective concept. Structural social capital enables information sharing, collective action and decision making through established roles, social networks and other social structures added by rules, procedures, and precedents. It is an objective and externally observable construct.

The adoption of an innovation like plastic crates is commonly understood as a rational investment decision. This decision is often influenced by the following selected (cognitive) social capital items:

- Trust between actors in the value chain (i.e. famers and their buyers); and
- Social norms between farmers in a farmer group and between value chain actors;
- The risk attitude of the farmer.

Stable relationships and (contractual) arrangements between farmer groups and buyers are important for VC actors to reduce risk and increase their ability to invest (Ruben and Fort, 2012). As such, increased trust levels reduce risks, and can increase the motivation to adopt improved practices (e.g. Good agricultural practices and Good business practices) or other innovative (e.g. conservation, equipment) technologies. In the end, this will lead to a more reliable and sustainable supply, increased quality of the procured goods (including less loss) and will contribute to an improved welfare of the involved VC actors.

2.1 Trust

For a successful participation of smallholder farmers in a formal VC, trust between smallholders and their buyers is an important factor (Blandon et al., 2009). Especially for smallholder farmers it can already be a challenge to be included in formal VCs because of bad experiences with buyers. Historical events can also cause a culture of low trust levels in regions, such as in Nigeria and other West African countries due to the slave trade history (Nunn and Wantchekon, 2011). In such countries with a historical culture of mistrust, trust is an important aspect to consider when developing value chain partnerships. Six (2007) defines trust as:

> 'Interpersonal trust is a psychological state comprising the intention to accept vulnerability to the actions of another party, based upon the expectation that the other will perform a particular action that is important to you.'

This implies that when value chain participants are placed in a relational context where trust is involved, trust and action mutually reinforce each other. Interpersonal trust-building is a reciprocal process in which both actors are involved interactively in building trust.

In an open market situation, buyer-to-seller trust in a VC is important, because it concerns direct trading partners, not only now, but also in the future. VC participants are not integrated in the same company and do not work under the same management. As such VC actors are independent, but trade with each other based on formal agreements (e.g. a contract) and informal agreements (e.g. trust). Das (1998) confirms the importance of trust and indicates that there is a balance between formal and informal agreements. If the level of trust in the other actor is low then the level of formal agreements is likely to be high (e.g. need to sign detailed contracts to compensate for non-compliance. Committed and collaborative relationships between VC participants are based on mutual trust.

2.2 Social norms

Social norms can affect an individual's behaviour in a variety of ways (Nolan et al., 2008). Social norms are defined as the influence on a person's decision making of the perception this person has about how other people value each behaviour the person can choose from or about the collective behaviour of other people. The first example is part of the type of social norm influence known as injunctive norms: collective perceptions about what others find socially appropriate behaviour in a certain situation (e.g. White et al., 2009). The second example is part of the type of social norm influence known as descriptive norms: collective perceptions about how others behave in a certain situation (e.g. Schultz et al., 2007). Overall, social norms have been found to play a role in many types of decision-making, ranging from recycling (Cialdini et al., 1990) to making choices on the stock market (Hong and Kacperczyk, 2009). Social norms influence in value chains can be vertical and horizontal. According to Ostrom (2003), horizontal cooperation is the core link between networks and collective action and the most relevant factor to provide voluntary cooperative action. It is enhanced when individuals are trustworthy and connected to each other within institutions that reward honest behaviour. By being involved in successful cooperatives, farmers can work together and are able to exchange agricultural techniques, and together they have more means to access financial inputs and markets.

2.3 Risk attitude

Risk is a key concept in the adoption of new technologies is often defined as the function of probability and magnitude of different impacts. Risk is mainly guided by risk perceptions, which in turn may be influenced by the risk attitude (Barham et al., 2014; Feder et al., 1985).

Resource-poor farmers in developing countries are generally found to be risk averse (De Brauw and Eozenou, 2014). Binswanger (1981) was one of the first to provide a formal test of risk aversion among farmers in a developing country. These studies found that most Indian farmers in the study were risk averse, and that the degree of risk aversion increased with the monetary payoff of the lotteries. Overall, these results suggested that farmers' choices were consistent with increasing relative risk aversion and decreasing absolute risk aversion.

3 Material and methods

In this study we used the Value Chain Laboratory (VC-Lab) method to assess the long-term effectiveness of the introduction of plastic crates instead of raffia baskets to transport tomatoes in Nigeria. The VC-lab method compromises three components:

1. A Value Chain Analysis (VCA) in order to understand the structure of the value chain, to identify all value chain stakeholders from input suppliers to final consumers and to analyse stakeholder group size and composition, key resources and assets, objectives of stakeholders and key chain dynamics. Next to field visits, this includes a survey under the VC actors and a search of the literature and a living lab workshop.
2. Value Chain Games (VCG) with the actual VC partners to gather data on trust between value chain actors, the risk attitude of the value chain actors and social norm, i.e. the extent to which an actor is guided by the perception this actor about how other people value each potential behaviour.
3. An Agent-Based Model (ABM) to simulate behaviour of the value chain actors. In the ABM, the behavioural characteristics of the VC agents as derived from the VCA and VCG, are captured as 'what-if' rules. The ABM model allows for exploration of alternative value chain options (e.g. alternative prices, trust levels or alternative incentive mechanisms).

Figure 3.1 gives a visualisation of the VC-Lab method. The VCA provides insight into the configuration of the VC, the VC actors and their relationships, and the product and financial flows. With the VCG the level of trust and risk aversion and free riding of individual VC actors are measured. The VC actors are selected based on the VCA. The results of these two steps are used as input data in an ABM to simulate the behaviour of the VC actors. In this ABM, the use of crates instead of baskets can be simulated in simulation runs and the long-term effects of trust, social norm and risk and prices can be identified on the continuity of the use of these crates in the tomato value. The results of these simulation runs can be used to provide policy and practical advice on the long-term use of the crates. In the next sections we describe each component in more detail.

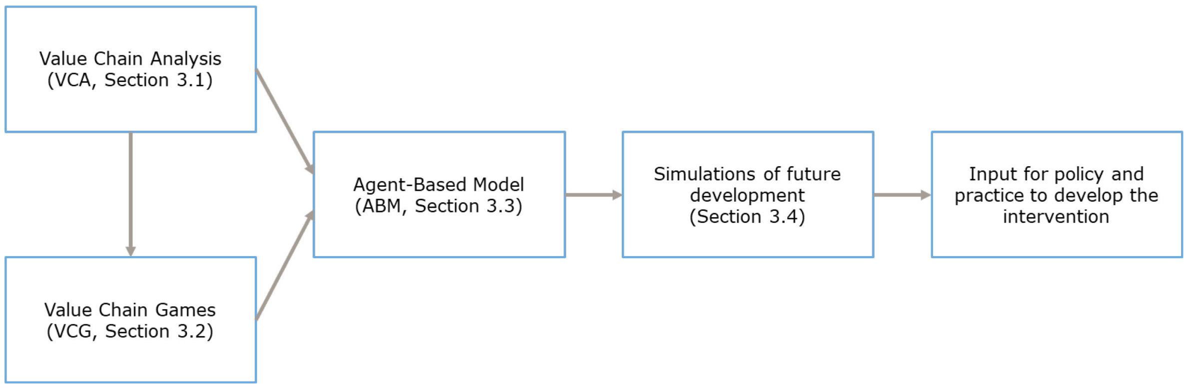

Figure 3.1 *Visualisation of the Value Chain laboratory (VC-Lab) methodology*

3.1 Value Chain Analysis

The VCA consisted of two parts: 1) a field visit including a scoping survey and a desk research and 2) a living lab workshop to identify the most relevant intervention to reduce post-harvest losses. In 2017, we organised a field mission to map the tomato VC and the relevant key VC actors were visited, i.e. farmers, wholesalers, transporters, retailers. The VCA was complemented with a desk study in order to understand the sectors and their dynamics. We reviewed literature and consulted additional data sources in order to collect secondary data on production statistics and production seasons of tomato in the region. Finally, to identify the most relevant intervention to reduce post-harvest losses in the tomato value chain, we used living lab workshops. In such workshops, the VC actors themselves identify their most pressing problems and the most likely solutions.

Scoping survey

As part of the VC study a scoping survey was held with actors from the value chains from both regions. In the South-West, actor-specific scoping surveys were conducted among 48 farmers, 44 transporters, and 48 traders/retailers. The survey for traders/retailers was performed on the largest markets in the area, Sasa and Mile 12, which were the major end markets for the value chain of tomatoes.

Survey participants were randomly selected after the researchers had 'followed the chain', which means that in an initial visit (prior to survey execution), the researchers had interviews with various actors in all parts of the value chain in the areas of interest, e.g. the market (traders, retailers, wholesalers), farmer groups, and individual farmers who often supplied these markets (or supply other market actors), as well as hauliers who transported fresh produce (including tomatoes). These initial meetings enabled identification of the chain structure and networks, which enabled the research team to have access to participants who were later selected for the survey. Simple random sampling and a structured questionnaire was used. The main criteria for participants in the survey was that they had to be involved commercially in the tomato chain regardless of level—in other words, small, medium, or large-scale growers, traders, or hauliers had to be involved directly in growing, transporting, or selling the product. Limitations in the sampling methodology are acknowledged, and this technique was chosen primarily to give the researchers insight into the status quo of the tomato value chain in Nigeria.

Plaisier et al. (2019) describe the result of the scoping survey and the majority of respondents were male, a member of an association (either producer, transporter, or trader), and used raffia baskets as packaging material (Table 3.1). The majority of transactions took place at the farm gate, collection centres, or markets. Poor infrastructure conditions, unsuitable tomato varieties, and poor post-harvest handling were identified as critical drivers of PHL for farmers, and transporters were more concerned with poor infrastructure conditions, roadblocks, and poor post-harvest handling. In addition limited post-harvest infrastructure and unsuitable tomato varieties were identified as critical drivers of PHL for farmers, while traders were more concerned with poor transportation conditions. These challenges are consistent with earlier findings published by Muhammad et al. (2012) for the North of Nigeria.

Table 3.1 *Descriptive results of the scoping survey*

Characteristic	Option	Producer (n=48)	Transporter (n=44)	Trader/Retailer (n=48)
Gender (%)	Male	85	100	55
Education (%)	Primary school (in)complete	23	46	52
	Secondary school (in)complete	46	48	43
	Arabic school		2	
	Higher education	32	5	7
Age (%)	25-35 years	28	23	27
	36-45 years	24	57	64
	>45 years	48	43	9
Member of association (%)	Yes	92	85	72
Main function of association (%)[1]	Information and training	73		42
	Seeds and other inputs	56		
	Sales	46		
	Government liaison		45	31
	Transport regulations		41	
	(Off)loading coordination		41	
	Collect Levies			23
	Price setting			19
Packaging material (%)[1]	Raffia basket	63	100	90
	Sack	2	100	
	Crate	13	8	
	Mixed/other	6	2	10
Tomato Growing Experience (%)	1-3 years	35		
	3-10 years	28		
	>10 years	37		
Tomato land size (ha)	Wet season	2		
	Dry season	1.2		
Productivity (kg/ha)	Wet season	3,523		
	Dry season	4,838		
Truck/car ownership (%)[1]	Owns the truck		41	
	Driver of individual/ company		85	
Truck/car backhaul (%)	Empty		95	
	Loaded		5	

Source: Plaisier et al. (2019).

Living lab workshop

A Living Lab workshop was held in Ibadan (South-West) and lasted for two days. In the living lab workshop, five groups were established of value chain participants that encompassed the entire value chain. Each group represented a value chain with at least one farmer, one transporter, one trader, and one retailer. The Living Lab workshop started with a plenary session, discussing and validating the outcomes of the scoping surveys. Local enumerators were present to guide participants through the assignments and to assist and translate where needed. The participants analysed product, information and monetary flows in their own value chain, identify causes for PHL, and selected potential interventions to reduce these. The most relevant intervention selected by the participants was changing the packaging material to transport tomatoes by using reusable plastic crates instead of the traditional raffia baskets. This intervention was implemented, tested and monitored in pilot projects in five different value chains with the workshop participants. Pilot projects were implemented in December 2017 and July 2018. This was followed by an evaluation workshop. For a detailed description of the method see Plaisier et al. (2019).

To quantify the post-harvest losses across multiple stages, load tracking was used in the pilot projects. Load tracking is the evaluation of the weight and visual observations of the product quality of a sample of the crop as it moves through a value chain under normal commercial conditions. At several stages in the value chain, total weight and quality were measured. In each transport both crates and baskets were used, to ensure comparable circumstances between the two packaging materials, such as weather, transport distances, road conditions, transport time, and type of vehicle. The initial procedure for load tracking is described in detail in Kok et al. (2019).

The participating farmers filled the plastic crates up to an average weight of 21.3 kg with a variation between 16.1 and 23.8 kg. On the other hand, the total volume of tomatoes in the raffia baskets was dependent on the raffia baskets used. Some value chains used smaller raffia baskets compared to others. The weight of tomatoes in the baskets varied between 5.7 and 30.3 kg (Kok et al., 2019). During the transportation process losses occurred in the raffia baskets and plastic crates. In our pilot, the average loss of tomatoes in baskets was 12% and for crates 5%. So, on average the plastic crates performed better based on the overall losses. As model input we used these data and the results from the survey data, and assume a weight loss for crates of 15% and for baskets of 30%. Tomatoes are visually graded in three quality grades, A, B and C. Grade A is the best quality, with firm, round, red tomatoes. Grade B and C are damaged tomatoes, where the damage is larger in grade C. At farm level, baskets were filled on average with 75% tomatoes of grade A and the crates with 69% grade A. At retail level the tomatoes are sorted and sold to consumers for different prices.

3.2 Value Chain Games

In the VCGs, data were gathered about trust, horizontal cooperation, and risk attitude using experimental economics games. With such games, hypothetical and socially desired answers can be avoid as much as possible. The games played are presented in Table 3.2.

Table 3.2 *Game, the behavioural norm that is measured with the game, and the frequency of playing the games*

Game	Behavioural norm	Frequency
Trust game	Trust	Twice
Trust game	Trust update	Once
Risk game	Risk attitude	Once
Voluntary contribution mechanism game	Social norm	Twice

The trust and VCM games were conducted twice: first during the kick-off workshop at December 10, 2018 in Ibadan. The second game round took place on October 5 2018 after closure of the pilot project, again in Ibadan. Data collection was done by two researchers of Wageningen University & Research. Five independent local research assistants were trained on the objectives, the process and procedures of the games. The games were played in the local Yoruba language to ensure understanding. The games were played with five value chains of: producers, transporters, traders/dealers and retailers who regularly collaborate in the tomato chain. The actors are from the following regions of Southern Nigeria: Ipapo, iseyin, Onila, Oloka, Ayepe-Opomu (Ibadan and Lagos). The following actors participated: 8 producers, 4 transporters, 6 traders and 6 retailers. They operate on different markets: Shasha (Ibadan), Oja-Oba (Ibadan), Mile 12 (Lagos), Ileepo Oja (Lagos), Odo-Oba (Lagos). Out of the participants 17 were male and 7 female (all retailers were female and one trader). Not all participants showed up at the second round of games in 2018, so we could only play four VCM games instead of five. Also, two persons were replaced, one farmer and one retailer of the first game round were replaced by a new farmer and retailer. We think that this did not influence the results much, because the behaviour in the first and second round of games is similar. The game results are only used in the ABM and not for any further analysis as the number of respondents it too low for any statistical tests or regressions.

Enough time was taken to explain the games to all the participants. The level of education and age varied resulting that understanding took some time for some participants. The games were only played after ensuring that all participants understood the games. All participants stayed till the end of the games and left after having their payment. The games were played with numbers and all participants picked a badge with an identification number themselves. The participants played the games with this number only and did not know their counterpart in the game. It was prohibited to talk and to look at each other and the set up was designed to stick to these rules of the game. Data were entered immediately to minimise errors in calculation.

All the games were played with coins, each coin representing 100 Nigerian Nairas (NGN) (0.23 euro). The amount of coins a participant had won at the end of the games were converted to NGN and the participant received this amount of NGN. In the first round of games in 2017, farmers won on average an amount of almost NGN 7,000 (16.50 euros) with the games. In the second round of games in 2018, the average amount won was NGN 7,400.

Trust game
In a trust game, a first mover and a second mover send each other money. The players don't know their counterpart. The first mover receives an initial amount of 10 coins (10 coins times NGN 100 equals NGN 1,000 in total) from the game leader and has to decide how much of this to send to the second mover. The amount of money that the first mover sends is tripled by the game leader before it reaches the second mover. Then, the second mover has to decide how much of this received money to send back to the first mover. The social optimum is that the fist mover sends 100% to the second mover, and the second mover returns half of the received money (Berg, Dickhaut, and McCabe 1995). Trust of the first mover in the second mover is measured as the fraction of the playing money, which the first mover sent to the second mover. Thus, trust can take a value from 0 to 1. Trust games were played to measure three trust parameters:

- Trust between farmer and trader, between farmer and haulier, and between trader and retailer;
- Farmers' trust in their group members;
- Trust update between farmer and trader, between farmer and haulier, and between trader and retailer, which is the development of trust when the other actor in the value chain fulfils his expectation (positive trust update) or not (negative trust update).

The first two were measured with trust games between the respective value chain actors. Trust update was measured using three consecutive trust games between the same players. Trust update games were played between farmer and trader and between trader and retailer. The counterpart in each game was a fake value chain actor introduced by the researchers (i.e. a fake trader playing with the farmers, a fake farmer playing with the traders, a fake retailer playing with the traders and a fake trader playing with the retailers). Part of the players were confronted with consistent a negative experience, i.e. they received in return only half of the amount of coins they sent. The remaining part were confronted with a positive experience, i.e. they received in return twice the amount of coins they sent.

Risk attitude game
A risk attitude game was used to measure the risk preference of the participants (Liebenehm and Waibel, 2014). In this game the multiple price list was used (Holt and Laury, 2002). The six choices were printed on separate pieces of paper. In a random order the participant had to choose six times between option A, win for certain, or B flip a coin. The six values in the multiple price list in option A 'win a certain amount of money' were NGN 100, 200, 300, 400, 500, or 600. After this, the participant rolled a dice to select one of the six options that will be played. If on that choice option A was chosen, the participants received a certain amount of NGN, or if option B was chosen the coin was flipped. The risk attitude game was only played once, because we expect that the risk attitude would remain the same during the running of the project. The game was played individually with each value chain actor. The game was played quietly and with no one present or watching to prevent influencing the decision making of the actor involved.

To estimate relative risk aversion λ of a value chain actor, the following exponential utility function was used $U(r)=1-e^{(-\lambda \cdot r)}$, where r is the amount of money to gain. For example, for the 'Certain from NGN 100 to 600' group, the utility of getting NGN 100 for certain ($U(100/600)=1-e^{(-\lambda \cdot 100/600)}$) was set equal to that of the gamble between flipping a coin with winning NGN 600 for head and NGN 0 for tail ($0.5 \cdot U(600/600)+0.5 \cdot U(0/600)=0.5 \cdot (1-e^{(-\lambda \cdot 600/600)})+0.5 \cdot (1-e^{(-\lambda \cdot 0/600)})$) and this equation was solved for λ.

Voluntary contribution mechanism game

The third game played is a VCM game to measure social norm parameters. This game allows players to contribute to a public good, which has the incentive structure of a prisoners dilemma (Cardenas and Carpenter 2008). In this game, players contribute a fraction of their initially received 10 coins (10 coins times NGN 100 equals NGN 1,000 in total) to a public account, the rest is stocked in their own private account. The amount is given anonymously and players are not obliged to give anything. The amount in the public account is doubled and shared equally among the participants. The players earn the amount in their private account plus their fraction of the public account. In this game it can be attractive to 'free-ride', but in a social optimum everything is stored on the public account (Croson, Fatas and Neugebauer, 2005). We played the game with each value chain (5x) with the actors participating in that value chain: tomato producer, transporter, trader and retailer. The common good represents the reduction of post-harvest losses as a result of the joint efforts and commitment of the VC.

Game sequence

The games were played in the following sequence:

1. Trust game between farmers and traders (B -> T) (game 1)
2. Trust game between traders and farmers (T -> B) (game 2)
3. Trust game between retailers and traders (R -> T) (game 3)
4. Trust game between traders and retailers (T -> R) (game 4)
5. Trust game between farmers and hauliers (A ->T) (game 5)
6. Trust game between hauliers and farmers (T -> A) (game 6)
7. Risk attitude game (game 7-12)
8. VCM game (3 rounds) (game 13-15) per VCM:
   – VCM Game: VC 1 (3 rounds)
   – VCM Game: VC 2 (3 rounds)
   – VCM Game: VC 3 (3 rounds)
   – VCM Game: VC 4 (3 rounds)
   – VCM Game: VC 5 (3 rounds)

3.3 Agent-Based Model

In order to capture the value chain interactions, analysis should be based on interactive approaches that are able to reveal behavioural drivers and constraints for value chain coordination. ABM can simulate the simultaneous operations and interactions of multiple agents in an attempt to re-create and predict the appearance of complex phenomena. The process is one of emergence from the lower (micro) level of systems to a higher (macro) level. An ABM enables assessment of possible alternative outcomes (Tykhonov et al. 2008). This approach allows for a detailed assessment of existing systems, and ex-ante assessment of potential future options, which is either impossible or impractically expensive with other approaches.

The objective of the ABM in this study is to address the effects of trust, social norm and risk in the value chain and the effect of prices on the continuity of the use of crates in the tomato value chain in the South West of Nigeria. The modelled value chain is represented by four types of actors: farmers producing tomatoes, haulers bringing tomatoes to the wholesalers, wholesalers who buy tomatoes from the farmers and sell tomatoes to the retailers and, retailers selling their purchase to the consumers. The ABM is used to test how changes in individual behaviour of these actors will affect the system's emerging overall behaviour in terms of post-harvest losses of tomatoes. Within the model the impact can be estimated of the underlying but also of alternative intervention strategies. The effects are measured in the reduction of losses of A-quality tomatoes, the fraction of farmers using crates during a time-span and use of crates by wholesalers. The ABM is implemented as a computer simulation in the software package NetLogo. For simplicity reasons and due to a lack of data on consumer behaviour and on difference in load capacity (hauler) when using crates or baskets, neither the relation between retailers and consumers is taken into account nor the possibility for haulers to return to using crates. We calibrate our simulation model with primary data collected in the VCA and VCG.

The modelled value chain

The tomato value chain dynamic was split into two sub-processes: production of tomatoes and transport to the market (Figure 3.2) and selling of tomatoes at the market to the retail (Figure 3.3). Central in the model is the process of negotiation, and depending on these outcomes, changing trust-levels and the decision to use crates or baskets. This negotiation process takes place at three moments: hauler and farmer, farmer and wholesaler and wholesaler and retailer. Modelling of the negotiation process is based on the model of Verwaart et al. (2016), in which the value chain of sorghum from farmer to buyer in Kenya was modelled. In their model, utility functions were introduced to determine the expected value for the 'market' and 'contract' payment. We used the same principle, and replaced 'market' for the expectation value for payment in case of using baskets and replaced 'contract' for payment in case of using crates. We assume that all participants start with only plastic crates. In case the expected payment for baskets is higher than the expected payment for crates, trust in the trading partner and in the crates as a system will decrease. At a certain level of trust, the payment receiver can decide to return to us baskets instead of crates. In the model, no mechanism for switching back from baskets to crates is included yet. This could be included in a newer model version.

Sub-process transport to the market

The farmer produces tomatoes and negotiates with a hauler to bring the tomatoes to the market. Before they negotiate, the farmer decides what he wants to pay and the hauler decides on the expected price. Depending on the difference between the payment of the farmer and expected payment, the hauler might decide to return to use baskets. Once a hauler returns to using baskets, the farmer will also have to use baskets. When using crates, the hauler is satisfied with the payment if it is at least similar to the payment using baskets (indicated as expected price in figure 3.2). We assumed that the hauler can transport the same amount of tomatoes in crates as in baskets. In reality, the amount of tomatoes transported with crates could differ from the amount of tomatoes transported with baskets in the same vehicle. This depends on the vehicle type. In a car or minivan with many round corners, baskets can be 'folded' around these corners, but crates cannot. In contrast, in larger square trucks, crates might fit better than baskets.

The wholesaler pays the farmer and the price is assumed to be related to the fraction A-grade tomatoes in his purchasing. The farmers expect that the amount paid by the wholesaler for tomatoes transported in crates should at least be the same as the amount for tomatoes transported in baskets increased with the additional purchase costs of crates compared to baskets. The expected amount depends on the level of trust the farmer has in the wholesaler. If trust is higher, the farmer is more certain that he will receive a higher price because he feels it less likely the wholesaler will cheat. If the amount the wholesalers pays exceeds a farmer's expectation, the farmer increases his trust in the wholesaler and trust in the crates. If the amount is lower than his expectation, he will lower his trust. If trust gets below until a certain level, his expected value of using crates will be lower than the expected value of using baskets and the farmer will decide to return to using baskets. When a majority of the farmers a wholesaler is dealing with will decide to use baskets, this wholesaler will also decide to use baskets and, consequently, the other farmers related to the wholesaler will need to use baskets.

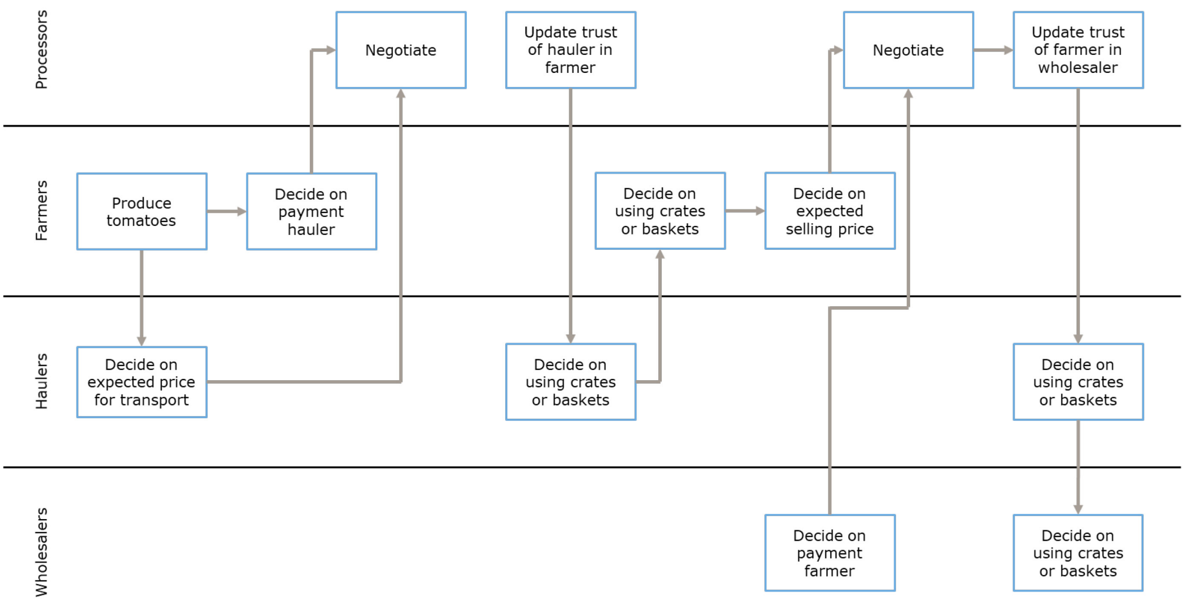

Figure 3.2 *Sub-process from producing tomatoes to tomatoes at the market (one season)*

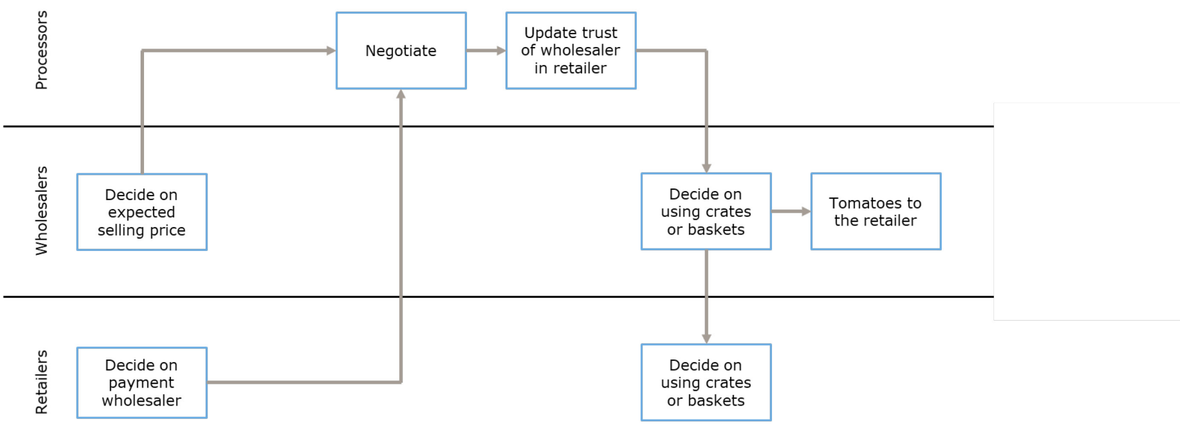

Figure 3.3 *Sub-process from selling of tomatoes at the market to the retail sector (one season)*

Each actor maintains a list of the actor(s) with whom he interacts and maintain an associated list of trust they have in these actor(s) (Table 3.3). During the simulation period, we assume no change in these relationships: haulers do not switch between farmers, farmers do not switch between wholesalers, and wholesalers and retailers do not switch.

Table 3.3 *Relations within the Agent-Based Model*

Interaction	Relation
Farmer – hauler	1 farmer – 1 hauler; 1 hauler – 1 farmer
Farmer – wholesaler	1 farmer – 1 wholesaler; 1 wholesaler – n farmers
Wholesaler – Retailer	1 wholesaler – n retailer; 1 retailer – n wholesalers

A typical simulation run includes 130 farmers, 50 wholesalers and 60 retailers. The span of a run is 30 seasons, covering 15 years. One tick in a model represents one season (half year). At the beginning of the simulation all actors use crates. Depending on the trust, risk and social norm levels, extra costs and paid prices, the actors may decide to return to using baskets.

The model starts with initialising global parameters and agents with values randomly drawn from intervals, which were extracted from survey data and pilot projects. Each actor is assigned a risk attitude, initial trust level and initial social norm level. Other state-variables like production volume and harvested area, which are season dependent, are randomly sampled from survey data or are derived from the pilot-projects (Table 3.4).

Table 3.4 *Input value of production parameters in the Agent-Based Model*

Agents and environment	Item			Average	Unit	Stochastic distribution a)	Source
Global	volume reduction	baskets	Farmer-wholesaler	20	%		Survey
			Wholesaler-retailer	10	%		Survey
		crates	Farmer-wholesaler	7	%		Kok et al. (2019)
			Wholesaler-retailer	8	%		Kok et al. (2019)
	reduction A-grade quality	baskets	Farmer-retailer	27.5	%		Kok et al. (2019)
		crates	Farmer-retailer	9.5	%		Kok et al. (2019)
	crate	volume		20	kg		Kok et al. (2019)
	purchasing costs	basket		250	N	N(250,100)	Coffey (2013)
		crate		2,600	N	N(2600,1000)	Kok et al. (2019)
	lifetime	basket		2	year	N(2,1)	Coffey (2013)
		crate		5	year	N(5,1)	Kok et al. (2019)
	use frequency	basket		50	1/year		Own estimation
		crate		50	1/year		Own estimation
Farmers	dry season	production		4,765	kg	P(4765)	Survey
		area harvested		1.17	ha	P(1.17)	Survey
	wet season	production		3861	kg	P(3861)	Survey
		area harvested		1.8	ha	P(1.8)	Survey
	price	paid to transporter		27.5	N/kg	U(15-35)	Survey
	% A-grade quality b)	Low percentage A-quality type		25.7	%	N(0.257,0.07)	Kok et al. (2019)
		High percentage A-quality type		78.8	%	N(0.788,0.077)	Kok et al. (2019)
Transporter	load capacity			4790	kg	P(4790)	Survey

a) N(.,.) = Normal distribution, P(.) = Poisson distribution, U(.,.) = Uniform distribution; b) Two types of farmers, the first type (20% of farmers) has a production with a low percentage of A-grade quality tomatoes and the second type (80% of farmers) with a high percentage of A-grade quality.

Because the model contains stochastic variables, we ran each simulation 3,000 times and take the average value. Trial-and-error showed that this number was convenient under the current values of the key parameters. We show the average results without the randomness of the technical parameters.

Adaption

Actors can chose to keep using crates or change to using baskets. Their decision depends on the price they expect to receive when using crates and when using baskets, and how this is related to the actual price they receive. At the beginning of a season, an actor decides to use crates, if the expected revenue (N/kg tomatoes) when using crates is at least equal to the expected revenue when using baskets increased with extra costs for using crates, such as the additional investment costs of crates compared to baskets and additional payments to other partners up in the value chain. The expected revenue of using crates depends on the level of trust the actor has in his/her trading partner and the expected tomato market price. If trust is higher, the actor is more certain that he will receive a revenue because he feels it less likely the trading partner will cheat. At the end of the season, the actor compares his/her expected revenue with the actual received revenue. The actual received price depends on the market price (Table 3.5). If the received revenue is less than expected revenue, the actor lowers his/her trust in the trading partner and lowers trust in the crate system. This process can happen several times, until trust will drop below a certain level and the expected revenue if using crates will be lower than the expected revenue if using baskets. Then the actor will decide for using baskets. Initial values of the different actor's risk, social norm and trust are sampled from the values of the corresponding agents in the VC-game (Table 3.6).

Table 3.5 *Initial values for the process of consideration crates or baskets*

Variable	Farmer-wholesaler	Wholesaler-retailer	source
Minimum market price	25	50	survey
Maximum market price	150	200	survey
Average expected price a)	65	90	calculations

a) Without price changes and extra costs for crates instead of baskets.

Table 3.6 *Distribution of the values for risk, social norm and trust from which the initial input values for the individual agents in the Agent-Based Model are randomly selected*

Variable	Agent	1	2	3	4	5	6	7	8	9
Risk	Transporter	0.57	0.57	0.68	0.68					
	Farmer	0.57	0.68	0.83	1.06	1.49	2.48	2.48	7.44	7.44
	Wholesaler	0.83	0.83	0.83	2.48	7.44	7.44			
	Retailer	0.57	0.57	0.57	0.83	0.83	7.44			
Social norm	Transporter	0.5	0.8	0.8	1.0					
	Farmer	0.2	0.4	0.5	0.5	0.8	1.0	1.0	1.0	
	Wholesaler	0.4	0.5	0.5	0.9	0.9	1.0			
	Retailer	0.2	0.3	0.5	0.5	0.5	0.7			
Trust	Transporter-farmer	0.7	0.8	0.8	1.0					
	Farmer-wholesaler	0.1	0.5	0.5	0.8	0.8	1.0	1.0	1.0	1.0
	Wholesaler-retailer	0.4	0.5	0.7	0.7	0.7	1.0			

The positive and negative update of trust levels were derived from the VCG and are equal for all cases: 0.03 upwards and 0.175 downwards. Social norm updates were estimated as 0.1 upwards and 0.1 downwards.

Software

The results of the simulation runs with NetLogo were written to MS Excel and analysed with the software R. We used Netlogo-plots for testing purposes. Examples of the plots for of a single simulation run can be found in Appendix 1.

3.4 Scenario analysis

We performed a scenario analysis on the most relevant factors affecting the use of crates in the tomato value chain. We defined a base-scenario and 25 additional scenarios (Table 3.7).

Table 3.7 *Description of the analysed scenarios*

Scenario name	Scenario description
BaseRun	Farmers pay for the crates with standard values of all inputs
Other-Scenario-1	Wholesalers pay for the crates
Other-Scenario-2	Use of crates per year minus 50%
Risk-Scenario-1	Risk + 20%
Risk-Scenario-2	Risk - 20%
Risk-Scenario-3	Risk high: all risk values at maximum
Risk-Scenario-4	Risk sub-high: risk values one below maximum
Risk-Scenario-5	Risk low: all risk values at minimum
Social-norm-Scenario-1	Social norm + 20%
Social-norm-Scenario-2	Social norm - 20%
Social-norm-Scenario-3	Social norm high: all social norm values < 0.9 => 0.9
Social-norm-Scenario-4	Social norm low: all social norm values > 0.3 => 0.3
Trust-Scenario-1	Trust + 20%
Trust-Scenario-2	Trust - 20%
Trust-Scenario-3	Social norm high: all social norm values < 0.9 => 0.9
Trust-Scenario-4	Trust low: all trust values > 0.3 => 0.3
Social-norm-Trust-Scenario-1	Trust- Social norm high: trust high and social norm high
Social-norm-Trust-Scenario-2	Trust- Social norm low: trust low and social norm low
Price-Scenario-1	Price wholesaler to the farmer + 10%
Price-Scenario-2	Price wholesaler to the farmer - 10%
Price-Scenario-3	Price wholesaler to the farmer + 30%
Price-Scenario-4	Price wholesaler to the farmer - 30%
Price-Scenario-5	Wholesaler pays the crates and Price wholesaler to the farmer + 10%
Price-Scenario-6	Wholesaler pays the crates and Price wholesaler to the farmer - 10%
Price-Scenario-7	Price retailer to the wholesaler - 30%
Price-Scenario-8	Price retailer to the wholesaler + 30%

4 Results

4.1 Farmers' use of crates

Figure 4.1 shows the results of the scenario analysis on the use of crates by farmers. The number of farmers using crates in each scenario is presented relative to that in the BaseRun scenario, with the results of the BaseRun scenario being set at 100. Results are presented after 10, 20 and 30 seasons (5, 10 and 15 years). A table with the number of farmers and wholesalers using crates after 30 seasons can be found in Appendix 2. From Figure 4.1 we can conclude that the price a wholesaler pays to the farmers is the most important factor influencing the number of farmers using crates after 10, 20 or 30 seasons followed by the risk attitudes of the VC actors. Social norms and trust between the VC actors have less influence on the number of farmers using of crates after 10, 20 or 30 seasons. If a wholesaler pays a price premium to farmers for using crates, than farmers will keep using crates. In value chain with more risk averse actors than in the BaseRun scenario, the use of crates after 30 seasons is lower than in the BaseRun scenario. A more risk averse farmer is less likely to use a crate than a basket, because a crate requires a larger investment. A farmer with a low social norm factor cares less about if others want to remain using crates, and thus switches quicker to baskets. Trust, the price a retailer pays to the wholesaler, the lifespan of a crate and the actor in the value chain who invests in the crates (farmer/wholesaler) have less influence. Whether wholesalers or farmers invest in the crates does hardly influence the number of farmers using crates (BaseRun <-> Other-Scenario-1), even in combination with an increase in the price the wholesaler pays to the farmer (Price-Scenario-1 <-> Price-Scenario-5) or with a price decrease (Price-Scenario-2 <-> Price-Scenario-6). If a crate would only be used 25 times in a year instead of 50 times, a farmer would need to purchase twice as much crates. This resembles a scenario in which the price of a crate is doubled. This does not have a large effect on the use of crates by farmers (BaseRun <-> Other-Scenario-2), because of the relatively low investment costs of crates.

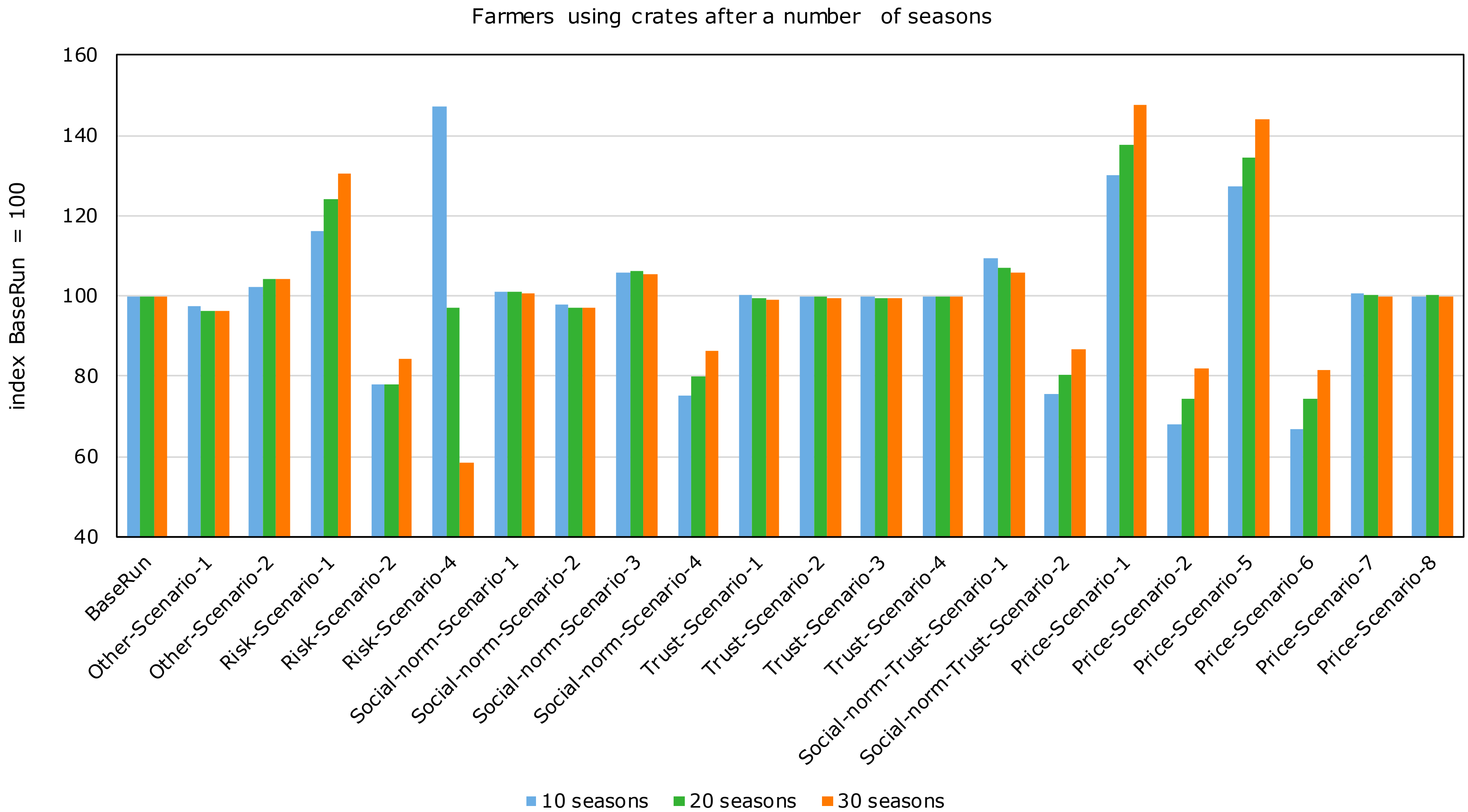

Figure 4.1 *Use of crates by the farmer after three periods and different scenarios. Some scenarios are not presented. Risk-Scenario-3, Price-Scenario-3 and Price-Scenario-4 are left out because almost 100% of the farmers use crates after 30 seasons. If we express the results relative to those in the BaseRun this means an outcome of more than 300%, which would result in the outcomes of the other scenarios to be visually very close. Risk-Scenario-5 is left out as it results quickly in zero farmers using crates. Results of these scenarios are presented in Appendix 3*

Figure 4.2 compares the BaseRun scenario with scenarios with the highest impact: the price a wholesaler pays farmers (+30% and -30%), the risk-averse attitude of all agents (+20% and -20%) and social norm of all agents (high and low). All scenarios show a steep decrease in the use of crates up to about season seven, after which the decrease slows and flattens out. The largest effect can be observed for the price the farmers get from the wholesaler. If this price is high, almost 60% of the farmers will keep using crates. However, if this price is low, the number of farmers using crates after 30 seasons is almost zero. The percentage of farmers using crates in the other scenarios varies between 21 and 35%.

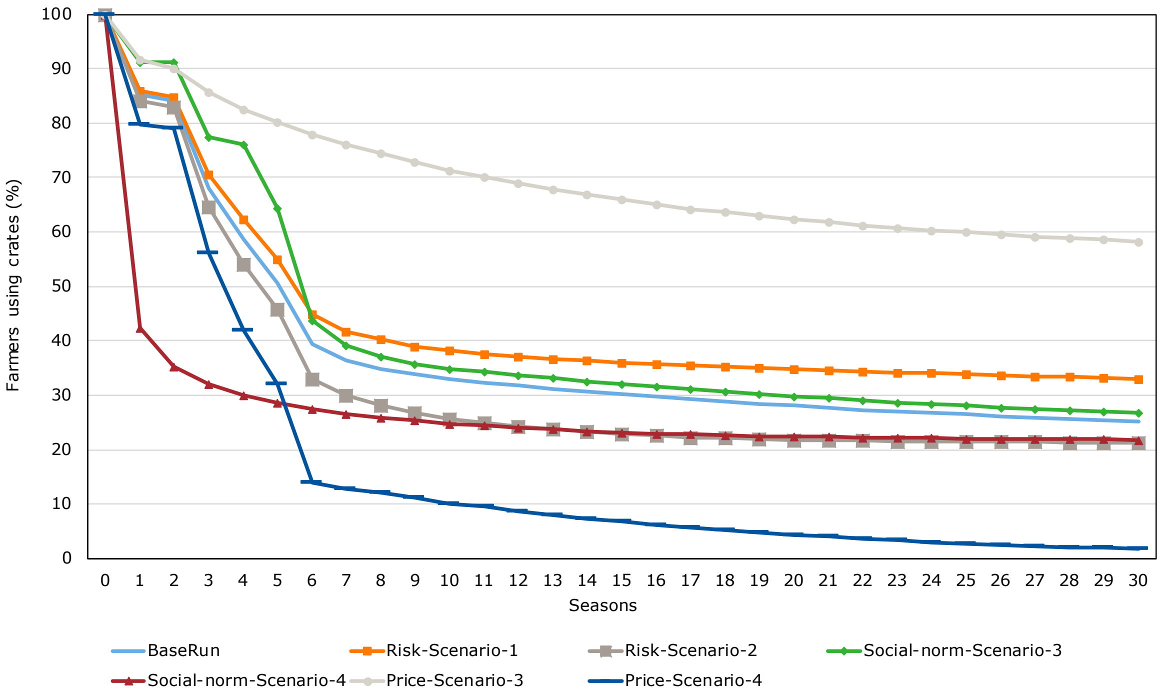

Figure 4.2 *Percentage of farmers using crates under different scenarios*

Figure 4.2 shows that after seven seasons the decline in the use of crates almost fades away. Because we assumed in the model that farmers can only switch to baskets and not vice versa, a group of farmers remains using crates and the remainder is using baskets. Table 4.1 shows the results of a Kolmogorov-Smirnov test on how farmers in these two groups differ in trust, social norm and risk-averseness. Farmers using crates have higher trust in the wholesaler, higher social norm and a lower level of risk aversion. For the trust in wholesaler, this is quite interesting as we concluded that trust is not affecting the use of crates by the farmer after 30 seasons. This discrepancy is caused by the distribution of the trust-values from which is sampled and a relative few number of observations.

Table 4.1 *Differences in trust, social norm and risk-aversion between farmers using crates and farmers using baskets after 30 seasons*

Parameter	Average value farmers using baskets	Average value farmers using crates	P-value of Kolmogorov-Smirnov test on difference a)
Social norm	0.2876	0.6273	0.000
Farmer trust in wholesaler	0.1422	0.9703	0.000
Risk-aversion	1.3351	6.9891	0.000

a) At a p-value of <0.05 the difference between the average value of farmers using crates and farmers using baskets can be considered to differ significantly.

4.2 Relative amount of A-grade quality tomatoes

The use of additional inputs such as improved seed varieties, fertilisers, pesticides or harvesting technologies can increase the amount of A-grade tomatoes during harvest. With crates, a bigger portion of this would end up at consumers, making their investment more quickly economically viable. We only present the results of the A-grade quality tomatoes for the scenarios with the highest impact: the price a wholesaler pays farmers (+10%, +30%, -10% and -30%), the risk attitude of all agents (+20% and min 20%) and social norm of all agents (high and low). In the BaseRun scenario, the loss in A-quality between farmer and retailer is calculated at 18.8% after 30 seasons (Table 4.2). If only baskets would have been used, this would have been 27.5%, so due to the use of crates the loss in A-grade quality tomatoes was reduced with more than 31%. In the scenario with a higher price between wholesaler and farmer, the loss in quality A-grade is even lower at 13.8%, a reduction of almost 50% compared to only using baskets. In the other scenarios, the reduction in loss of A-grade quality tomatoes is around 30% compared to only using baskets after 30 seasons.

Table 4.2 *Effect on losses of A-grade quality tomatoes between farmer and retailer after 30 seasons after introduction of crates for the six scenarios with the highest impact*

Scenario	A-grade quality loss between farmer and retailer (%)	Reduction in A-grade quality losses due to using crates a)	Farmers using crates compared to the BaseRun scenario (%)
BaseRun	18.8	31.6	
Risk-Scenario-1	17.7	35.6	7.8
Risk-Scenario-2	19.4	29.5	-3.9
Social-norm-Scenario-3	18.6	32.4	1.4
Social-norm-Scenario-4	19.3	29.8	-3.5
Price-Scenario-1	17.0	38.2	12.0
Price-Scenario-2	19.5	29.1	-4.5
Price-Scenario-3	13.8	49.8	33.0
Price-Scenario-4	22.3	18.9	-23.5

a) When all farmers use baskets the average percentage of A-grade quality loss is 27.5%. For the BaseRun scenario A-grade quality loss is 18.8%. This is 31.6% ((18.8/27.5)-1) lower than the A-grade quality loss if no farmer was using crates.

5 Discussion

In this study, we developed used the VC-laboratory method (VC-Lab) to simulate the impact of trust, risk attitude and prices on the long-term development of the use of crates in the tomato value chain in Nigeria. Data on the tomato value chain were gathered with a Value Chain Mapping exercise. Data on trust and risk of actual value chain actors were gathered with Value Chain Games. These data were combined in an Agent-Based Model to simulate the development and analyse alternative scenarios. In all scenarios we assumed that all actors start with crates and can switch to baskets, if they find the baskets more attractive than crates. The results show that the trust a farmer has in the wholesaler, the price a farmer receives from the wholesaler, risk attitude of the actors, and social norm are the most important drivers for the use of crates by farmers. Farmers with low levels of trust in the wholesaler switch from crates to baskets within a few seasons, whereas farmers with high levels of trust mostly remain using crates. A 30% bonus on the price from wholesaler to farmer when using crates increased the number of farmers using crates after 30 seasons from 25% to 60% and decreased the loss of A-grade quality tomatoes with almost 50%. In a value chain with more risk averse actors than in the BaseRun scenario, the use of crates after 30 seasons is lower than in the BaseRun scenario, because a crate requires a larger investment. A low social norm factor resembles low trust in the crates system, and thus a quicker switch to baskets. Whether the farmers or wholesalers invest in crates has only minor effect on the results. The lifespan and the price of a crate also have minor impact on the results, because of the relatively low investment costs of crates. Paying a price premium to farmers using crates seems the most effective way of stimulating the use of crates in the system.

In our study we assumed that actors started with crates and could switch to baskets. No switching back to crates was implemented in the model, due to lack of data on the underlying decision making process. Incorporating such mechanisms in the model would make the model results more realistic. Furthermore, input suppliers for farmers and consumers were not included in the ABM. Farmers could use additional inputs such as improved seed varieties, fertilisers, pesticides or harvesting technologies to increase the amount of A-grade tomatoes during harvest. With crates, a bigger portion of this would end up at consumers, making their investment more quickly economically viable. Consumers are interesting to include, because the A-grade quality tomatoes are more expensive than the other quality grades B and C. Increasing the amount of A–grade tomatoes relative to the B- and C-grade could result in tomatoes becoming unaffordable for consumers with the lowest incomes.

The calculations are conducted with data retrieved from actors in five actual value chains. This means that the results are representative for these five value chains. In this study, we also presented results of an extrapolation to more value chains. However, the number of actors in each value chain was limited to a maximum of two actors per stage. This means that per stage of the value chain often data of only five persons were available. In the calculations, we assumed that all simulated actors were represented by characteristics present at one of these five persons. The results are thus not representative for all tomato value chains in Nigeria. The results can only be interpreted as indicative but provide valuable input for discussion at policy and practitioner level. Data is needed from more value chains and more value chain actors to determine the potential of using crates to transport tomatoes in a broader scope.

From our study, we can draw several implications. If implementing new technologies in a value chain to reduce post-harvest losses in which several value chain actors have to cooperate, it is important to build mutual trust between these actors in addition to capacity building on the use of the technology. The probability of a project on such an intervention to succeed is higher when the value chain actors in the project trust each other more. Therefore, prior to selection of case study value chains, it can be helpful to measure the mutual trust between the value chain actors of potential value chains. Especially when such projects are set up as examples for other value chains, this could be helpful. In our study, trust between farmer and the wholesaler buying the tomatoes was found to be very important. This is also reflected in the importance of the price the wholesaler pays to the farmer. Providing an additional (bonus) price to farmers that transport the tomatoes in crates was found to be an important driver for farmers to use crates. Finally, risk averse farmers were less likely to remain using crates. Mechanisms to reduce the risk for individual farmers or to share the risk among a group could help to overcome the risk aversion and stimulate the use of crates.

The VC-Lab applied in this study showed the importance of behavioural aspects such as trust, risk attitude and prices on the use of crates to transport tomatoes in Nigeria. The data gathered by the VC analysis and the VC games were combined in an ABM. The price a farmer receives from the wholesaler, risk attitudes of the actors, and social norms (sticking to crates because other VC-actors trust you to use crates) were found to be the most important drivers for the use of crates by farmers. Thus, the availability of a technical innovation by itself is not enough for acceptance, implementation and adoption. Application of the VC-Lab in other countries, commodities, or interventions is needed to determine the effectiveness of the VC-Lab in a broader scope.

6 Conclusion

With the VC-Lab method, consisting of a Value Chain Analysis, Value Chain Games and an Agent-Based Model, we analysed the expected impact of trust between value chain actors, risk attitudes of the actors, social norms of the actors, bonuses on the price of tomatoes transported in crates, the price of crates, the lifespan of crates and whether farmers or wholesalers invest in crates on the long-term development of the use of plastic crates to transport tomatoes through the value chain in Nigeria. The most important factors for the long-term success were the additional price a wholesaler pays to farmers to transport the tomatoes in crates instead of in baskets, the risk attitudes of the VC actors and social norms of the VC actors. Trust in other value chain actors, the price and lifespan of crates and weather farmers or wholesalers invest in crates did only mildly influence the long-term use of crates. Providing financial incentives for farmers to use plastic crates, developing mechanisms to reduce the risk for individual farmers and strengthening social norms of value chain actors working together in the value chain can improve the long-term use of plastic crates.

References and websites

Barham, B.L., J.P. Chavas, D. Fitz, V.R. Salas and L. Schechter (2014) 'The roles of risk and ambiguity in technology adoption.' Journal of Economic Behaviour & Organization 97: 204-218.

Binswanger, H.P. (1980) 'Attitudes Toward Risk: Experimental Measurement in Rural India.' American Journal of Agriculture Economics 62(3): 395-407.

Blandon, J. S. Henson and J. Cranfield (2009) 'Small-scale farmer participation in new agri-food value chains: Case of the supermarket value chain for fruit and vegetables in Honduras.' Journal of International Development 21(7): 971-984.

Brauw, A. de., and P. Eozenou (2014) 'Measuring Risk Attitudes among Mozambican Farmers.' Journal of Development Economics 111: 61-74.

Cialdini, R.B., R.R. Reno and C.A. Kallgren (1990). A focus theory of normative conduct: recycling the concept of norms to reduce littering in public places. Journal of personality and social psychology 58(6): 1015.

Coffey (2013). Tomato Production and Marketing; Value Chain Analyses. Draft report December 2013, Coffey international development.

Collier, P. (2002) 'Social capital and poverty: A microeconomic perspective.' In: Grootaert, C., van Bastalaer, T. (Eds.), The Role of Social Capital in Development. Cambridge University Press, New York, pp. 19–41.

Das, T.K. (1998) 'Between trust and control: Developing confidence in partner cooperation in alliances.' Journal Academy of Management Review 23(3): 491 – 512.

Feder, G., R.E. Just and D. Zilberman (1985) 'Adoption of Agricultural Innovations in Developing Countries: A Survey.' Economic Development and Cultural Change 33(2): 255-298.

Grootaert, C. and T. van Bastelar, Eds. (2001) 'Understanding and Measuring Social Capital: A Multidisciplinary Tool for Practitioners.' Washington D.C.: The World Bank

Hill, R. (2009) 'Using stated preferences and beliefs to identify the impact of risk on poor households' The Journal of Development Studies 45(2).

Hong, H. and M. Kacperczyk (2009). The price of sin: The effects of social norms on markets. Journal of Financial Economics 93(1): 15-36.

Isham, J., (2002) The Effect of Social Capital on Fertiliser Adoption: Evidence from Rural Tanzania. Journal African Economics 11(1): 39-60.

Muhammad, R.H., G.C. Hionu and F.F. Olayemi (2012) Assessment of postharvest knowledge of fruit and vegetable farmers in garun mallam l.G.A. of Kano, Nigeria. International Journal of Development and Sustainability 1: 510-515.

Nolan, J.M., P.W. Schultz, R.B. Cialdini, N.J. Goldstein and V. Griskevicius (2008). Normative social influence is underdetected. Personality and social psychology bulletin 34(7): 913-923.

Nunn, N. and L. Wantchekon (2011). The Slave Trade and the Origins of Mistrust in Africa. American Economic Review 101(7): 3221-3252.

Kok, M.G., S. Dastoum, J.J. Groot, C. Plaisier, Y. Dijkxhoorn and C.P.A. van Wagenberg (2019). A measurement tool on food losses and waste: applied in a tomato value chain in Nigeria. Report 1906, Wageningen Food & Biobased Research, Wageningen, doi:10.18174/470201/1906.

Plaisier, C., M. Sibomana, J. van der Waal, L. Clercx, C.P.A. van Wagenberg and Y. Dijkxhoorn (2019). Approach for designing context specific, locally owned interventions to reduce postharvest losses – Case study on the tomato value chain in Nigeria. Sustainability 11(1): 247, doi:10.3390/su11010247.

Ruben, R., and R. Fort (2012) 'The impact of fair trade certification for coffee farmers in Peru.' World Development 40(3): 570-582.

Schultz, P.W., J.M. Nolan, R.B. Cialdini, N.J. Goldstein and V. Griskevicius (2007). The constructive, destructive, and reconstructive power of social norms. Psychological science 18(5): 429-434.

Six, F.E. (2007) 'Building interpersonal trust within organizations: a relational signalling perspective.' Journal of Management & Governance 11(3): 285-309.

Uphoff, N. (2000) 'Understanding Social Capital: Learning from the Analysis and Experience of Participation.' In P. Dasgupta and I. Serageldin (eds.), Social Capital: A Multifaceted Perspective, Washington, D.C.: World Bank.

Verwaart, T., Y. Dijkxhoorn, C. Plaisier and C. van Wagenberg (2016). Simulating the role of trust in supply development. 20-21 September, Artificial Economics, Rome, Italy.

White, K.M., J.R. Smith, D.J. Terry, J.H. Greenslade and B.M. McKimmie (2009). Social influence in the theory of planned behaviour: The role of descriptive, injunctive, and in-group norms. British Journal of Social Psychology 48(1): 135-158.

Appendix 1 NetLogo plots

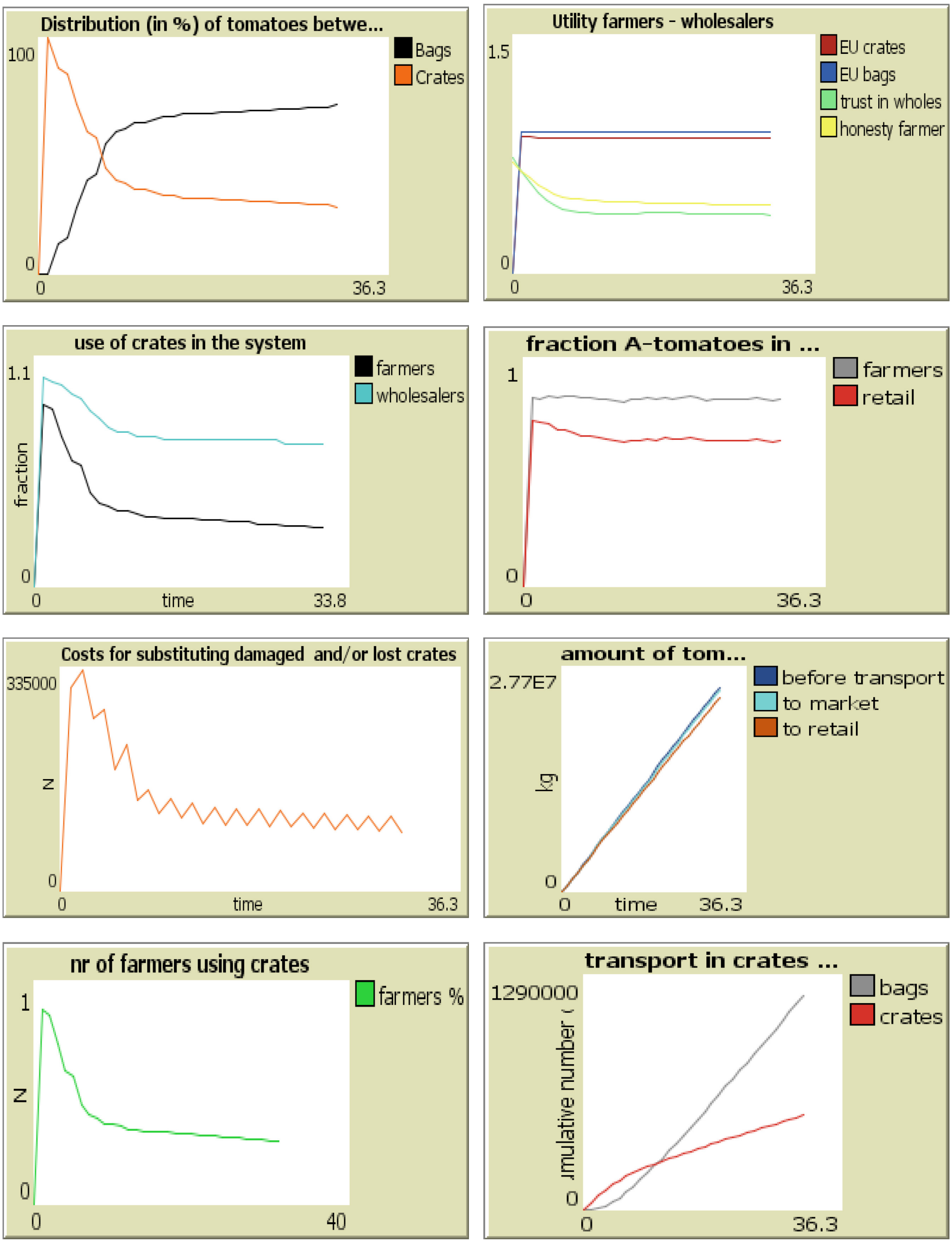

Figure A4.1 *NetLogo plots for testing purposes*

Appendix 2 Use of crates after 30 seasons

Table A2.1 *Use of crates after 30 season in each scenario*

Scenario	Loss of A-grade quality tomatoes between farmer and retailer (%)	Farmers using crates after 30 seasons (%)	Wholesalers using crates after 30 seasons (%)
BaseRun	18.8	25.3	64.5
Other-Scenario-1	19.0	24.4	63.4
Other-Scenario-2	18.6	26.4	65.8
Risk-Scenario-1	17.7	33.0	72.8
Risk-Scenario-2	19.4	21.3	59.5
Risk-Scenario-3	8.0	98.8	99.9
Risk-Scenario-4	20.4	14.8	50.4
Risk-Scenario-5	22.6	0.0	0.0
Social-norm-Scenario-1	18.8	25.5	64.7
Social-norm-Scenario-2	18.9	24.6	63.6
Social-norm-Scenario-3	18.6	26.7	66.2
Social-norm-Scenario-4	19.3	21.8	60.0
Trust-Scenario-1	18.8	25.1	64.2
Trust-Scenario-2	18.8	25.2	64.4
Trust-Scenario-3	18.8	25.2	64.5
Trust-Scenario-4	18.8	25.3	64.5
Social-norm-Trust-Scenario-1	18.6	26.8	66.3
Social-norm-Trust-Scenario-2	19.3	21.9	60.3
Price-Scenario-1	17.0	37.3	76.9
Price-Scenario-2	19.5	20.7	58.8
Price-Scenario-3	13.9	58.2	91.0
Price-Scenario-4	22.3	26.8	66.3
Price-Scenario-5	17.2	36.4	76.1
Price-Scenario-6	19.5	20.6	58.6
Price-Scenario-7	18.8	25.3	64.5
Price-Scenario-8	18.8	25.3	64.6

Appendix 3 Effects of risk, social norms and prices on farmers' use of crates

In this appendix, we will discuss the different scenarios for risk, social norms and price paid by the wholesaler to the farmer.

Risk

If you maximise the risk-aversion the farmers will keep on using the crates (figure A3.1). Under extreme conditions, this means that about 100% of the farmers will keep using crates even after 30 seasons (Risk-scenario-3). In case of minimal risk-aversion, the use of crates will be reduced to within 4 years (Risk-Scenario-5). However, the functions used for the decision-making are quite sensitive for the assumptions. Therefore, we do not consider these scenarios further. Increasing the risk-aversion with 20% can lead to 30% more use if crates by farmers after 30 seasons. On the other hand, a decrease in risk-aversion can lead to a decrease of 15% in the use of crates after 30 seasons.

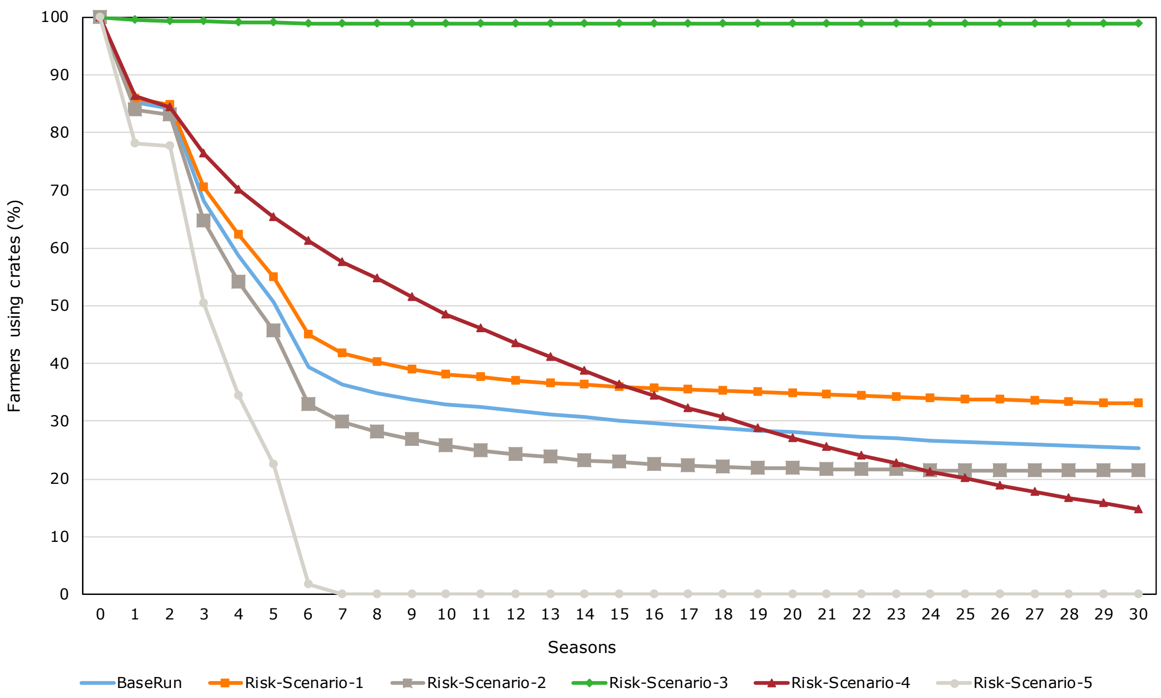

Figure A3.1 *Effect of risk on the use of crates by farmers*

Social norms

The effect of social norms is best visible in the first six seasons (figure A3.2). Here a higher social norm results in a lower decrease in use in crates compared with the BaseRun and lower social norm results in a reduction of the use of crates by farmers of more than 60% in the first two seasons, while in the BaseRun this reduction is 15%. The lower social norm results in 15% less use of crates after 30 seasons. Trust between value-chain partners is hardly affecting the use of crates. This holds also in combination with social norm.

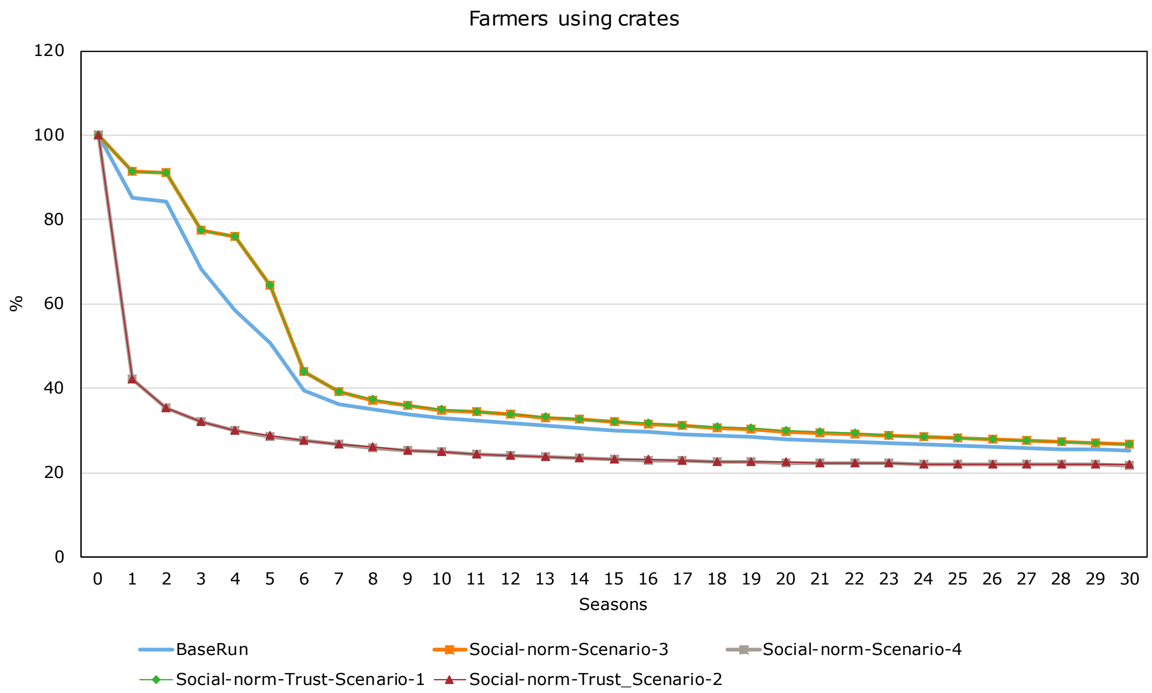

Figure A3.2 *Effect of social norm and trust on the use of crates by farmers*

Price

As is mentioned in the main text (ref) current price setting between the retailer and the wholesaler is not affecting the use of crates. Therefore, we will not discuss them here further. At a 10% higher price between wholesaler and farmer, 30% more farmers will still use crates after 30 seasons compared to the BaseRun (figure A3.3). At a 30% higher price, this is even higher at 130% more farmers using crates compared to the BaseRun scenario.

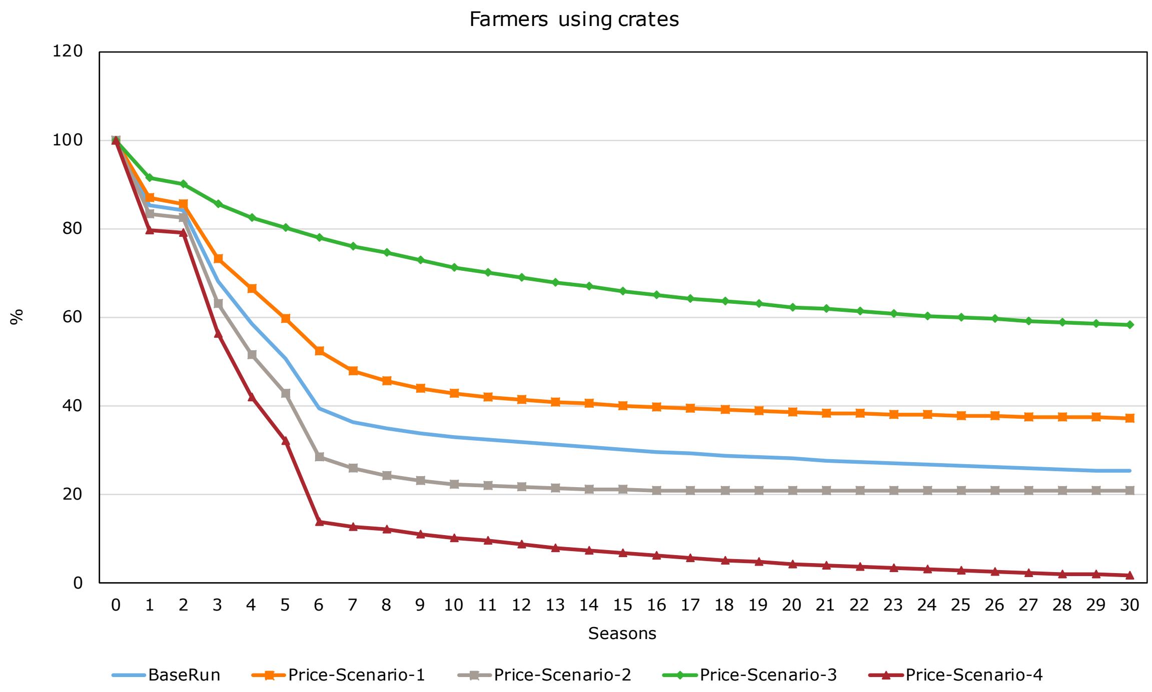

Figure A3.3 *Effect of prices on the use of crates by farmer*

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The mission of Wageningen University & Research is "To explore the potential of nature to improve the quality of life". Under the banner Wageningen University & Research, Wageningen University and the specialised research institutes of the Wageningen Research Foundation have joined forces in contributing to finding solutions to important questions in the domain of healthy food and living environment. With its roughly 30 branches, 5,000 employees and 10,000 students, Wageningen University & Research is one of the leading organisations in its domain. The unique Wageningen approach lies in its integrated approach to issues and the collaboration between different disciplines.