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Adoption behavior of market traders: an analysis based on Technology Acceptance Model and Theory of Planned Behavior

RESEARCH ARTICLE

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Abstract

High tomato losses in the fruit supply chain can be prevented by use of improved or new technologies but these are not usually adopted where adoption behavior is barely known. Based on the Theory of Planned Behavior and the Technology Acceptance Model, this study analyses socio-psychological factors that influence the adoption behavior of traders on new postharvest handling technology, as exemplified by the use of lining material for improving tomato packaging in Tanzania. The study results conclude that the perceived behavioral control and subjective norm were the most important factors explaining respondents' behavioral intention. Attitude, though found not to be a significant determining factor, was however significantly influenced by perceived usefulness and perceived ease of use. As technology adoption is a prerequisite for structural transformation of developing economies, our results provide new insights in the field of behavioral acceptance research in the tomato production sector of relevant developing countries.

Keywords: technology adoption, vegetable traders, developing country, tomato supply chain, Tanzania
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1. Introduction

Food losses from waste and spoilage are a fundamental issue, especially in developing countries. On a global level, food losses amount to about one-third of total production (FAO, 2011), which places greater strain to increase the cultivation of marginal lands. While this is certainly a global problem, the explanations tend to vary depending on context. For instance, whereas food waste in developed countries mostly occurs at the consumer stage, low-income countries record the highest food losses during the postharvest and processing stages of the food supply chain (FAO, 2011). As a potential cause, it has therefore been noted that developing countries lack both the infrastructure and advanced postharvest technology options available to developed countries in order to better handle perishable food (Shewfelt *et al.*, 2014). Even within developing countries moreover, there are various causes of postharvest losses along the food supply chain; for example, the use of inappropriate varieties; use of poor quality packaging material; and inadequate and poor post-harvest handling practices (Abass *et al.*, 2014; Affognon *et al.*, 2015; Aidoo *et al.*, 2014; Dome and Prusty, 2016; Kader, 2005; Kasso and Bekele, 2016; Kereth *et al.*, 2013; Kitinoja *et al.*, 2011; Parmar *et al.*, 2016). In spite of their differences, all of these issues influence the physical and quality parameters of the food and can therefore result in loss of market value and diminished incomes for farmers, and particularly smallholders, in developing countries.

Given the prevalence of such problems, the importance of technology development has therefore been highlighted as one broad strategy to reduce postharvest losses in developing countries. Among others, improvements in non-plastic (for example, wood and baskets) packaging through better lining or the usage of plastic crates have both been suggested as a potential solution (Campbell *et al.*, 1986; Eaton *et al.*, 2008; FAO, 2011; Kader, 2005; Kamrath *et al.*, 2016; Kitinoja *et al.*, 2011). Nonetheless, the viability of such a strategy is inextricably limited by the slow adoption of novel technologies. In general, adoption has been defined as 'a decision to make full use of an innovation as the best course of action available' (Rogers, 2003). Hence, there has been a variety of research into how individual decision-making can be explained by psychological constructs such as motivation, attitude, personality (e.g. Ajzen, 1991). What determines the 'best course of action' is however not determined by the individual alone. Instead, many social and economic factors have the potential to hinder and influence adoption of improved or new technologies (Ali, 2012; Affognon *et al.*, 2015; Kitinoja, 2013; Tenge *et al.*, 2004; Wasala *et al.*, 2014). Further, it can be expected that the types of factors will significantly differ across socioeconomic and cultural groups in developing countries, particularly in countries where there exist social and cultural norms and other related issues that influence the adoption of new agricultural technologies (Yamano *et al.*, 2015). Thus, it is invariably necessary to determine which types of factors influence adoption behavior in the specific context that is being explored. For instance, according to Kitinoja *et al.* (2010), technology adoption in the context of East Africa is broadly contingent on how much the intended beneficiary perceives there to be a value and a variety of external factors. Regarding the latter, the authors enumerate the relative advantage that is afforded, the compatibility with socio-cultural values, the perceived needs of clients, the complexity of the technology and the potential for actors to make trials with it, and finally the observability of effects and changes.

The major operators in the food supply chain for fresh fruit and vegetables are farmers, traders and consumers (Koenig *et al.*, 2008). Traders generally function as intermediaries between the various actors, and therefore occupy a more or less dominant position. As one potential motivation for technology adoption, traders are likely to benefit from improvements in postharvest handling and practices, which would allow them to provide higher quality produce and increase their profits (Kitinoja *et al.*, 2010). Yet, to the best of our knowledge, no research about technology adoption behavior of traders has been undertaken. Rather, most of the studies in this domain tend to focus on farmers' perspective. In addition, several studies have reviewed the psychological behavior toward adoption of new technologies at farm level. However, little is known at traders' level about the factors influencing adoption of improved packaging materials, particularly in relation to their psychological constructs. To the best of our knowledge a study on packaging acceptance has not been conducted in Tanzania or in a developing country context. Therefore, addressing adoption behavior by

tomato traders toward postharvest technologies in the tomato value chain is important to reduce losses in the food value chain which ensures better marketing efficiency and serves as a blue print for other studies.

Based on this research gap, this study addresses two research questions: first, what are the main psychological factors (e.g. attitude, social norms and perceived control) driving the acceptance of a new type of wooden crate with lining that is intended to be useful for traders? Second, what are the main explanatory factors (e.g. age, trading experience, knowledge, etc.) that affect the psychological constructs of the acceptance of improved packaging? Against this background, this study seeks to contribute to the existing literature in two aspects. First, we aim to understand technology acceptance in the specific context of tomato packaging for those traders who are prominently involved in the tomato value chain. Second, we intend to offer complementary insights in order to improve the general understanding of this area as well as to facilitate methodological and theoretical development of technology adoption in developing countries in the agricultural sector. For this reason, this study adopted the Arusha region of Tanzania in order to explore these research questions. The following section therefore describes the adoption of new agricultural technologies in developing countries in a general sense, before explaining the underlying reasons for selecting Tanzania as a study area.

2. Review of literature on adoption behavior in developing countries

The following section describes the adoption behavior of new technologies in developing countries particularly focusing on postharvest handling techniques.

2.1 Adoption behavior of new technology in developing countries in agricultural context

The high level of postharvest losses caused by mechanical damage that often facilitates incidence of diseases indicates the importance of the adoption of improved postharvest handling techniques. It is particularly applicable for a highly perishable crop like tomato (Aba *et al.*, 2012).

At the farmer level, the factors affecting adoption of different technologies and improved agricultural practices have been analyzed (Afari-Sefa *et al.*, 2016; Affognon *et al.*, 2015; Agwu *et al.*, 2008; Aidoo *et al.*, 2014; Ali, 2012; Feder *et al.*, 1985; Hodges *et al.*, 2011; Isgin *et al.*, 2008; Lazaro *et al.*, 2017; Tenge *et al.*, 2004) but few studies have assessed adoption behavior at farm level in the food value chain (Affognon *et al.*, 2015; Yamano *et al.*, 2015). The main observed factors that determine traders' adoption of recommended practices in existing studies mainly include socioeconomic factors such as age, gender, education, experience (Agwu *et al.*, 2008; Hansson *et al.*, 2012), income, lack of access to credit (Aidoo *et al.*, 2014; Namara *et al.*, 2014), farm size (Adrian *et al.*, 2005; Isgin *et al.*, 2008; Nkonya *et al.*, 1997), knowledge and perception of technology and net benefits accrued from application of recommended practices (Adesina and Baidu-Forson, 1995; Adrian *et al.*, 2005; Mbaga-Semgalawe and Folmer, 2000) and further the underlying psychological construct – attitudes toward new technology, social norms and perceived behavioral control (Hansson *et al.*, 2012; Yamano *et al.*, 2015; Yazdanpanah *et al.*, 2014), which are adapted from Ajzen (1991). Some studies argued that the behavior of actors within the value chain has the potential to promote more sustainable technologies that can reduce postharvest losses (Hodges *et al.*, 2011; Parmar *et al.*, 2016).

2.2 Overview of the current tomato value chain in Tanzania

As it is the case for many developing countries, the tomato is an important horticultural crop in Tanzania, both for home consumption and as a major cash crop with the potential for poverty reduction (Koenig *et al.*, 2008). In spite of its potential benefits, however, tomatoes are very vulnerable to food losses and spoilage due to their high water content, high respiration rate, and soft texture (Isack and Monica, 2013). Accordingly, some of the major challenges in the rather complex and opaque tomato supply chain (Mwagike and Mdoe, 2015), include: poor transportation facilities (i.e. reliance on feeder roads where travel is difficult), lack of market infrastructure facilities (e.g. lack of cold storage), rough and poor post-harvest handling practices, as well as poorly constructed packaging materials and use of open trucks to transport produce over longer

distances. Currently, the type of packing materials used by wholesalers are rough wooden crates, that hold around 40 kg and are mainly used to transport tomatoes in Arusha, Tanzania. This explains the high share of tomato losses caused by bruises and cuts (Kamrath *et al.*, 2016), numerical 30 to 40% per crate in developing countries (Kader, 2005; MUVI-SIDO, 2009). In order to cultivate a shift in this value chain however, it is necessary to understand who bears the responsibility for any risks and, moreover, who it is that makes decisions about packaging materials. Overall, it is the case that a number of different channels of the tomato value chain exist in Tanzania (for detailed description and visualization, see Koenig *et al.*, 2008). Nevertheless, it is generally the traders who buy tomatoes from farmers and then sell them at markets who are mostly responsible for transportation and must therefore incur any related risks (Koenig *et al.*, 2008; Mwagike and Mdoe, 2015). As a result, wholesalers are broadly influential for the approaches and types of packaging that are used. Nonetheless, it must also be noted that any initial packaging is generally done by the farmers, and wholesalers or village collectors who are responsible for the transport and selling the produce at the market (Koenig *et al.*, 2008; Mwagike and Mdoe, 2015). Facilitating changes in the tomato value chain therefore requires attention to the (joint) decisions of both traders and farmers.

Kamrath *et al.* (2016) concluded that perforated paper lining is the simplest and most cost-effective improvement for use with the traditional rough wooden crates for tomato packaging. The authors further argued that recommended improvements were not adopted by supply chain actors due to lack of awareness, knowledge and evidence of any success for its use. But further results have shown that willingness to use is positively correlated with perceived net benefits.

Accordingly, this study specifically focuses on the decisions of tomato traders, given that such actors not only occupy an intermediate and mostly dominant position in value chains but are also the ultimate beneficiaries of any efficiency gains in postharvest handling and practices (Kitinoja *et al.*, 2010; Musebe *et al.*, 2017). In general, most of the transactions between farmers and 'middlemen' (i.e. those who connect local farmers and regional markets) are based on spot-market negotiations whereby traders enjoy most of the bargaining power (Mwagike and Mdoe, 2015). In addition, when traders engage in further purchases directly at the farmgate, they must then, in their role as middlemen, organize their own transport and packaging for the produce. As such, it is the traders who determine which type of postharvest handling practices are employed. Generally smallholders, having no or limited access to higher-value markets such as supermarkets, are therefore subject to being exploited by middlemen (Chagomoka *et al.*, 2014). Accordingly, it is potentially problematic to focus only on farmers when it comes to adoption decisions about new technologies. Given that farmers ultimately lack strong bargaining power in the tomato supply chain in developing countries (Koenig *et al.*, 2008), this study therefore takes the unique approach of focusing on the adoption behavior of traders vis-à-vis improvements in postharvest handling practices.

3. Conceptual framework and development of hypotheses

In order to address the gaps in the current research landscape of the adoption behaviors of traders, two well-known and widely applied behavior theories are chosen – both of which are based on the Theory of Reasoned Action (TRA). The TRA proposed by Fishbein and Ajzen (1975) (Ajzen, 1991; Venkatesh *et al.*, 2007) is extensively used to explain human behavior and asserts that both behavioral attitude (A) and subjective norm (SN) affect behavioral intention (BI), which in turn affects actual behavior. The Theory of Planned Behavior (TPB) differs from the TRA in its addition of perceived behavioral control (PBC) as an influencing factor on behavioral intention (Ajzen, 1985). Together with behavioral intention, PBC can be used directly to predict actual behavior (Ajzen, 1991). The TPB is a general model to analyze human behavior and it has been applied mainly to study technology adoption behavior and use in several cases (Mathieson, 1991); particularly few studies have applied this theory in the agricultural context more so at smallholder farmers' supply chain level in developing countries (Hansson *et al.*, 2012; Senger *et al.*, 2017; Yamano *et al.*, 2015; Yazdanpanah *et al.*, 2014) but not at traders' level.

In general, analyzing technology adoption and use specifically, the Technology Acceptance Model (TAM) was developed in the context of Information Technology Systems (*inter alia*: Holden and Karsh, 2010; Lee *et al.*, 2003; Legris *et al.*, 2003; Venkatesh and Morris, 2000; Venkatesh *et al.*, 2007) and its importance and extensive application examined in technology-driven oriented sectors (*inter alia*: Holden and Karsh, 2010; Lee *et al.*, 2003; Legris *et al.*, 2003; Venkatesh and Davis, 2000; Venkatesh and Morris, 2000; Venkatesh *et al.*, 2007), but has also been applied in the context of acceptance of new agricultural technologies at farmers' level in the context of precision agriculture in southeastern United States (Adrian *et al.*, 2005) and of dairy farming in New Zealand (Flett *et al.*, 2004). The TAM, originally introduced by Davis *et al.* (1989), is an adaptation of TRA and assumes that the acceptance of information technology is determined by two key beliefs: perceived usefulness (PU) and perceived ease of use (PEOU) (Davis *et al.*, 1989; Morris *et al.*, 2005).

TAM and TPB have different emphases but both are extensions of the TRA, which makes the inclusion of TAM and TPB rational, theoretically compatible and potentially complementary. PEOU and PU by TAM may serve as important antecedents of attitude in TPB, which reciprocally may enhance the explanatory power of TAM (Chau and Hu, 2002; Mathieson, 1991). In this study, TAM is used to identify the usefulness and ease of use of the standard wooden crate covered by paper lining (improved packaging, for more detail: Kamrath *et al.*, 2016), and further the variables attitude toward using (A), SN and PBC by TPB might give insight to factors disturbing the BI of new technology (Figure 1). Thereby PEOU and PU may serve as important antecedents of A. Each determinant will be influenced by explanatory variables which help to understand the psychological construct underlying adoption behavior.

Based on the theoretical framework, we derive a set of seven hypotheses, which are detailed in the following. Attitude (A) is defined by Ajzen (1991) as the 'degree to which a person has a favorable or unfavorable evaluation or appraisal of the behavior in question'. According to TAM and TPB, the attitude toward using a new technology impacts users' behavioral intention. Transferred to the case of improved tomato packaging, it is when supply chain actors form a positive attitude toward an improved packaging, they will have a stronger intention toward adopting it, and thus they are more likely to use it. The first hypothesis of this study is:

H_1: Behavioral attitude (A) toward improved packaging is positively related to the behavioral intention (BI) to use improved packaging.

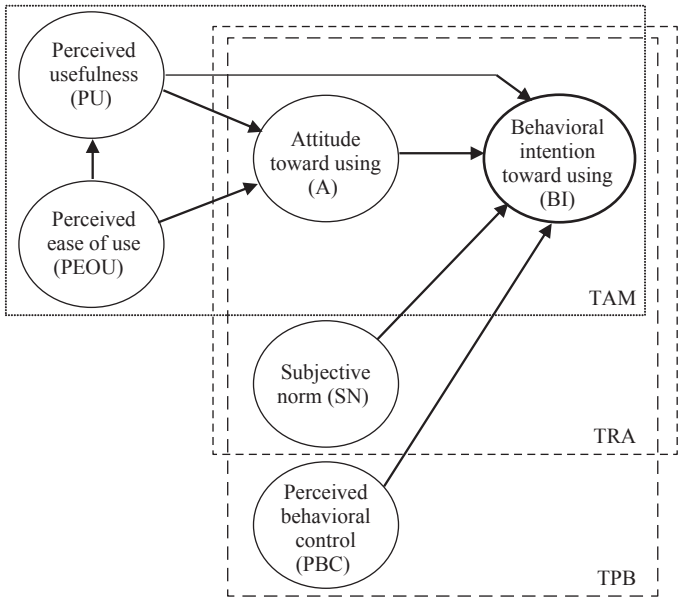

Figure 1. Research model. TAM = Technology Acceptance Model; TRA = Theory of Reasoned Action; TPB = Theory of Planned Behavior.

Not only the relationship between A and BI is fundamental to TRA and adapted in the TAM, but also the direct effect of a belief (such as PU) on BI (Davis *et al.*, 1989). PU, i.e. the extent to which using a technology will improve productivity, and PEOU, i.e. the extent to which using a technology will be free of effort, are the two key beliefs of TAM (Davis *et al.*, 1989). The major beliefs are that PU and PEOU will affect a user's attitude. According to the trader respondents in this study, acceptance depends on the usefulness (PU) and easiness of use (PEOU) of new packaging material for improvement of their business operations. Thereby 'usefulness' in this context means if traders believe that the improved packaging improves the job performance and will be beneficial to them. It is assumed that a better job performance will influence the attitude toward produce packaging positively. Additionally, the more complex it is to use the improved packaging, the less positive traders will evaluate the packaging. The second and third hypotheses of this study are as follows:

H_2: PU is positively related to attitude toward improved packaging (A).

H_3: PEOU is positively related to attitude toward improved tomato packaging (A).

Further, it is argued that the more traders' value improved packaging as easy to use, the more useful they consider the improved packaging technology. This hypothesis is adapted from the original theory by Davis *et al.* (1989). Therefore, fourth hypothesis of this study is:

H_4: PEOU is positively related to PU of improved tomato packaging.

Additionally, TAM specifies a causal effect of PEOU on PU, so that behavioral intention will be indirectly affected by PEOU through PU (Davis *et al.*, 1989). Therefore, it is assumed that the easier it is for a trader to recognize an improvement in produce packaging, the more useful the trader will find the improved packaging option. Further it is assumed, that traders are more likely to accept the proposed improved packaging when perceived usefulness and ease of use is high. The following hypotheses are thus formulated:

H_5: PU is positively related to BI to use improved packaging.

According to TPB, SN refers to the belief by users that their neighbors and/or fellow group members would evaluate them positively (or negatively) if they behaved in a certain way (Ajzen, 1991). Group members might consist of family, similar ethnic group, social group, friends, opinion leaders or people in authority, each of whose beliefs are likely to be influential and important to the individual. In this regard, it is crucial to understand how members of one's peer group can determine individual intentions. Notably, the opinions of others are likely to prove especially influence at the early stages of new technology adoption, given that it is exactly at this point where the individual decision-maker has the least experience with the technology and is therefore likely to be more susceptible to the reactions and input from important members of his or her peer group. In other words, it is for such reasons that the direct effect of SN on BI is likely to be highly significant and positive (Venkatesh and Morris, 2000). Based on a similar assumption, Kamrath *et al.* (2016) found that less experienced traders might be influenced in their opinions and decisions by more powerful peer members in the group, i.e. more experienced traders and the chairman of the traders' association of the tomato supply chain in the Arusha region of Tanzania. This suggests that the influence of peer members who are most influential in decision making, will have an impact on trader's intention to use improved packaging, therefore this study hypothesized that:

H_6: SN will have a positive effect on the BI to use improved packaging.

Further, perceived behavioral control (PBC) is defined as the perceived ease or difficulty of performing the behavior (Ajzen, 1991). This means an individual is perceived to have the necessary resources, capability, and a sense of control in successfully performing the behavior (Lu *et al.*, 2009). The PBC can influence behavior directly or indirectly through BI. Although the improved packaging 'wooden box with lining' is an improved technology which is relatively easy to use, users still need to know where they can get the resources

(paper lining). Furthermore, traders need to understand the economic benefits and how to implement those improved boxes in the tomato supply chain. Thus, it is posited that:

H_7: PBC is positively related to the BI to use an improved packaging.

In the context of this study, it could be also argued that PU and PEOU invariably influences PBC on the adoption of the improved packaging. The more useful the traders perceive the new packaging technology, the easier it will be for them to get associated with it and manage its implementation. We however did not find any relevant literature to support this anticipated relationship.

Table 1 summarizes the operational definition of the constructs and Table 2 represents an overview about the hypotheses within the proposed research model.

4. Materials and methods

4.1 Study area and sampling approach

To explore the adoption of novel technologies more broadly, this study focuses on the decisions of traders within the tomato value chain. Conducted in the Arusha region of Tanzania in June, 2014, the study uses a sample of eighty traders comprising of 19 retailers, 13 village collectors and 48 wholesalers. Initially, our aim was to utilize a stratified sampling procedure; however, this ended up not being possible because the

Table 1. Definitions of latent constructs within research model.

Variable	Construct	Operational definition
BI	Intention to use packaging	An individual's behavioral intention to use improved packaging
A	Attitude toward using	An individual's overall evaluation toward using improved packaging
SN	Subjective norm	Users' perception of whether peers within their group perceive they should use improved packaging
PBC	Perceived behavioral control	Users' perception if they have the necessary resources and capability in successfully using improved packaging
PU	Perceived usefulness	An individual's perception that using improved packaging will enhance job performance
PEOU	Perceived ease of use	An individual's perceived exerted efforts when using improved packaging

Table 2. Hypotheses of research model.

Relationship	Hypotheses	
A → BI	H_1	Behavioral attitude toward improved packaging is positively related to the behavioral intention to use improved packaging.
PU → A	H_2	Perceived usefulness is positively related to attitude toward improved packaging.
PEOU → A	H_3	Perceived ease of use is positively related to attitude toward improved tomato packaging.
PEOU → PU	H_4	Perceived ease of use is positively related to perceived usefulness of improved tomato packaging.
PU → BI	H_5	Perceived usefulness is positively related to behavioral intention to use improved packaging.
SN → BI	H_6	Subjective norm will have a positive effect on the individual's intention to use improved packaging.
PBC → BI	H_7	Perceived behavioral control is positively related to the behavioral intention to use an improved packaging.

sampled population of wholesalers, village collectors and retailers was unknown in the study region. Thus, we decided to interview nearly all wholesalers and village collectors who were present at the Kilombero wholesale market at the time of sample collection. It is important to note that the Kilombero wholesale market is one of the biggest tomato wholesale markets in the Arusha region of Tanzania. Indeed, the only wholesale market for tomatoes in Arusha exists at the Kilombero market, which is why it was selected as the context of this study. As a further step, we also gathered approximate census figures from the market manager in order to determine both the number of tomato retailers that operate in the Kilombero wholesale market (approximately 160 retailers) and how many retailers located outside the market tend to source and buy their produce from here. From the resulting list that was generated, 19 retailers were then randomly selected.

A structured survey questionnaire was used to test the theoretical model of this study. Three enumerators were trained on how the survey had to be conducted. As part of the enumerator training, enumerators were made to become conversant with the knowledge about the improved packaging and how to introduce the concept to traders and place it in context for the interview (Supplementary Methods S1). An example of the lining material proposed was shown to traders. Following a pre-test of the survey instrument, face-to-face interviews on the paper based questionnaire was translated from English to Swahili, were then conducted directly in the market.

4.2 Measurement of psychological constructs

Psychological constructs are non-observable, also known as latent constructs (DeVellis, 2012) and are represented by measurable observable – either formative or reflective – indicators (Hair *et al.*, 2014). In order to measure the latent constructs, the following reflective items (see Table 3) have been deduced from extensive literature (Adrian *et al.*, 2005; Davis, 1986; Davis *et al.*, 1989; Hansson *et al.*, 2012; Venkatesh and Bala, 2008; Yazdanpanah *et al.*, 2014). Thus consistent with previous studies on technology acceptance, we applied the six psychological latent constructs (Table 3) into the research context of the improved tomato packaging materials in the Arusha region of Tanzania, which were measured on a five-point Likert scales, ranging from (1) 'strongly disagree' to (5) 'strongly agree' to operationalize the constructs BI, A, PU, PEOU, SN and PBC with the exception of the item BI4 (Table 3). Answer options of BI4 ('will make effort to switch to the wooden crates with lining') are (1) never, (2) by the next year, (3) by the next month, (4) by the next week and (5) by the next day. Table 3 summarizes the constructs of the research model and its source. The second part of the questionnaire focused on respondents' demographics and socioeconomic characteristics, trading activities, marketing infrastructure and social capital.

4.3 Analytical framework

The variance which is based on the Structural Equation Modeling (SEM) approach using partial least squares (PLS) was used to analyze the relationship among variables by applying SmartPLS 3 software package (Smart PLS version 3.2.6, SmartPLS GmbH, Boenningstedt, Germany). In general, SEM is designed to test theoretical models, and in particular some studies have applied this method for testing theories such as TPB and TAM (Aboelmaged, 2010; Chen and Chao, 2011; Lu *et al.*, 2009; Nasri and Charfeddine, 2012). The partial least square approach of structural equation modeling (PLS-SEM), developed by Wold (1975, 1982) and Lohmöller (1989), is based on exploratory research to develop theories and is a variance based approach which also allows analyzing lesser sample size datasets for which the assumption of a normal distribution does not hold true (Hair *et al.*, 2013). It combines confirmatory factor analysis (outer model) and regression analysis in one framework (inner model) (Hair *et al.*, 2013).

In sum, PLS-SEM is used for the combined model of TAM and TPB with PU, A and BI as endogenous (dependent) and PEOU, SN and PBC as exogenous (independent) variables that are key determinants for dependent constructs. The direct relationships between latent constructs, unobserved variables represented by measurable variables, are considered as an inner model. PEOU is further considered as having a mediator effect through PU to A, also known as an indirect effect that means the relationship involves at least one

Table 3. Constructs, items and statements.[1]

Latent variables	Manifest variables		Source
Perceived usefulness	PU1	I believe that wooden crate with lining can be useful to me as a trader	Adrian *et al*. (2005)
	PU2	Using the wooden crate with lining will improve my job performance of tomato transportation/*of tomato seller*	Davis *et al.* (1989)
	PU3	I believe that using wooden crate with lining can improve the quality of my work/*tomatoes*	Davis *et al.* (1986)
	PU4	For me, the wooden crate with lining is more beneficial than the standard wooden box	New
	PU5	Overall, I find the wooden crate with lining practical in my job	Davis *et al.* (1986)
Perceived ease of use	PEOU1	It is easy and understandable for me to learn how to use the wooden crate with lining/*how paper lining will reduce postharvest losses and increase tomato quality*	Adrian *et al.* (2005)
	PEOU2	For me, it will be easy to put lining in the wooden crate/*for me, it will be easy to change to the wooden crate with lining*	New
	PEOU3	Overall, wooden crate with lining will be easy to use	Adrian *et al.* (2005)
Behavioral attitude	A1	For me, it is important to reduce postharvest losses of tomato during transportation	New
	A2	I think that our trader communities are responsible for reducing postharvest losses during transportation	New
	A3	I believe it is necessary to improve tomato packaging	Yazdanpanah *et al*. (2014)
	A4	To run my business efficiently, I need to use/*to buy* the wooden crate with lining	Hansson *et al.* (2012)
	A5	I could consider using/*buying* the wooden crate with lining instead of the standard wooden crate	Hansson *et al.* (2012)
	A6	The best thing for me would be to reduce postharvest losses through tomato packaging with lining	Hansson *et al.* (2012)
	A7	I like to try using/*buying* the wooden crate with lining	Hansson *et al.* (2012)
Subjective norm	SN1	If I implement/*buy* the wooden box with lining, people who are important to me would support it	Yazdanpanah *et al.* (2014)
	SN2	Most people who are important to me think that implementing/*buying* wooden crate with lining is desirable	Yazdanpanah *et al.* (2014)
	SN3	People whose opinions I value, prefer that I use/*buy* wooden crate with lining	Venkatesh and Bala (2008)
	SN4	Other traders ask my advice	New
	SN5	Other traders/*retailers* believe that I adopt new technology/packaging (that will be used for reducing postharvest losses)	New
Perceived behavioral control	PBC1	If I wanted to, I could easily implement/*buy* wooden crate with lining	Yazdanpanah *et al.* (2014)
	PBC2	It is mostly up to me whether or not I implement/*buy* wooden crate with lining	Yazdanpanah *et al.* (2014)
	PBC3	For me, it is not difficult to implement wooden crate with lining	Yazdanpanah *et al.* (2014)
	PBC4	I can influence in the tomato value chain needed for implementing the wooden crate with lining	New
	PBC5	In my opinion, it is possible to implement the wooden crate with lining in the tomato supply chain	Yazdanpanah *et al.* (2014)
	PBC6	The wooden box with lining is compatible with the old system of the standard wooden boxes	Holden and Karsh (2010)

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Table 3. Continued.

Latent variables	Manifest variables		Source
Behavioral intention	BI1	I think I will intend using/*buying* wooden crates with lining for tomato transportation	Yazdanpanah *et al.* (2014)
	BI2	My intention to switch from the standard wooden crates to wooden crates with lining is strong	Chen and Chao (2011)
	BI3	The likelihood of my switching to wooden crates with lining is high	Chen and Chao (2011)
	BI4	I will make an effort to switch to the wooden crates with lining by the [choose]	Chen and Chao (2011)
	BI5	I will use/*buy* wooden crate with lining	Various

[1] Words in italic are different formulations in questions for retailers in comparison to wholesalers and village collectors.

intervening construct (Hair *et al.*, 2013). The outer model is determined by reflective measured variables. According to the required sample size, the maximum number of arrows is pointing at BI (4 arrowheads). According to Hair *et al*. (2013) based on Cohen (1992), to achieve a statistical power of 80% for detecting R^2 values at least 0.25 (with a 5% probability of error), the recommended sample size should exceed 65 observations with four arrowheads pointing at BI. Thus our 80 observations in this study exceed the threshold amount.

For this study, we applied a two-stage approach for evaluation, following the guidelines suggested by Hair *et al.* (2013): (1) evaluation of reflective measurement model (outer model); (2) assessment of structural model (inner model) and hypothesis test.

Due to the small sample size of the sub groups, all three subsamples are treated as a homogeneous trader group. This is supported by further statistical tests (FIMIX procedure as well as Kruskal-Wallis-Tests), lacking identification of significant moderating effects to explain group segmentation.

5. Results

5.1 Background of tomato traders and their role in tomato packaging

The survey results (Table 4) show that most of the traders in our sample are men and have been engaged in tomato trade for an average of 15 years, and mostly used standard wooden crates (STA) without any lining material. Alternative packaging are plastic basins that are mostly used by village collectors. No trader had experience in the use of lining material for the standard wooden crates. About 45% of the traders answered yes for the question on the willingness to implement/buying wooden crates with lining. Concerns were usage during the rainy season and the availability of the lining in villages where tomatoes are grown.

5.2 Results and evaluation of reflective measurement model

The outer model is determined from reflective measured constructs, because the items of each latent variable are highly correlated and interchangeable (Hair *et al.*, 2013). The PLS-SEM algorithm could find a stable solution within six iterations (Table 5).

Table 4. Trader characteristics of survey in June, 2014 at Kilombero Market, Arusha.

Independent variables	**Sample characteristics**		
Age (average in years)	41 years		
Gender (female/male in %)	34% female	66% male	
Trader experience (in years)	16 years in trading in general (average)	15 years being tomato trader (average)	
Using/buying STA[1] (in %)	85% yes	15% no	
Using/buying lining for STA already (in %)	0% yes	100% no	
Willingness to use STA + lining (in %)	45% yes	38% no	17% undecided

[1] STA = standard wooden crate.

Table 5. Results summary for reflective outer models.[1]

Variables	**Indicators**	**Loadings**	**Cronbach's alpha**	**Composite reliability**	**AVE[2]**
Perceived usefulness	PU1	0.950	0.957	0.967	0.854
	PU2	0.957			
	PU3	0.927			
	PU4	0.889			
	PU5	0.894			
Perceived ease of use	PEOU1	0.835	0.871	0.921	0.796
	PEOU2	0.908			
	PEOU3	0.931			
Attitude	A1	0.782	0.940	0.951	0.735
	A2	0.745			
	A3	0.799			
	A4	0.910			
	A5	0.911			
	A6	0.928			
	A7	0.904			
Subjective norm	SN1	0.931	0.940	0.955	0.809
	SN2	0.958			
	SN3	0.940			
	SN4	0.753			
	SN5	0.900			
Perceived behavioral control	PBC1	0.845	0.920	0.938	0.716
	PBC2	0.715			
	PBC3	0.839			
	PBC4	0.887			
	PBC5	0.891			
	PBC6	0.887			
Behavioral intention	BI1	0.907	0.958	0.967	0.856
	BI2	0.954			
	BI3	0.944			
	BI4	0.912			
	BI5	0.907			

[1] Output of SmartPLS3 (PLS-SEM) based on research sample.

[2] AVE = average variance extracted.

■ *Convergent validity*

First, the convergent validity was tested and is defined by Hair *et al.* (2014) as 'items that are indicators of a specific construct should converge or share a high proportion of variance in common.' Thereby two measurements are undertaken – the outer loadings of the indicators should exceed the threshold of 0.708 to be strong in strength and the average variance extracted (AVE) values should exceed the threshold of 0.50 (Hair *et al.*, 2013). According to the results presented in Table 5, both criteria are met for all latent constructs.

■ *Internal consistency reliability*

In addition, the internal consistency reliability – the 'measure of the degree to which a set of indicators of a latent construct is internally consistent based on how highly interrelated the indicators are with each other' (Hair *et al.*, 2014) – was tested using Cronbach's alpha value and composite reliability. Both, Cronbach's alpha and composite reliability, are generally interpreted in the same way. Values above 0.95 indicate that variables measure the same phenomenon and are thus not preferred (Hair *et al.*, 2013). Transferred to the results of the research model, PEOU, A and PBC are internal consistent reliable constructs, but PU, SN and BI lack on internal reliability due to the fact that respondents perceived the questions posed to them to be similar for each latent variables. Thus, deleting the items PU1, PU2 and further SN2 as well as BI2 and BI3 solved the problem for the constructs PU, SN and BI.

■ *Discriminant validity*

Finally, the PLS-SEM generates the discriminant validity which 'is the extent to which a construct is truly distinct from other constructs' (Hair *et al.*, 2014). The Fornell-Larcker criterion is considered to indicate lack of discriminant validity when a square root of a construct's AVE is lower than its highest correlation with any other construct (Hair *et al.*, 2013). The correlation matrix shows that constructs are discriminant valid except between the latent constructs PEOU and A (Table 6). As the correlation of PEOU on A (0.887) exceeds the square root of AVE of the construct A (0.857) only slightly, both constructs are kept for further analysis. The questionnaires of PEOU and A differ and measure different latent perspectives, therefore merging both constructs is not suggested.

5.3 Assessment of structural model

After assessing reliability and validity, the structural equation model is evaluated to assess the impact of TAM and TPB constructs on acceptance behavior by means of Smart PLS3. Testing the hypotheses, if path coefficients are significant, the bootstrapping procedure with 5,000 subsamples, a significance level of 0.05 and on basis of a two tailed test was run. Results are shown in Figure 2 and Table 7.

Table 6. Fornell-Larcker criterium – discriminant validity.[1]

	A	**BI**	**PBC**	**PEOU**	**PU**	**SN**
A	0.857					
BI	0.590	0.925				
PBC	0.768	0.762	0.846			
PEOU	0.887	0.469	0.736	0.892		
PU	0.816	0.586	0.669	0.770	0.924	
SN	0.696	0.713	0.730	0.667	0.622	0.899

[1] Output of SmartPLS3 (PLS-SEM) based on research sample.

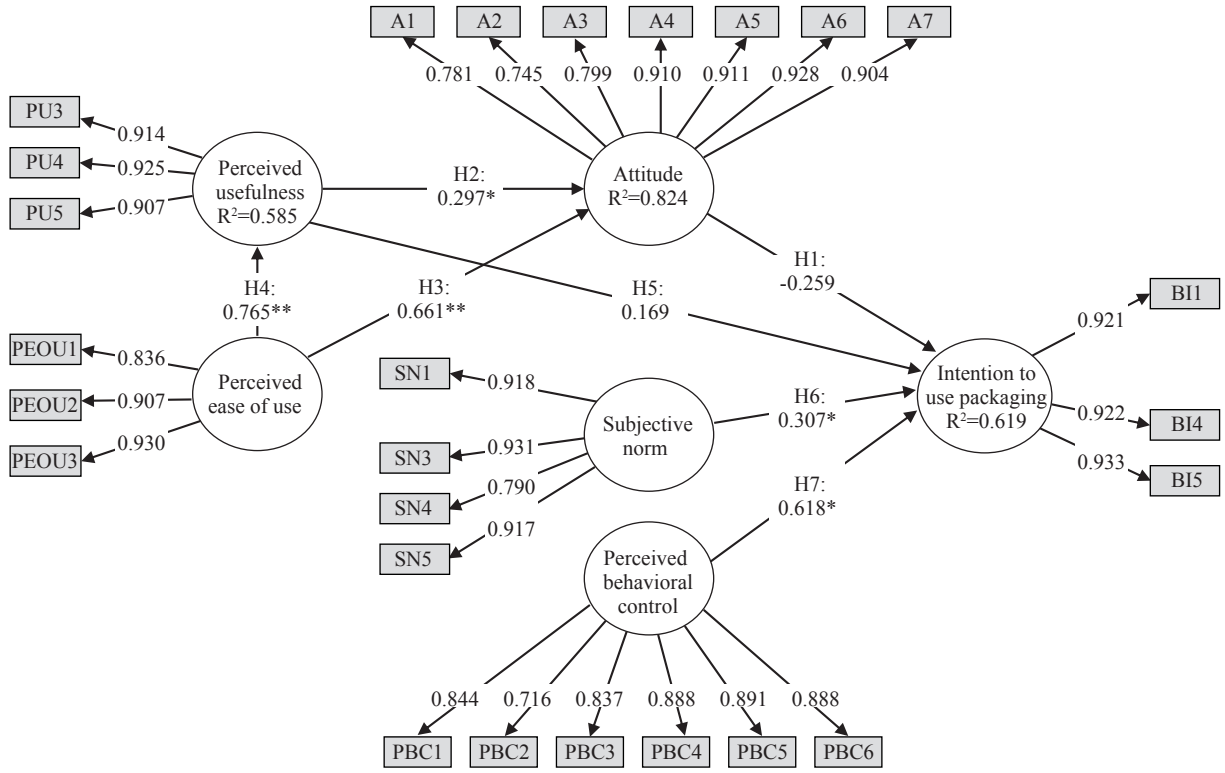

Figure 2. PLS path coefficients and bootstrap statistics. Outer loadings = between manifest variable and latent construct; path coefficient = between two latent constructs, $^{*}P<0.05$; $^{**}P<0.01$. Output of SmartPLS3 based on research sample: PLS-SEM with maximum 300 iterations and stop criterion at 10^{-7}.

Table 7. Significance testing results of the structural model path coefficients.[1,2]

	Relationship	Direct effect	Total effect
H_1	A→BI	-0.259	-0.259
H_2	PU→A	0.297*	0.297*
H_3	PEOU→A	0.661**	0.887**
H_4	PEOU→PU	0.765**	0.765**
H_5	PU→BI	0.169	0.092
H_6	SN→BI	0.307*	0.307*
H_7	PBC→BI	0.618*	0.618*

[1] $^{*}P<0.05$; $^{**}P<0.01$.

[2] Results of bootstrapping procedure with SmartPLS 3 based on research sample.

■ *Multicollinearity assessment*

First testing for multicollinearity problems, VIF values below the threshold of 5 indicate that collinearity is not a problem in the structural model among the predictor constructs (Hair *et al.*, 2013). In this study values ranged from 1.000 (PU) and 4.126 (BI), indicating that the results were not negatively affected by collinearity.

■ *Coefficient of variance (R^2)*

R^2 values of 0.75, 0.5 and 0.25 describe substantial, moderate and weak, respectively, the explanatory power of endogenous latent variables, according to Hair *et al.* (2014). Thus, the variance of the endogenous variables PU and BI in the proposed structural model are explained moderately and A has a substantial R^2 value.

■ *f^2 effect size*

The f^2 effect size enables one to analyze the relevance of constructs in explaining the endogenous latent constructs. Guidelines for assessing f^2 are that values of 0.02, 0.15 and 0.35, respectively, represent small, medium, and large effects on the exogenous latent variable (Hair *et al.*, 2013). The predictors PU (0.026), A (0.043) and SN (0.107) contribute relatively little explanation to the R^2 value of BI. In accordance with the rules of thumb for the f^2, the effect size of PBC (0.335) can be nearly considered as large. Therefore, PBC has highest explanation impact on BI. The variance of A is mainly explained by PEOU (1.029) not so much by PU (0.208). PEOU (1.411) has large effect on the R^2 value of PU.

■ *Cross-validated redundancy (Q^2)*

For reflective items, the Stone-Geisser's Q^2 value, developed by Geisser (1974) and Stone (1974), indicates model's predictive relevance for values larger than zero whereas Q^2 smaller than zero represents a lack of predictive relevance, calculated through blindfolding procedure. The Q^2 of all three endogenous constructs A (0.599), BI (0.508) and PU (0.488) have larger values than zero after the blindfolding procedure, which implies that the model has predictive relevance for these constructs.

■ *The path coefficients*

Considering first the endogenous construct BI, the most influencing factor is PBC (0.618). The hypothesis H_7 can be confirmed at a 5%-significance level in the context of the adoption of wooden crates with paper lining (Figure 2). In other words, traders who think they can implement the wooden crate with lining material do have a higher intention to switch to the wooden crates with lining.

The hypothesis H_6 receives support by the study about adoption of wooden crates with lining. At a significance level of 5%, traders who perceive that other important people would support him/ her to use improved packaging are more likely to switch to the wooden crates with lining and is the second most important factor influencing BI.

The hypotheses H_1 and H_5 need to be rejected as the relationships are not significant. Both relationships are well examined in the literature in other contexts (*inter alia*: Aboelmaged, 2010; Hansson *et al.*, 2012; Mathieson, 1991; Nasri and Charfeddine, 2012) but in this study A and PU do not have a significant effect on BI. The hypothesis H_2 is supported at the 5%-significant level. Therefore, it is supported that the more traders evaluate the packaging as useful the more they have a positive attitude toward the wooden crates with lining. PEOU is for both constructs A and PU a highly significant influencing factor. Thus hypotheses H_3 and H_4 are supported and confirm that easiness of use contributes positively to usefulness and attitude.

6. Discussion, implications and limitations

This study used a combined model of TAM and TPB to explore how underlying psychological constructs can explain the decisions of traders to change from conventional wooden crates to wooden crates with a new lining material. The application of this novel framework allows us to derive new insights for this context.

Furthermore, use of this combined theoretical approach to explain adoption behavior of new packaging is supported by the moderate (PU, BI) and substantial (A) values for R^2. Overall, there is good model fit, as demonstrated by the f^2 and Q^2 effect sizes. In addition, both perceived behavioral control and subjective norm are shown to strongly predict the behavioral intentions of traders. No significant effect is found however for the influence of attitude toward the packaging. Moreover, from the results, we are able to ascertain that both social network and the distribution of power in value chains and market structures are responsible for the successful implementation of new packaging, not to mention the overall perception of the technology. These findings were also underlined by observation of market activities at the time of data collection. For

instance, we identified the crucial (and pervasive) role of the Chairman of the Kilombero Market Association, i.e. the leader of the local organization of tomato traders, who both determined who would have access to the market and more generally exerted an influence on traders' knowledge and opinions. In this regard, the significant effect of subjective norms can also be explained by the higher complexity of social and business networks and the greater willingness by traders to collaborate. This is perhaps best exemplified by the fact that most wholesalers were members of the Kilombero Market Association. Further, many traders bring their own crates when going to the farmgate to buy tomatoes from farmers. This indicate that traders have a certain level of resources (Parmar *et al.*, 2016), contributing positively to the significant effect of perceived behavioral control. On the other hand, it must be noted that the characteristics of the social structure can broadly differ across African countries. Taking the example of Ghana, it is actually the female 'market queens' who generally have the most power in the tomato supply chain (Lyon, 2003).

In addition, explanatory variables such as the characteristics of traders, type of packaging, network, trading patterns, profit and transportation issues, were not however generally predictive of adoption behavior of traders. In part, this can perhaps be explained by the small sample size in this study. In general, however, the importance of socioeconomic factors (e.g. gender) for adoption behavior is both well-known and broadly established by several studies (e.g. Abass *et al.,* 2014; Affognon *et al.,*2015; Aidoo *et al.,* 2014; Ali, 2012; Feder *et al.,* 1985; Tenge *et al.,* 2004). For this reason, it seems safe to assume that these factors are also likely to be relevant in the context of trader adoption decisions.

The significant relationship between perceived usefulness and attitude seems to contradict the insignificant relationship between A and BI, as well as that between PU and BI. If a person has more positive views about the usefulness of packaging, this is found to strengthen the positive attitude of the improved packaging. However, are not able to find support for either a further effect of these factors on behavioral intention or for the direct relationship between perceived usefulness and behavioral intention. This lack of significance could perhaps be attributed to the fact that, while traders like the idea of reducing losses by improving packaging, they do not necessarily have confidence in the practical use of the packaging to improve the shelf life of produce. This could be, for instance, because the viability of the new lining has not yet been demonstrated for the rainy season. Another reason could be that traders are reluctant to change and would instead prefer to retain the business-as-usual approach. Indeed, such reluctance was rather apparent from our field observations. Furthermore, traders might expect, and indeed require, higher returns on investments in return for adopting new the lining technology. However, due to the oligopolistic behavior of traders, and wholesalers in particular, there could be a tendency for traders to lack a feeling of responsibility for losses that are incurred in marketing, which they might instead pass along to farmers and others. As a result, the incentive to change their behavior is likely to be low even if their expressed attitudes and intentions to do so are high (e.g. Lagerkvist *et al.*, 2013). Accordingly, the more careful the traders are, the more they need to be convinced of the potential returns from technology adoption, especially given the potential that higher (perceived) risks could outweigh any expected returns. In sum, all of the above could therefore provide an explanation for the non-adoption of the improved packaging.

As a possible avenue for further research, it could be useful to extend the model to include additional important variables such as the perceived net benefit, i.e. the belief that the technology will provide benefit greater than its costs, as another potential determinant of adoption intentions. In specific, this could mediate the relationship between perceived usefulness and behavioral intentions (Adrian *et al.*, 2005). Measuring the problem awareness of traders, as proposed by Subedi *et al.* (2009), could also give further insights on whether traders might behave differently if they assigned greater urgency to reduce postharvest losses. Similarly, in order to understand if and why traders refuse to make changes to their behavior (and therefore do not adopt new technology), the technology readiness index by Parasuraman (2000) can be considered as a further explanatory factor in the technology acceptance model. In specific, this factor could be used to explain perceived ease of use and perceived usefulness (Walczuch *et al.*, 2007). Accordingly by considering these changes, we envision even greater potential to extend our novel framework and thereby improve the understanding of adoption decisions across the entire supply chain.

Nonetheless, there are a number of potential limitations and, as a result, suggestions that can be used to improve future studies in this vein. First, due to the small sample size of 80 traders, it cannot necessarily be assumed that all results and statements can be generalized for all traders in Tanzania. Rather, it is more likely that the validity of these findings is broadly meaningful for this sample and within this study region. Similarly, the tomato value chain in the Arusha region is not representative for the whole of Tanzania, given the existence of other systems in other regions. However, as mentioned before, this region is one of the major tomato market in Tanzania. Aside from this, some issues also emerged during data collection. For instance, many traders evaluated the statements for one latent construct identically, e.g. PU1-PU5 all with '4' Likert scale, which could suggest that full attention was not necessarily given to the task at hand. Indeed, as might be expected, traders were still engaged in their business transactions throughout the field interviews – and it seems that the loud, hectic and full market environment is not necessarily optimal for the collection of high-quality data. Of course, issues such as these are endemic to the use of field studies in the social sciences. On the other hand, another explanation for why traders may have answered identically for all the items of the aforementioned construct might be due to the similar formulation of statements. With regard to the task of field observation, limitations also include the potential (biasing) influence of both prominent respondents and the Chairpersons of the traders association. As a result, it cannot be ruled out that the answers of the respondents were not determined by the market environment in which data collection took place. In a more positive light, the presence of these factors could also be seen to impart a greater reality to the experiment, given that individual traders are unlikely to make decisions about the adoption of new technologies in an isolated manner. Finally, it was also the case that, during data collection, the questions and statements for explanatory variables were not necessarily clear to all enumerators. That is, in spite of a training and pre-test with subsequent discussion, there remains substantial room for, e.g. improving further applications of the theories, developing new statements for latent constructs, and more thoroughly standardizing the questionnaire to suit the actual interview context (i.e. as it was the case of translating English to Swahili for this study). Through such improvements, it will be possible to ensure that such questionnaires are more broadly suitable for a range of experimental circumstances and, moreover, able to provide generalizable results regarding the adoption decisions of traders. To further advance the understanding of the factors for technology adoption a real experimental design would be desirable especially in the light of the attitude-behavior gap.

7. Conclusions

For a successful implementation of new packaging or better postharvest handling techniques it is important to understand the adoption behavior of users of the techniques. Even though traders were not aware about the paper lining technology, knowledge and adoption rate are low (Kamrath *et al.*, 2016), the factors influencing the adoption behavior give an idea for improving technologies and its introduction in the supply chain.

To the best of our knowledge, systematic and model-based research at traders' level in developing country context has been barely researched. Based on literature traders are the dominating actors – representing a special and important role – in the fresh fruit and vegetable supply chain in the developing world, future research is required for more in-depth studies in this domain. Underlying factors that contribute to rejection or acceptance of technology offer insights to the psychological construct of traders (i.e. attitude, social/subjective norms and perceived behavioral control) in the tomato supply chain. Findings of the significant influence of subjective norm shows that we need to investigate the entire network as peers seem to dominate technology adoption decisions. As a second important factor, perceived behavioral control influences significantly the adoption behavior. The factor attitude toward the packaging is positively influenced by perceived usefulness but perceived ease of use has no significant influence on adoption behavior. This is useful for further research about tomato packaging to meet the requirements of users and avoid risks by traders. The findings of this study may not apply to the overall population as samples and study regions were selected purposively, but there are similar situations where traders play an important role in the food value chain in postharvest loss reduction in other developing countries. It is therefore plausible that our findings are applicable in the context of other developing countries with a similar situation as exists in Tanzania.

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Supplementary material

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Methods S1. Context.

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