DIGITALISING AFRICAN AGRICULTURAL VALUE CHAINS

The Role of ICT Platforms in smallholders' uptake of agricultural inputs in Uganda

Connetie Ayesiga

Propositions

1. The expected decline of ICT platforms for smallholders will benefit agricultural development in Uganda.
   (this thesis)

2. Building loyalty between value chain actors makes ICT platforms more effective.
   (this thesis)

3. Locally-perceived development indicators are more important than internationally recognized sustainable development ones.

4. Researchers who disregard interdisciplinarity hinder sustainable development.

5. The concept of 'Ceteris Paribus' is detrimental to achieving the sustainable development agenda.

6. Interventions offering free support have rendered poor smallholder farmers poorer.

7. Family is a more important concern for PhD candidates and their supervisors than a completed PhD thesis.

Propositions belonging to the thesis, entitled

Digitalising African agricultural value chains: The role of ICT platforms in smallholders' uptake of agricultural inputs in Uganda

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Digitalising African agricultural value chains: The role of ICT platforms in smallholders' uptake of agricultural inputs in Uganda

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Digitalising African agricultural value chains:

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Abstract

To address low yields and contribute to food security in sub-Saharan Africa, policy-makers encourage smallholders to use productivity-enhancing agricultural inputs. Despite the wide promotion of agricultural inputs, the uptake of such technologies remains low, among others, due to limited access to input and output markets. Information and communication technology (ICT) platforms are seen as promising tools for 'pushing' information on input use, providing links to input suppliers, or 'pulling' input use through improved information on and links to output markets. Researchers nevertheless disagree on how ICT platforms can best fulfil their role. More specifically, there are disagreements concerning whether the main role of ICT platforms should be limited to providing information on input or output markets or whether they should play a coordinating role within the value chain. In addition, it remains unclear whether supply push or market pull is more effective in increasing input use.

To provide empirical evidence to reconcile the different arguments in the literature, we first employed case study methods to compare four case studies of ICT platforms. We explored the motivations and actions of ICT platforms to understand the strategies used by the four ICT platforms in improving the uptake of agricultural inputs among smallholders and their future strategic directions. The study revealed that, ICT platforms are moving away from an exclusive focus on providing information towards the coordination of value chains and from an exclusive concentration on either input or output markets to include both markets. Thus, they are moving towards taking on a role as full value-chain coordinators to address the multiple barriers to uptake farmers face.

In the next step, we zoomed into one of the ICT platforms in the previous study that was had adopted a business-ecosystems approach to reach out to other actors within the value chain (e.g. agro-insurance companies, microcredit organisations and related service providers) to address the many challenges faced by farmers. In addition, the platform had interacted with farmers in

the design of its current ICT services and was now considering the inclusion of other actors to co-create value and improve access to and the use of its services amongst all value-chain actors in what could be referred to as 'experience-led evolution'. We explored ICT service needs and preferences for interface design features in a smallholder-based value chain context involving key actors using focus group discussions and key informant interviews to derive potential synergies, trade-offs, and solutions. The findings of this study show that many value chain actors have similar needs for ICT services such as coordination of the entire value chain, buyer-seller loyalty building, digital literacy and multifaceted interface tools. Results also showed trade-offs in the preferences for interface design features related to reach versus efficiency and inclusion versus exclusion such as differ between actors, and, in some cases, they even contradict each other. In light of these contradictions, the study highlights the need for ICT platform managers must first prioritise needs that cut across all value chain actors and make trade-offs concerning whose needs they consider most important.

Following insights from the previous study, the lack of loyalty between farmers and produce buyers was one of the key design challenges hampering farmers' access to output markets, resulting in low incomes earned by farmers, which in turn forms a negative self-reinforcing loop that further constrains their use of agricultural inputs and productivity. We therefore implemented and examined the effects of loyalty incentives shared by an Information and Communication Technology (ICT) platform on farmers' use of agricultural inputs and soybean yields using survey data from 234 farmers in Northern Uganda. The study results indicate a significant (P<0.001) influence of financial and non-financial loyalty incentives on farmers' use of improved seed and fertiliser compared with no incentives. Average soybean yields significantly increased above the control (619 kg ha^{-1}) by 525, 747 and 854 kg ha^{-1} for non-financial, financial, and a combination of financial and non-financial incentives, respectively.

This thesis suggests that loyalty incentives are effective instruments in removing market uncertainties, resulting in increased adoption of agricultural inputs and consequent farm yields.

Lastly, the growing presence of mobile phones in distant rural areas of emerging economies opens new opportunities to overcome challenges that hinder marketing relationships that are important to provide sufficient food for rapidly growing populations. This study presents results from a field experiment on ICT-based loyalty incentives as a relationship-building mechanism between farmers and a buying company in Uganda. Both financial and non-financial loyalty incentives appear to affect (P<0.001) farmers' loyalty positively. Affective and calculative commitment mediate (P<0.001) these relationships. The effects appear to be stronger for farmers that have greater trust in the ICT platforms. Pressure from other buyers negatively affects (P<0.001) farmers' loyalty intentions, but the effect is weaker than that of loyalty incentives. These findings suggest that loyalty incentives are effective innovations for value chain development in rural markets of emerging economies.

This thesis provides some main insights. Chapter 2 shows how ICT platforms in smallholder-based agricultural value chains start converging towards becoming coordinators of value-chain ecosystems to solve the many value-chain challenges smallholder farmers face. Chapter 3 emphasises the need for ICT platforms to first prioritise needs that cut across all value chain actors and make trade-offs about whose needs they consider most important, if they are to improve access and use of ICT-based services among key value chain actors. Chapter 4 showed that loyalty incentives (common with larger firms) are also effective in smallholder-based value chains, and that farmers' access to output markets linkages with competitive prices are necessary for enhancing farmers' investment in agricultural inputs. Chapter 5 provides insights as to why loyalty instruments eventually influence loyalty, suggesting that relationships in agricultural value chains are strengthened more effectively when the new ICT institutions are also trustworthy.

Finally, this thesis has some key implications. First, addressing the low use of inputs and low yields among smallholder farmers necessitates improving farmers' physical linkages to inputs through input loans, quality inputs within their localities and knowledge about the benefits and use of the inputs. Second, business models for input markets such as fertiliser and rhizobial inoculants need to be redesigned to allow greater access by farmers in rural areas. Third, ICT platforms should develop multi-faceted interfaces that integrate tools for both simple-feature phones and smartphones, customised to different languages, types of access (on-demand, online and offline) and the capabilities of different value chain actors. Fourth, to play multiple roles, including input demand articulation, network building, and knowledge brokering ICT platforms must develop their capacity in terms of human resources, as well as the capacity of those on whom they rely to provide this range of services (e.g. village agents).

Fifth, in collaboration with NGOs and input and output companies, ICT platforms should design loyalty-building interventions that enhance buyer-seller relationships, increase transparency and exchange of credible information (e.g. bulking alerts and price information), to increase market certainty for both farmers and output buyers, thereby enhancing the use of ICT services amongst both categories of actors. Sixth, with the advent of technological advancements in smallholder agricultural market systems, policymakers should partner with ICT platforms as potential partners that can stimulate smallholders' food production to increase food security for the growing population. Intervention should involve engaging with existing platforms to integrate and strengthen relationships between market actors to increase smallholders' farm productivity. Lastly, this thesis recommends a one-stop centre ICT platform to ensure a well-functional and coordinated value chain between the demand and supply of agricultural markets (inputs, outputs, microcredit, and associated services) across value chain actors. This will ensure that farmers access all the required farming-related services without the need to register and navigate different platforms that cause digital fatigue.

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Chapter 1

General Introduction

1.1 Food security and uptake of agricultural technologies by smallholders

Despite the development and wide promotion of agricultural inputs to boost productivity in smallholder farming systems and meet the increasing food demands in Africa, uptake of these inputs by farmers remains low (Macours, 2019b; Stevenson et al., 2019). Various factors contribute to farmers' low uptake, including limited access to input, output and financial markets, production risks, high operation costs and knowledge and information gaps (Dannenberg et al., 2018; FAO et al., 2020; Simtowe et al., 2019a; Van Campenhout et al., 2021). The current rapid development and deployment of Information and Communication Technologies (ICTs) in smallholder agriculture can help overcome some obstacles and 'push' input use through information on inputs and links to input suppliers or 'pull' input use through improved information on and links to output markets. Researchers nevertheless disagree on whether the main role of ICT platforms should be limited to providing information on input or output markets or whether they should play a coordinating role within the value chain. In addition, it remains unclear whether the supply push or market pull is more effective in increasing smallholders' uptake of agricultural inputs. This thesis aims to explore and analyse the roles of ICT platforms on farmers' uptake of agricultural input technologies and find entry points for improved functioning of ICT platforms in smallholder-based value chains focusing on Uganda as a case.

Uptake of agricultural inputs among smallholders is crucial to increase food production and meet the demand for food in Africa, projected to double by 2050 (FAO, 2017; Van Ittersum et al., 2016) due to population growth, growing incomes and rapid urbanisation. However, crop yields in sub-Saharan Africa remain low due to dependence on rain-fed smallholder agriculture, declining soil fertility and decreasing farm sizes (Lowder et al., 2021; WorldBank, 2018). In this regard, substantial investments in agricultural research and technological innovations are made, resulting in high yielding and disease resistant seed varieties, soil fertility enhancing

inputs and good agronomic practices to increase smallholders' farm productivity and income. However, barriers remain that constrain the uptake of such technologies.

The economics literature largely attributes these constraints to the information asymmetry problem. Some studies argue that the lack of production information makes it hard for farmers to assess the suitability of agricultural inputs for use on their farms and the potential associated risks (Chavas and Nauges, 2020; Magruder, 2018). For instance, the input market system in Uganda has been characterised by counterfeits (Lybbert et al., 2017), making it difficult for farmers to differentiate genuine and fake inputs, thereby hampering uptake decisions (Shiferaw et al., 2015). Jack and Tobias (2017) argue that without the awareness of the technology, its benefits, and usability or application, farmers are unlikely to use it. Other studies indicate that the lack of information makes rural farmers vulnerable to the already poorly developed markets (McGuire and Sperling, 2016), making it difficult for farmers to forecast the output demand, which in turn limits their use of inputs to increase productivity.

The recent proliferation of Information Communication and Technologies (ICT) in sub-Saharan Africa is a major opportunity to improve access to agricultural information and overcome the information-related deficiencies in agriculture (cf. Aker and Mbiti, 2020; Foster and Graham, 2017; Nakasone et al. 2014). ICTs are digital tools on which multiple interfaces and applications are integrated for users (Baryamureeba, 2004; Zahedi and Zahedi, 2012), including farmers and other value chain actors. Through ICTs, low-cost and real-time agricultural information across the entire production cycle can be generated, stored, analysed, disseminated to farmers and other value chain actors (Aker et al., 2016; Orr, 2018). This is now possible as access to and use of mobile telephones in sub-Saharan Africa has increased to about 66 percent coverage (ITU, 2018). With increased access and use of mobile phones, it is possible to reach many farmers with information on new varieties, weather forecast, prices and market

information in a timely manner (Frow et al., 2014; Nakasone and Torero, 2016). Hence, enhancing uptake decisions through greater inputs access.

1.2 Roles of ICTs in smallholder-based value chains

Various studies have explored how the application of ICT platforms could potentially improve the uptake of agricultural input technologies in smallholder agriculture in sub-Saharan Africa. In this regard, many ICT tools have been developed to provide farmers with information on issues such as weather forecasting, crop variety selection and management practices, among others (Baumüller, 2018). For example, some authors show how videos and audio-visual extension information and SMS messages increased farmers' knowledge and use of inputs (seed purchases) and improved farm practices (Cole and Fernando, 2016; Fabregas et al., 2019; Larochelle et al., 2019; Van Campenhout, 2017; Vandevelde et al., 2021). Other authors show positive effects of ICT-based output market information services on farmers' market access, sales income, input allocation decisions and use of inputs (purchased seed and fertilisers) (Aker and Fafchamps, 2015; Aker et al., 2016; Aker and Ksoll, 2016; Baumüller, 2018; Courtois and Subervie, 2015; Minkoua Nzie et al., 2018; Ogutu et al., 2014; Okello et al., 2020). However, others found no positive effects of ICT-based extension information or market information on use of inputs among farmers (Voss et al., 2021; Van Campenhout et al., 2021; Maredia et al., 2018).

Based on the above mixed evidence of impacts of ICT platforms on smallholders' uptake of agricultural technologies, questions remain on *how* ICT platforms might fulfil their promise, bringing the research frontier at two questions. The first question concerns what market(s) should be prioritised by ICT platforms: input markets, output markets, or perhaps both, to create transparency on the incentives for farmers invest in inputs.

Next to the provision of information, the relationships between value chain actors to create output market certainty are crucial for uptake of inputs stemming from reliable produce markets and better prices for farmers (Agyekumhene et al., 2020; Barnes et al., 2021). In this respect, relationship building has been discussed in the relationship marketing literature through loyalty interventions to improve business relationships, while allowing customers earn future benefits or rewards from their engagement and relationship with the firm (Kwiatek and Thanasi-Boçe, 2019). Thus, improved loyalty between buyers and sellers could have beneficial effects on their relationships to create output market certainty that could pull farmers' use of inputs.

The second question is whether market information provision alone is enough to make markets function in the African context, where market players such as output buyers and input providers may be few and far between (e.g., Ingenbleek et al., 2013). Interestingly, some authors have advocated for ICT platforms to coordinate linkages across input and output markets (Aker and Ksoll, 2016; Chavas and Nauges, 2020; Ezeomah and Duncombe, 2019). However, in coordinating smallholder-based value chains, ICT platforms face low usage of their services among the key actors. The low usage is attributed to farmers' low literacy levels (Ayim et al., 2020; McCampbell et al., 2021a), a lack of awareness about the services offered by the platforms (Kieti et al., 2022), and the donor-oriented designs of the platforms rather than focusing on the users (McCampbell et al., 2021a; Smidt and Jokonya, 2022b; Steinke et al., 2021), among others.

Studies that address the ICT design challenges largely focus on the design of a single set of services for one group of users (Agyekumhene et al., 2020; Chiputwa et al., 2022; Ortiz-Crespo et al., 2020). Yet, ICT platforms for smallholder value chains require complex service designs for multiple actors like input providers, output buyers, and microfinance-insurance providers, among others. The design of such typical platform services requires understanding of ICT service needs and preferences for interface design features for all actors, which is yet to be

addressed in literature. By focusing on the key actors in smallholder-based value chains and issues related to input and output markets, this thesis tries to further explore ICT service needs and preferences for interface design features to improve smallholders' use of agricultural inputs.

1.3 Theoretical approach

To explore and analyse the roles of ICT platforms on farmers' uptake of agricultural input technologies, this thesis draws on perspectives from the economics, actor network ecosystem and marketing literature. In economic theory, the significance of information for adequate functioning of markets has been a prominent concern, with this being a key topic since Stigler's (1961) seminal work on the economics of information. Several authors in the economics literature on smallholder agriculture argue that information asymmetry is the largest barrier faced by smallholders (Aker and Ksoll, 2016; Barrett, 2008; Chavas and Nauges, 2020; Qiu et al., 2016). These studies argue that access to information can correct market uncertainties by increasing market transparency which would increase the functioning of agricultural markets, thereby reducing transaction costs.

The focus on ICT platforms in smallholder agriculture is driven by the role they can play in facilitating access to information in a time-effective manner to increase transparency in input and output markets. Transparency in agricultural markets can enhance linkages to agro-input dealers, credit providers and produce buyers, and reduce transaction costs among participating farmers, thereby creating incentives, such as higher produce prices which could stimulate re-investment in agriculture including uptake of productivity enhancing inputs (Ayalew and Belay, 2020; Okello et al., 2020).

Another branch of literature deviates from the economics perspective on markets. This literature builds on emerging lines of literature that sees African markets not so much as perfect

markets but as hybrid forms in between markets and organizations (Fafchamps, 2003), namely as networks in which actors are connected in the form of a value chain or other structural network forms (Sklyar et al., 2019; Vargo and Lusch, 2016). Such networks are described under different concepts, like business ecosystem (Graça and Camarinha-Matos, 2017), service ecosystems (Payne et al., 2021; Vargo and Lusch, 2016), or market systems (Masasi and Ng'ombe, 2019). This perspective does not reject the idea posited by economics that information-provision can smoothen the functioning of markets and increase adoption of inputs. Yet it further recognizes that collaborative networks can leverage the benefits of sharing and collaborating among individuals and organisations (Kapoor, 2018; Sako, 2018). By obtaining information from various actors and making it of value to others, ICT platforms typically co-create value for parties involved (Akaka and Parry, 2019; Stallkamp and Schotter, 2021).

Following the business ecosystem approach specifically on actor networks, strengthening of relationships to build trust and commitment among various actors in the network is crucial. For ICT platforms, this implies that successful collaboration between input and output market actors requires the integration of key actors' challenges and needs in the design of ICT services. However, there is only a handful of studies that look into the design of ICT services for smallholder-based value chains, and they all focus on the design needs for one user group. There is limited guidance on how to design ICT services encompassing different value chain actors, and how to build the actor relationships that are crucial for stabilising agricultural input and/or output markets.

To design ICT services encompassing different value chain actors and to strengthen value chain actor relationships, this thesis uses the marketing literature, specifically a user orientation approach, derived from the New Service Development (NSD) process (Lindh and Nordman, 2018) and the relational marketing literature, particularly on loyalty programmes (Agarwal and

Mehrotra, 2018; Kwiatek et al., 2020; Viswanathan et al., 2022), respectively. With regard to the New Servce Design process, this involves understanding the experiences of users and using this information to systematically improve the attributes and features of the services offered, resulting in successful new services (Wetter-Edman et al. (2014, p. 109). Such design thinking has led to the use of user-driven and participatory approaches in service development (Wetter-Edman et al., 2018). One example of a user-driven approach is 'user-centric design', which guides the design of services that match the needs and context of users. Within the context of smallholder-based value chains, smallholder-centred design could be regarded as a specific case of the user-centric design approach that places the perspectives of smallholders and the actors with whom they interact with at the centre of service design (Graham, 2019; Steinke et al., 2021). In this regard, two aspects of design appear central to a user-centric design approach: (1) understanding the needs of value-chain actors for ICT services that address their challenges; and (2) identifying preferences for interface design features that enable actors to access and use ICT services.

With regard to relational marketing literature, particularly on loyalty programmes, improving farmers' use of agricultural technologies requires proper coordination of the value chain such that farmers can access and are informed about inputs as well as buyers (Chavas and Nauges, 2020). Value chain coordination thus help remove market uncertainty for farmers to persuade them to participate by purchasing and using the inputs (Minkoua Nzie et al., 2018; Minten et al., 2016). To do this, loyalty incentives may help. To date, loyalty incentives for smallholders have only been offered as part of contract farming arrangements (Arouna et al., 2021; Bellemare, 2018). Implementing loyalty incentives through contracts comes, however, with high transaction costs to reach individual farmers or farmer groups through extension or buyer agents. With the rapid development of ICT platforms in agricultural value chains, implementation of loyalty incentives is becoming more feasible (Tong et al., 2020). ICT

platforms can play an important role as they can easily communicate the loyalty incentives and stimulate a change of behaviour among farmers in an effective way (Vieira et al., 2019). By taking the different perspectives from economics, actor network and marketing literature, this thesis aims to explore and analyse the roles of ICT platforms on farmers' uptake of agricultural input technologies and find entry points for improved functioning of ICT platforms in smallholder-based value chains. To address the general aim, the following research questions were answered:

1. What strategies do different types of ICT platforms use to improve the uptake of agricultural input technologies among smallholder farmers?
2. What are the needs of farmers and other key actors in smallholder-based value chains for ICT services, and what are their preferences for interface design features?
3. What is the effect of an ICT-coordinated loyalty intervention with an assured produce market on farmers' use of agricultural inputs and crop yields?
4. What is the effect of ICT-based loyalty incentives on farmers' loyalty intentions to output buyers?

1.4 Thesis Structure and research methods

The thesis comprises of four research chapters around the four research questions (see **Figure 1.1**), followed by a general discussion. Chapter 2, entitled *"The evolving role of ICT Platforms for smallholders as value chain coordinators: A comparative case study in Uganda",* addresses the first research question building on the actor network/ ecosystem literature on digital platforms in the fields of marketing and consumer research, in particular the network/ecosystem approach, looking at how different ICT platforms cover information provision and coordinating roles of the input and output markets. The actor network perspective recognises that collaborative networks can leverage the benefits of sharing and

collaborating amongst individuals and organisations (Kapoor, 2018; Sako, 2018) beyond just a price mechanism, but also other aspects, including value co-creation and delivery mechanisms. This actor network perspective has also been useful in studying other platforms such as Alibaba and Amazon (Jindal et al., 2021; Wu and Gereffi, 2018). This chapter thus, adopted the network perspective to investigate the strategies of ICT platforms for increasing farmers' use of agricultural inputs in terms of market system positioning, services provided, value co created and future strategic directions. By taking the ICT platforms as the objects of investigation and using key informant interviews, desk reviews and observations, this chapter reconciles the different views on the two dimensions within which ICT platforms can operate: the market dimension (*input* versus *output* markets) and the intervention dimension (*information provision* versus *coordination).*

Chapter 3, entitled "*Actor needs in ICT platforms for smallholder agricultural value chains: A case in Uganda"***,** builds on findings from Chapter two to focus on one ICT platform that stood out because of its business ecosystems approach to reach out to other value chain actors such as agro insurance companies, micro-credit organisations and related service providers to solve the many challenges faced by farmers. The chapter uses the marketing literature, particularly the new service development, to address the research question. The chapter empirically elicits the ICT service needs and preferences for design features through key informant interviews with key value chain actors and focus group discussions with farmers. This chapter provides insights into the ICT service design process that can integrate smallholders and other value chain actors. It identifies the synergies and trade-offs in needs and preferences for ICT interface design of key smallholder-based value chain actors. The chapter gives practical implications for ICT platforms to solve the trade-offs in needs, to keep all value chain actors on board and contribute to the development of smallholder-based agricultural value chains.

Chapter 4, entitled "*Effect of an ICT-based loyalty programme on farmers' use of agricultural inputs and productivity: Evidence from a field experiment in rural Uganda",* addresses the third research question by further extending the insights from Chapter 3 and building on the relational marketing literature. Using a cluster randomised controlled trial (CRT) experiment involving 234 farmers, this chapter assesses the effects of financial and non-financial benefits of an ICT-based loyalty programme with output market linkages on farmers' use of agricultural inputs and soybean yields.

Chapter 5 entitled "*Marketing innovations in rural markets in emerging economies: strengthening loyalty through an ICT platform in Uganda",* addresses the fourth research question by further extending the insights from Chapter 3 and building on the relational marketing literature to understand the effects of loyalty benefits on farmers' loyalty intentions to an output buyer.

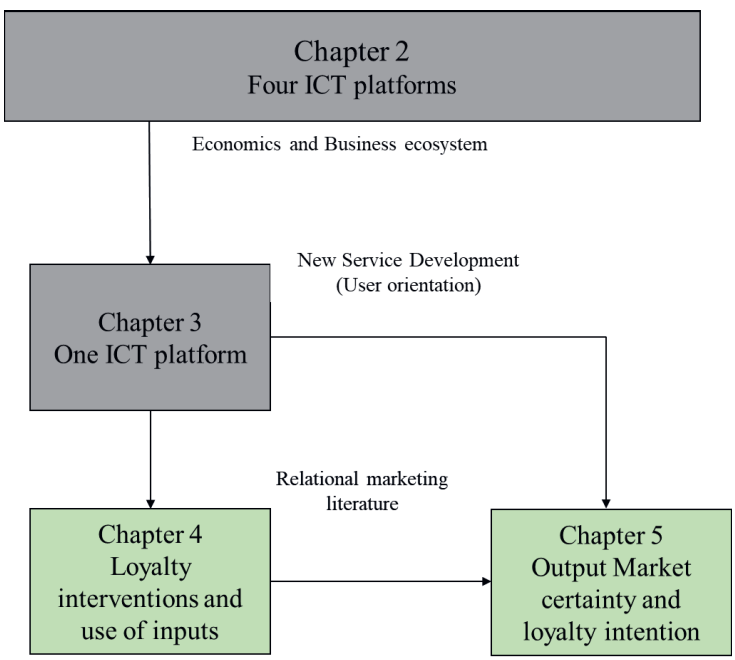


Figure 1.1 Thesis outline showing how the chapters are linked

Chapter 6 with "*General conclusions and implications*" discusses the outcomes of the four research chapters in the light of the broader literature. Some general conclusions are drawn and the implications for ICT developers, businesses and policymakers are discussed. The chapter also reflects on the limitations of the approaches used in the thesis and proposes directions for future research.

Chapter 2

The evolving role of ICT platforms as value chain coordinators for smallholder farmers: A comparative case study in Uganda

This chapter will be submitted as Connetie Ayesiga, Esther Ronner, and Paul T.M. Ingenbleek. The evolving role of ICT platforms as value chain coordinators for smallholders: A comparative case study in Uganda

Abstract

Despite the development and wide promotion of agricultural inputs to boost productivity in smallholder farming systems, the uptake of such technologies remains low. Platforms for information communication and technology (ICT) are seen as promising tools for 'pushing' information on input use, providing links to input suppliers, or 'pulling' input use through improved information on and links to output markets. Researchers nevertheless disagree on how ICT platforms can best fulfil their role. More specifically, there are disagreements concerning whether the main role of ICT platforms should be limited to providing information on input or output markets or whether they should play a coordinating role within the value chain. In addition, it remains unclear whether supply push or market pull is more effective in increasing input use. To provide empirical evidence to reconcile the different arguments in the literature, this study draws on lessons learnt by ICT platforms in practice by comparing four case studies of ICT platforms. The findings indicate that ICT platforms are moving away from an exclusive focus on providing information towards the coordination of value chains and from an exclusive concentration on either input or output markets to include both markets. Thus, they are moving towards taking on a role as full value-chain coordinators to address the multiple barriers to uptake farmers face. These insights call for researchers to approach ICT platforms from a systems perspective rather than a traditional information perspective.

Keywords: ICT platforms, organisational strategies, agricultural value chains, technology adoption, market access, coordination, smallholder farmers.

2. 1 Introduction

By 2050, the demand for food in Africa will double due to population growth, increasing incomes and rapid urbanisation (FAO, 2017; Van Ittersum et al., 2016). At the same time, however, food production is impaired by the reliance of smallholders on rain-fed subsistence agriculture, declining soil fertility (World Bank, 2017) and decreasing farm size (Lowder et al., 2021). While various agricultural technologies (e.g., improved seed varieties, fertiliser and farm practices) could increase smallholders' farm productivity and income, the uptake of such technologies has generally remained low (Macours, 2019b; Sheahan and Barrett, 2017). Smallholders have been reluctant to invest in agricultural input technologies due to various factors, including limited access to input, output and financial markets, high transaction costs, risks and uncertainty (Simtowe et al., 2019a). These constraints to adoption have been attributed to market information asymmetry, and several studies have indicated how information access can reduce market failure, risk and uncertainty (Abdulai et al., 2023; Deichmann et al., 2016; Mohammed and Abdulai, 2022; Van Campenhout et al., 2021).

In light of the points outlined above, the recent proliferation of platforms for information communication and technology (ICT) in sub-Saharan Africa is being welcomed as a major technological and social innovation that will improve access to agricultural information and overcome the information asymmetry problem amongst smallholder farmers (cf. Aker et al., 2016; Foster and Graham, 2017). An ICT platform is a mobile or web-based digital base on which multiple interfaces and applications are integrated for users (Zahedi and Zahedi, 2012), including farmers and other actors within the value chain. Such platforms enable the provision of agricultural information at low cost and in real-time in order to correct market failures and reduce transaction costs, risks and uncertainties (Aker et al., 2016; Duncombe, 2018; Ezeomah and Duncombe, 2019; Orr, 2018). This ultimately enhances access to and use of agricultural

inputs needed to increase smallholders' productivity (McGuire and Sperling, 2016; Shiferaw et al., 2015).

Despite their optimistic expectations, researchers disagree on *how* ICT platforms can fulfil their promise. This disagreement raises two questions for the research field. The first concerns which markets should be prioritised by ICT platforms: input markets, output markets or, both. Some authors argue that ICT investments could start with input information to push the use of inputs (Campenhout, 2021; Fabregas et al., 2019; Gupta et al., 2020; Maredia et al., 2018), while others suggest that output market information is used to create transparency on the incentives for farmers to 'pull' investments in inputs (Aker and Fafchamps, 2015; Aker et al., 2016; Courtois and Subervie, 2015; Nakasone et al., 2014). The second question concerns whether the provision of market information alone is sufficient to ensure the functioning of markets within the African context, where market players (e.g. output buyers and input providers) may be few and, in some cases, non-existent (e.g. Dorward et al., 2009; Ingenbleek et al., 2013). While many studies rely on information provision as the main intervention of an ICT platform (Ayim et al., 2022), others have started to advocate for ICT platforms to *coordinate* linkages across input and output markets (Chavas and Nauges, 2020; Ezeomah and Duncombe, 2019).

Proponents of the different views rely primarily on theoretical arguments and impact studies. Within this debate, the voices of organisations behind ICT platforms concerning the lessons they have learnt in their markets and the directions they will take based on these insights are largely absent. For this reason, the current study focuses on ICT platforms as the object of investigation. By exploring the motivations and actions of ICT platforms, we aim to reconcile the different views on the two dimensions within which ICT platforms can operate: the market dimension (*input* versus *output* markets) and the intervention dimension (*information provision* versus *coordination).* Based on these two dimensions, we identify four types of ICT platforms (see Table 2.1), which we compare systematically in a qualitative case study intended to address

three research questions: 1) How do the four types of ICT platforms help to improve the uptake of agricultural input technologies by smallholder farmers? 2) What strategies do the different types of ICT platforms use to improve smallholder farmers' uptake of agricultural input technologies? 3) In which direction are these strategies developing towards the future?

Table 2.1 Typology of ICT Platforms based on the market and intervention dimensions

Main focus of interventions by ICT platforms:	**Main focus of ICT platforms in the smallholder-based value chain:**	
	Input markets	**Output markets**
Information	Input-information provision	Output-information provision
Coordination	Input-market coordination	Output-market coordination

By answering these questions, this study contributes in-depth insight into the strategies that ICT platforms can use to increase the uptake of productive inputs by smallholders. Adopting the perspective of ICT platforms makes it possible to identify the directions in which they are heading and why. We thus provide comprehensive empirical insight into the different pathways—the alternative steps and actions towards different strategic directions (Werners et al., 2021)—of the different ICT platforms. The results indicate that ICT platforms have started converging towards becoming coordinators of value-chain ecosystems in order to solve many value-chain challenges faced by smallholder farmers.

The rest of the paper is organised as follows. We start by reviewing the existing literature on ICT platforms for smallholders and introduce the theoretical perspective adopted in our study. In the Methods section, we indicate how we selected and examined four cases for systematic comparison to answer our research questions. We report the most important insights from these cases in the results section, followed by implications and conclusions.

2.2 Literature review

2.2.1 Uptake of new technologies by smallholders

As indicated by several studies, ICT platforms can help to eliminate barriers that smallholders encounter in the uptake of agricultural input technologies (Cole and Fernando, 2021; Krone and Dannenberg, 2018; Maredia et al., 2018; Steinke et al., 2021). Within this context, uptake—or adoption (Feder et al., 1985)—refers to a decision made by a smallholder to substitute existing techniques, artefacts and practices with newer and better ones (Mica, 2013). Existing research on the uptake of technologies by smallholders acknowledges that uptake is not a straightforward yes/no decision—given the possibility of adopting only some parts of available technology—and that adoption decisions are subject to change (Glover et al., 2016). As suggested by Glover et al. (2019), however, adoption can be regarded as an outcome of interrelated socio-technical networks (e.g. input/output markets and providers of support services) that can eliminate barriers, such as poor extension services, poor infrastructure, limited credit access and ineffective policy frameworks (Adekambi et al., 2015; Zhang et al., 2021). In many cases, the value-chain actors needed in order to supply inputs or buy produce are few or non-existent, and the distances between farmers and other actors are often large (e.g. Ingenbleek et al., 2013). One possible solution is for ICT platforms to position themselves to eliminate barriers by connecting to and intervening in the socio-technical barriers that hinder the adoption of technology.

2.2.2 Economic studies on ICT and uptake

As mentioned above, ICT platforms can be used to share information with smallholders. In mainstream economics, the provision of information is an essential intervention for increasing market transparency, thereby enhancing the functioning of the market (Aker and Ksoll, 2016; Chavas and Nauges, 2020). On the input market side, Vandevelde et al. (2021) found that access to information on inputs through videos increased potato farmers' use of these inputs (e.g., seed

purchase and improved farm practices). In addition, Larochelle et al. (2019) found that an SMS-based programme increased knowledge and self-reported adoption of integrated soil-management practices for potato farmers in Ecuador. In other examples, Van Campenhout et al. (2021) and Maredia et al. (2018) found that audio-visual extension messages enhanced knowledge amongst farmers in Uganda and Burkina Faso, respectively, with the use of recommended practices and fertilisers increasing in Uganda, but not in Burkina Faso. Comparably, Voss et al. (2021) found no evidence that an ICT-enabled extension using radio and mobile-phone services affected farmers' use of certified improved seeds and fertilisers across Senegal. In a meta-analysis, Fabregas et al. (2019) found that, in general, digital extension information increased the odds of adopting recommended inputs by 22% while increasing yields by 4%.

On the output market side, ICT platforms can be used to increase transparency. Improving the functioning of the output market can create incentives (e.g. higher prices) for smallholders to adopt productive inputs. In a study conducted in Kenya, Okello et al. (2020) found that ICT-based market-information services increased farmers' share of output sold and sales income, increasing their likelihood to invest in farm inputs. Likewise, Belay and Ayalew (2020) found that output-price information provided by the ICT-based commodity exchange intervention influenced the crop choices and input-allocation decisions of farmers in Ethiopia. In a comparable study conducted in Kenya, Okello et al. (2020) found that ICT-based market information increased farmers' use of purchased seeds and fertilisers.

2.2.3 ICT platforms from a network perspective

Another branch of literature deviates from the economic perspective on markets. These studies build on emerging lines of literature that regard African markets less as perfect markets but as hybrid forms between markets and organisations (Fafchamps, 2003)—as networks in which actors are connected in value chains or other structural network forms (Sklyar et al., 2019;

Vargo and Lusch, 2016). Such networks have been described within a variety of concepts, including business ecosystems (Graça and Camarinha-Matos, 2017), service ecosystems (Payne et al., 2021; Vargo and Lusch, 2016) and market systems (Masasi and Ng'ombe, 2019).

This perspective acknowledges that information flows within networks can become distorted or interrupted (Burt, 1992). As such, it does not reject the idea posited by economists that information provision can smooth the functioning of a market and increase adoption. In addition, this perspective recognises that collaborative networks can leverage the benefits of sharing and collaborating amongst individuals and organisations (Kapoor, 2018; Sako, 2018). Exchange is thus coordinated not only by a price mechanism but also by other aspects, including value co-creation and delivery mechanisms (in most cases, at the organisational level).

For instance, Agyekumhene et al. (2018) found that credit access mediated by digital platforms helped create awareness and coordinated responsiveness to agroecological farm conditions amongst maize farmers in Ghana. In that case, the digital platform co-created value with farmers and maize traders to overcome uncertainties related to credit and information asymmetries in maize production. In a study conducted in Kenya, Duncombe (2018) found that digital technology empowered farmers to access information, collective output markets and inputs. In that case study, the author demonstrates a transition from intermediary-based transactions to collaborative action (a more organised, market-orientated approach), in which farmers collaborate to access better input and output markets. By stabilising agricultural input and/or output markets, ICT platforms may contribute to smallholders' initial trial of inputs and their repeated and consistent use (Deutschmann et al., 2019; Tjernström, 2017).

2.2.4 Theoretical approach

Given that the network/ecosystem approach to examining ICT platforms covers interventions aimed at coordination and information provision, we adopt this perspective for our investigation of the strategies of ICT platforms. This approach has also been employed in examining the

actions of digital platforms, including Alibaba and Amazon (Jindal et al., 2021; Wu and Gereffi, 2018). Strategies are long-term goals and objectives that a company adopts by aligning the required resources, skills and opportunities to attain benefits for the company and to fulfil stakeholders' expectations (Johnson and Scholes, 2012). The current study draws on four concepts to concretise the strategies of ICT platforms from the network/ecosystems approach guiding the research (Yin, 2018).

First, proceeding from the social network perspective, as Oparaocha (2016) demonstrated, ICT platforms carve out their own niches within existing networks. They forge connections with specific actors by establishing direct links, serving as intermediaries to connect others or creating indirect links. Therefore, they must decide how to position themselves within the market system by establishing links to other actors within the network to achieve their objectives. Second, as advocated by Vargo and Lusch (2017), studies that view networks as service systems emphasise that networks exist for actors to provide services to one another. In this respect, service is the application of resources to the benefit of others (Vargo and Lusch, 2017), and it is regarded as the basic unit of exchange, often taking the form of physical products or intangible services that are exchanged for payment (Vargo et al., 2017). Within the domain of ICT platforms, these services typically include the provision of information, as well as additional offerings, including awareness campaigns for smallholders on behalf of companies in the value chain, researcher questionnaires, input-demand aggregation, microloans, contracts for the purchase and delivery of farm inputs, crop insurance, and contracts with buyers (Parker et al., 2016).

Third, ICT platforms obtain the resources underlying their services from various actors within the value chain. ICT platforms typically co-create value by obtaining information from these actors and making it of value to others (Cusumano et al., 2020; Stallkamp and Schotter, 2021). The co-creation of value involves joint activities undertaken by parties engaged in direct

interactions to contribute to the value that emerges for one or both parties (Akaka and Parry, 2019; Lember et al., 2019; Wajid et al., 2019). In this regard, value is seen as value-in-use (Vargo and Lusch, 2016)—the significance of the service provided for the actor receiving it—rather than in terms of 'exchange value' (i.e. price). For instance, the value of fertiliser is the improved productivity of a crop, as experienced by the farmer, which is the result of co-creation by a fertiliser company that produced and transported the material, an agro-dealer who displayed it in the store, an ICT platform that notified the farmer that the fertiliser was available and gave directions for its application, and the farmer who applied it in the farm.

Fourth, it is important to note that these strategies may change over time, based on performance, as organisations may need to adjust them to achieve future success (Mirabeau and Maguire, 2014). The positions of ICT platforms within the market system, their services to other actors and their activities in the co-creation of value are crucial to increasing the uptake of input technologies by farmers. These strategies are not fixed, however, as market systems are dynamic and subject to change based on the needs and preferences of actors and competitive forces (Jovanovic et al., 2022; Layton, 2015). The co-creation of value and the provision of services also evolve as ICT platforms learn about the system structure and the changing needs of actors within the system, and as they establish new connections, reinforce existing relationships, abandon them, engage in new co-creation activities, provide additional services and enhance their own skills and resources (Giesler and Fischer, 2017; Layton, 2011). Consequently, the strategies employed by ICT platforms are likely to be adaptive and subject to change over time.

2.3 Methodology

2.3.1 Research design and case selection

We applied a purposive approach to select fitting cases for the four types of ICT platforms (Miles and Huberman, 1994), as indicated in Table 2.1. First, we conducted a desk search to develop a long list of smallholder-based ICT platforms in Uganda. The Ugandan context provides the most dynamic ICT platform community in sub-Saharan Africa, with more than 38 ICT platforms (GSMA, 2020). As such, Uganda provides an excellent context for identifying organisations fitting the ICT platform archetypes addressed in our study. We consulted policy documents and reports from the Ugandan government and development organisations to identify platforms for the long list.

Second, we reduced the number of platforms on the list by restricting our search to platforms that had been in operation for at least two years, that covered at least 2,000 farmers and at least one full region of the country, that targeted more than one major crop grown in the region and that used mobile-based and/or web-based technology. Third, we assigned the remaining platforms to the four cells of Table 1 and ranked them in order of fit according to the two dimensions of the table. We then approached the four highest-ranked platforms in the lists to invite them to participate in this study. All four platforms agreed (see Table 2.2 for descriptions of the four platforms). In a validity check, two experts on digital platforms in agriculture in Uganda (one from a research institution and one from a non-governmental organisation) confirmed the fit of these choices within the underlying dimensions.

Table 2.2 Selection criteria for and case descriptions of ICT platforms in Uganda

	Input-information provider	**Output-information provider**	**Input-market coordinator**	**Output-market coordinator**
Name of the platform	M-Omulimisa	Farmgain Africa	Ezy Agric	Kudu
Technology used	ICT platform accessible via SMS and simple mobile phone	ICT platform accessible via the internet and email	ICT platform accessible via the internet and smartphone (app-based)	ICT platform accessible via SMS and simple mobile phone

Focus region	Northern region	All regions	Central and Eastern regions	Eastern region
Target crops	Soybeans, maize, sunflowers, sorghum	All major crops grown in the regions	Maize, beans, potatoes, groundnuts	Maize, beans, soybeans, sesame, groundnuts, rice, sorghum etc.
Number of beneficiaries	20,000 farmers registered	2,000 subscriptions	80,000 farmers registered	3,000 farmers registered
Starting year	2014	2007	2015	2017
Core services	Provides agronomic and weather information, extension advisory services and profiles of input suppliers	Disseminates commodity prices on more than 23 agricultural commodities	Provides farmers with access to production inputs and support services Provides agronomy and weather information	Links produce sellers (farmers) to buyers
Other services	Agro-insurance Input microloans	Value-chain analyses	Farmer profiling	Provides commodity prices
Business model	Village agent model	Market scouts	Village agent model	Village agent model
Language used	Local languages of choice	English	English	English
Frequency	On-demand	Weekly	On-demand	On-demand
Fees	Free access	Annual subscription	Access requires internet Orders paid through mobile money wallet	SMS costs for registration and posting offers

2.3.2 Data Collection

Data were collected through interviews, observations and desk research. We conducted primary data collection in two steps. The first step involved four key-informant interviews with managers from the four platforms, who were typically responsible for general management decisions, operations, organisational structures and strategising. Their job titles included Director and Senior Market Specialist (Table 2.4). To guide the interviews, we prepared an interview guide based on case-study concepts derived from our theoretical background and Yin (2013)' approach to interviewing (see Table 2.3). The interview guide addressed approaches that the ICT platforms adopted to enhance farmers' uptake of agricultural input technologies and their strategies in terms of services provided, network structures, actor roles in the co-creation of value and expected strategic changes. We asked questions about the initial situation when the platform was first established and the current situation, including the reasons for any changes. Each interview lasted approximately one hour. The first round of interviews enabled us to map the larger actor networks of the platforms. We used this to approach people across

different actors, including village agents, traders, NGO field officers and farmers (see Table 2.4 for the full list of informants).

In the second step, we purposively selected representatives from the actor-network of each case based on their experience with the platforms, gender diversity (to obtain insights from both genders) and knowledge about the platforms' operations. We conducted 26 key-informant interviews across the four cases, with six respondents from each of the first three cases and four respondents from the fourth case. The interview guide in this second round included questions on the respondents' experiences with the ICT platforms, services they received, benefits and impact on their use of inputs (see Table 2.3 for example questions). Two categories of input technologies were explored to generate insight into input use. First, we looked at inputs for improved seed varieties, fertilisers and other agrochemicals (e.g. herbicides or pesticides). Given that such inputs often require different management practices, we also examined the use of better farm practices as a second category of input technologies.

When needed, people knowledgeable about the specific context of the cases and who could speak the local language were used as translators (e.g. Ingenbleek et al., 2013). Following Eisenhardt (1989), all interviews were recorded after obtaining consent from the respondents. To triangulate the information obtained from the responses gathered from the primary source of information, we also collected information from field observations and materials derived through desk research from several secondary sources, including the websites and annual reports of the ICT platforms in the case studies. These sources were used to mitigate the risk of informant bias, control subjective and individual judgements, and enhance the findings' validity (Gibbert et al., 2008).

Table 2.3 Case-study concepts used with key informants and smallholder farmers

Study concepts	Example Questions
Market system structure	What type of market actors or other stakeholders do you work within the delivery of services you provide? What is your reason for working with them? How are the market actors aligned with each other? How do the services improve the alignment between market actors?
Services provided by ICT platforms	What services do you offer to the various actors with whom you work? Why these services? How are they expected to contribute to farmers' uptake of agricultural input technologies?
Value co-creation	What mutual benefits do actors realise from being connected to the platform? How does the platform facilitate problem-solving amongst the various actors? How does the platform involve users in the delivery of services?
Uptake of agricultural input technologies	Which inputs or practices accessed through the platform have you tried on your own farm, and why? Which inputs or practices are you currently using on your farm, and why?
Expected strategic changes	What challenges do you currently face in providing services to different actors? In what ways would you solve those challenges? How do you see your strategy changing about the solutions mentioned?

Table 2.4 Brief descriptions of key informants interviewed

Cases	Study district(s)	Description of key informants interviewed	Location	Gender
Case 1: Input-information provider M-Omulimisa	Oyam and Lira	Director 1-1	Kampala	Male
		Village Agent 1-1	Oyam	Male
		Village Agent 1-2	Lira	Male
		Farmer 1-1	Oyam	Male
		Farmer 1-2	Oyam	Female
		Farmer 1-3	Lira	Male
		Farmer 1-4	Lira	Female
Case 2: Input-market coordinator Ezy Agric app	Namutumba and Mukono	Director 2-1	EzyAgric	Male
		Farmer 2-1	Namutumba	Female
		Farmer 2-2	Namutumba	Male
		Farmer 2-3	Mukono	Male
		Farmer 2-4	Mukono	Female
		Village Agent 2-1	Mukono	Male
		Village Agent 2-2/ Agro-dealer	Namutumba	Female
Case 3: Output-information provider Farmgain Africa	Soroti, Serere, and Kampala	Senior Market Specialist 3-1	Kampala	Male
		Farmer 3-1 (Marketing chair)	Serere	Male
		Farmer 3-2 (Cooperative chair)	Serere	Female
		Farmer 3-3	Soroti	Female
		Field Officer 3-1 (NGO)	Soroti	Male
Case 4: Output-market coordinator facilitator Kudu platform	Iganga, Butaleja and Kaliro	Director 4-1	Kampala	Male
		Farmer 4-1	Butaleja	Male
		Farmer 4-2	Butaleja	Female
		Farmer 4-3	Iganga	Male
		Farmer 4-4	Kaliro	Female
		Village Agent 4-1	Butaleja	Male
		Trader 4-1	Kaliro	Male

2.3.3 Data Analysis

Data from all key-informant interviews were transcribed verbatim, and personal identifiers (e.g. names) were removed from the transcripts to protect the confidentiality of the participants. Several steps were taken to analyse the transcripts. The first step involved thoroughly reading and re-reading the transcripts and other materials to familiarise with the dataset. We then analysed each case separately, following Eisenhardt (1989)'s within-case data-analysis procedure, using the Atlas.ti software (Woods et al., 2016b).

To understand how ICT platforms led to improved uptake of agricultural input technologies by farmers, we first explored the strategies used by these ICT platforms based on the case-study concepts from the first round of coding: market-system positioning, services provided and value co-creation activities. This led to the following second-level codes, which were later developed into two sub-second-level codes: initial (at the start of the platform) and current. For each sub-second-order theme, codes were derived across the strategies used: market-system positioning. services provided and value co-creation services (see Figure 2.1 for the coding structure). To obtain insight into how the strategies in each case influenced the uptake of agricultural input technologies by farmers, we derived initial codes concerning uptake (e.g. 'weed twice', 'now do row planting', 'use NPK', 'use foliar fertilisers' and 'use improved seed'), which were then grouped together to form broader theme categories (see the coding structure in Figure 2.1).

We then explored data on the future strategic outlook of ICT platforms and their expected strategic changes (see the coding structure for the codes derived). This generated insight into challenges faced by ICT platforms and suggested solutions leading to strategic changes. Following Yin (2013), we then conducted a cross-case analysis to identify, compare and discuss cross-case patterns in the strategies used, the uptake of inputs by farmers and expected strategic changes.

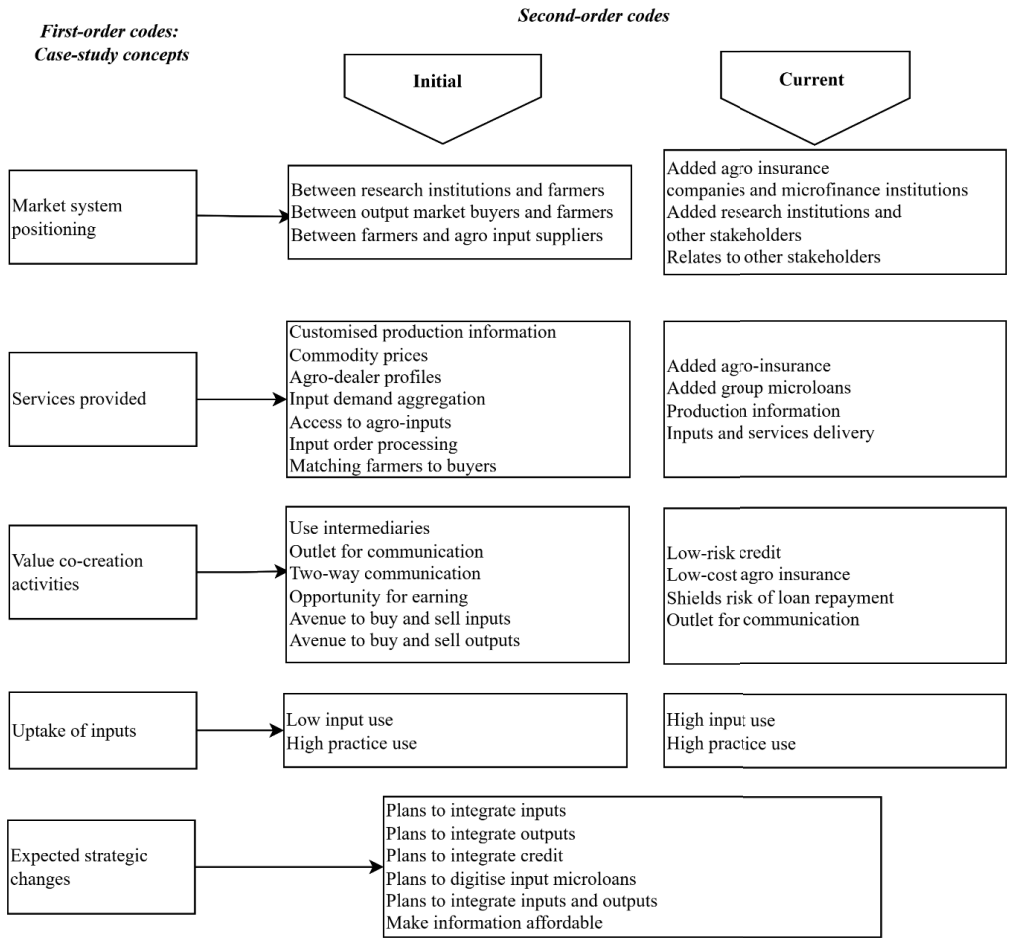


Figure 2.1 Coding structure

2.4 Results

In this section, we present the results for each case in order of complexity (in terms of the categories of actors with which the platforms interact), from the least to the most complex case. For each case, we present strategies (market system positioning, services provided and value co-creation activities), followed by insights into how the various strategies of the ICT platforms have led to the uptake of input technologies and their expected strategic changes in the future.

2.4.1 Output Market Information Provider (Farmgain Africa)

Founded in 2007 by individual agricultural experts as a for-profit private agribusiness support organisation, Farmgain Africa offers agribusiness-related services to various actors in agricultural value chains. Through a national market information platform, the organisation explicitly positions itself between farmers and output market buyers (Figure 2.2). The national market information platform is intended to create transparency in output-market prices and reduce transaction costs related to market search, thereby increasing farmers' access to produce markets and incomes to support investment decisions. As such, Farmgain Africa's philosophy revolves around creating transparency within output markets for farmers.

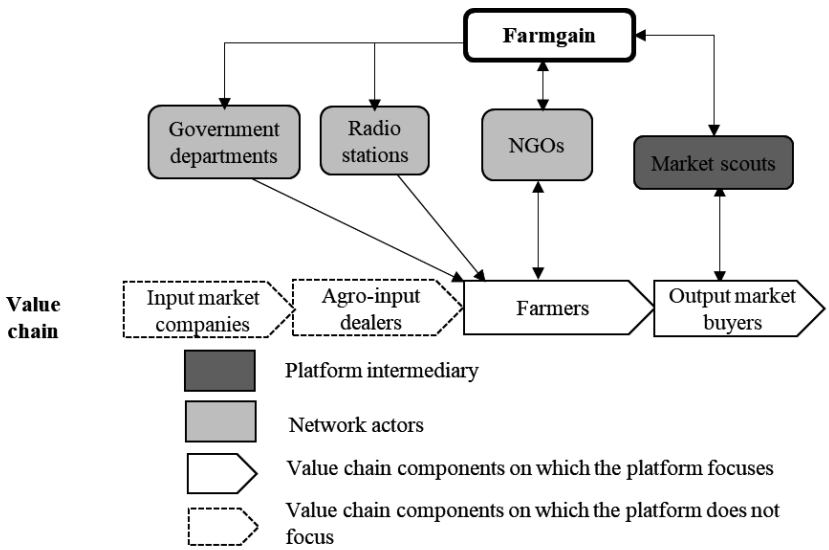


Figure 2.2 Market positioning of Farmgain Africa

The platform does not provide information to farmers directly, but works through various actors (e.g. NGOs, radio stations and government departments) who subscribe to the platform and share the information with the farming communities with which they work (Figure 2.2). To collect output-market information, the platform relies on produce dealers from the respective markets, referred to as 'market scouts'.

The main service that Farmgain provides is the dissemination of commodity-price information for the major crops grown and sold to markets across the country. This information is shared with over 2,000 subscribing organisations in the form of reports, which the organisations then share with the farmers. The farmers thus depend solely on subscribing organisations for access to market information. In addition, the platform uses the market information it collects to offer agribusiness support services (e.g. value-chain analyses and business-plan development) for its subscribers and other non-subscribing organisations.

Results from the interviews with farmers and NGOs indicate that Farmgain co-creates value for its network of value chain actors through commodity prices in two ways. First, the use of produce dealers as data collectors ensures the collection of quality data that will be widely trusted by the subscribers while also providing an opportunity for produce dealers to earn additional income. As noted by Field Officer 3-1, '*...we pay for the information because we trust the mechanism used by the platform to collect it*'. Engaging produce dealers who also deal in some or all the commodities covered by the platform thus helps users to be confident about the quality of data delivered by the platform. As the Senior Market Specialist noted, '*We use people who are knowledgeable about the market and have been in that market for at least five years*'.

Second, using NGOs (e.g. Socadido) as intermediaries amplifies the platform's coverage, helping many farmers make informed decisions concerning marketing and production. In addition, subscribing organisations use the information to support the agricultural interventions they extend to farmers based on crops for which there is high demand in the market. According to Field Officer 3-1, who was working for an NGO, '*...the platform shares market trends that help us design interventions for farmers*'.

Regarding input uptake, the interviews with farmers revealed that output-market information accessed through subscribing organisations increased their awareness about crops and varieties

demanded by the market and created transparency concerning expected prices. Transparency in produce prices influenced farmers to switch to improved seeds and/or varieties that were in high demand. As Farmer 3-3 noted, '*We find ourselves using improved varieties because the information we get is that such a variety fetches a higher price on the market*'. Interestingly, price information mainly increased the farmers' use of other inputs (e.g., fertilisers), whereas complementary services offered by subscribing organisations drove improved farm practices. For instance, Farmer 3-1 indicated, '*...Socadido provides us with extension advisory services to support our farming activities'.*

While output-market information may have influenced farmers' production and marketing decisions, their dependence on subscribing organisations for information was subject to limitations. For instance, Farmer 3-2 noted, '*The problem is that we sometimes receive this information when the prices have already changed*'.

Therefore, as part of its future strategic changes, Farmgain plans to adjust its business model and directly offer more affordable output information to farmers, focusing on smaller profit margins but drawing on a larger pool of subscribers. In this regard, the platform's Senior Market Specialist noted, '*One of our plans is to make this information affordable and accessible for many farmers to benefit from our information in a timely manner*'. In addition, the platform plans to add input information to its services, as noted by the Senior Market Specialist: '*...we intend to add fertiliser prices to our portfolio to help address the problem of low fertiliser use amongst farmers*'. It is interesting to note that providing information on input and output markets constitutes part of the company's strategic objectives, as evidenced by its strategic documents. The platform is thus moving towards input markets to solve challenges associated with limited access to and low use of inputs by farmers.

2.4.2 Output Market Coordinator (AgriNet)

The Kudu platform was developed in 2017 by Makerere University as a research-design project, and it was operationalised in the field by AgriNet Uganda, a for-profit private company operating within agricultural value chains since 2012. The platform positions itself at the level of the output market, explicitly between produce buyers and farmers, using community-based village agents as intermediaries within the chain (Figure 2.3). As explained by the director of AgriNet Uganda, the company aims to use its Kudu platform '*...to help farmers access better markets beyond their social circles to help increase their incomes while enabling us to earn a commission on produce sold through the platform*'. The platform also maintains relationships with various NGOs (e.g. CARD Uganda and Kilimo Trust) within its network to create awareness and mobilise farmers to use the Kudu platform. This mechanism registered more than 3,000 farmers in the first two years of its operation.

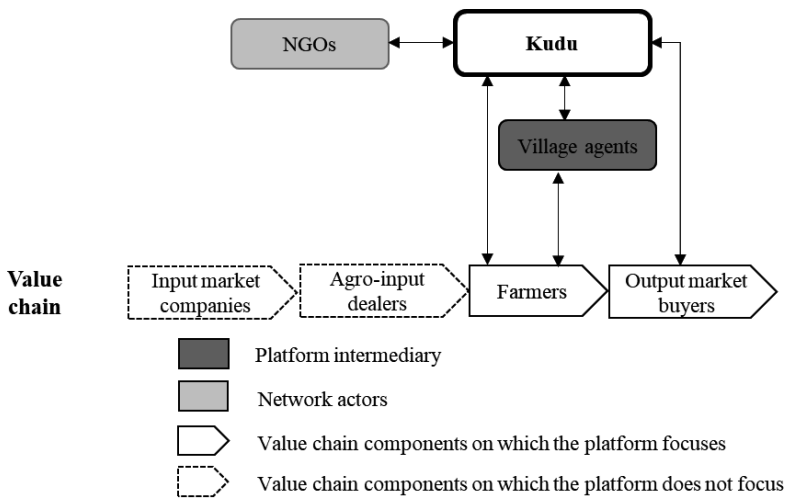


Figure 2.3 Market positioning of the Kudu platform

Emerging from the company's experience in produce marketing at the time, many farmers were decrying a lack of markets for their produce, while the buyers were also decrying a lack of produce for their businesses. Director 4-1 recounted, '*You know, farmers were citing lack of*

markets for their crops while buyers like me were saying they lack produce from the farmers, so we decided to bring these two together through Kudu'. To bridge the gap and improve the access of farmers to produce markets, AgriNet deployed the Kudu platform—a virtual market that directly connects farmers to buyers through an automated matching mechanism that matches sales requests to offers based on crop, price, quantity and location, as submitted by farmers and buyers, respectively. Farmers and buyers post produce sales and offers to the platform in real-time using a simple-feature phone through the Unstructured Supplementary Service Data (USSD) code.

With its market positioning and the direct virtual matching of farmers to output buyers, Kudu co-creates value for its network actors in three ways. First, the platform offers farmers and produce buyers an avenue to sell and buy farm produce without incurring high transactional costs related to market search and transportation. Reduced costs improve market efficiency, enhancing gains for farmers and buyers. This was illustrated by Trader 4-1: '*...and through the platform, we get linked to farmers who have the produce we want, without travelling long distances in villages looking for produce*'. Second, directly matching farmers to buyers eliminates intermediaries from the marketing chain, resulting in increased incomes for farmers. As explained by Farmers 4-1 and 4-3, '*...with Kudu, we are linked to buyers who have already agreed to the prices posted with our offers, so in this way, we gain more, as the prices are better than before with intermediaries*'.

Finally, using village agents as local intermediaries to oversee the physical transactions between farmers and buyers guarantees the transparency of transactions while providing an opportunity for village agents to earn income through commission. For instance, Farmer 4-1 noted that '*...agents help to ensure that the physical exchange of produce and money between the farmer and buyer takes place according to the offers made through the platform without any problems*'. Observations made through the platform interface revealed that, since AgriNet operationalised

Kudu, more than 700 successful transactions have been completed amongst the 3,000 registered farmers. Village agents have complained of low levels of facilitation: '*The commission we get is too low, and sometimes the* work we carry is not paid for, and we end up spending our own money for the good of farmers', Village Agent 2-1.

Results from key-informant interviews indicate that the direct matching of farmers to output buyers through the platform has created certainty for farmers with regard to produce markets, which has subsequently influenced the use of inputs—especially the improved seed varieties—by most farmers. As Farmer 4-2 described, '*Knowing what is marketable has helped us to use improved seeds to produce for the available market*'. Similarly, Farmer 4-3 remarked, '*...for example, we planted masavu beans* [an improved bean variety] *because that's what the buyers are looking for on the platform*'. As observed, farmers' use of better farm practices was more strongly influenced by their interactions with other organisations than it was by the information on output markets, as noted by Farmer 4-3: '*...we try to follow practices that are taught to us by the different extension officers from other CARD and local government*'.

The company is beginning to rethink its strategies, as it realised that offering a virtual market alone is insufficient to improve production potential and incomes for farmers. Farmer 4-1 indicated: '*We would like to produce more for the available markets, but we need credit to buy inputs that can improve our production*'. In the same vein, Director 4-1 explained, '*We know that farmers need inputs and credit linkages to improve their production, but we are constrained financially; maybe in the future, this is something we can add...*'. Despite these challenges, AgriNet's plans include moving towards input markets and potentially coordinating the entire value chain.

2.4.3 Input Market Coordinator (Ezy Agric app)

The Ezy Agric app was developed in 2015 by the Akorion Company LTD, a for-profit agritech company involved in the digitisation of agricultural value chains. The company start-up was supported by Chemonics, which implemented the Commodity Production and Marketing (CPM) activity of the Feed the Future Uganda programme. As Director 2-1 explained, '*Chemonics helped us develop our idea into a product best fit for the Ugandan and African Market*'. The main goal of the Ezy Agric app was to provide farmers with various production and marketing solutions.

Ezy Agric initially positioned itself between farmers and agro-dealers/input suppliers to improve farmers' access to and use of production inputs to enhance farm productivity. To this end, the company incorporated the e-VAM (Electronic Village Agent Model), a service-delivery model in which young people are employed as village agents and equipped with smartphones to conduct last-mile delivery of inputs and to gather data from farmers (Akorion 2016 report). Using Ezy Agric, village agents capture demographic, production, input and product-supply data on farmers, and they use GPS to map the cultivated land. With these digital farmer profiles, Akorion aggregates input demands to negotiate good prices from vetted suppliers of genuine agro-input products, as observed from the company's strategic document.

Through the app, individual farmers access a wide range of agro-inputs (e.g. improved seeds, fertilisers, chemicals and sprayers) previously inaccessible to most farmers in rural areas. As illustrated by Farmer 2-2, '*...with Ezy Agric, we can now order inputs, and the village agent will deliver them without travelling to town*'. The platform manages and processes input orders placed by farmers for last-mile delivery to farmers' doors through its e-VAM network. The company's revenue consists of a commission on each sale.

Knowing that input linkages alone could not stimulate the use of inputs and consistent with its mission of providing production and marketing solutions to farmers, Akorion added research

institutions and other stakeholders to its network (see boxes and arrows shaded orange in Figure 2.4). This was intended to close the knowledge gap concerning production and enable farmers to access other professional services relating to farm production that were currently lacking. For instance, as indicated by Director 2-1, '*From the experience, we realised that farmers lacked knowledge on how to use these inputs, so we added agronomic information and production-related services*'.

After expanding its network to include more actors, including a research organisation and agricultural service providers (some trained by the company), Ezy Agric now offers additional services, including production information (e.g. real-time weather information) and professional production-support services (e.g. land measurement, soil-type testing and spray services) that support overall farm production.

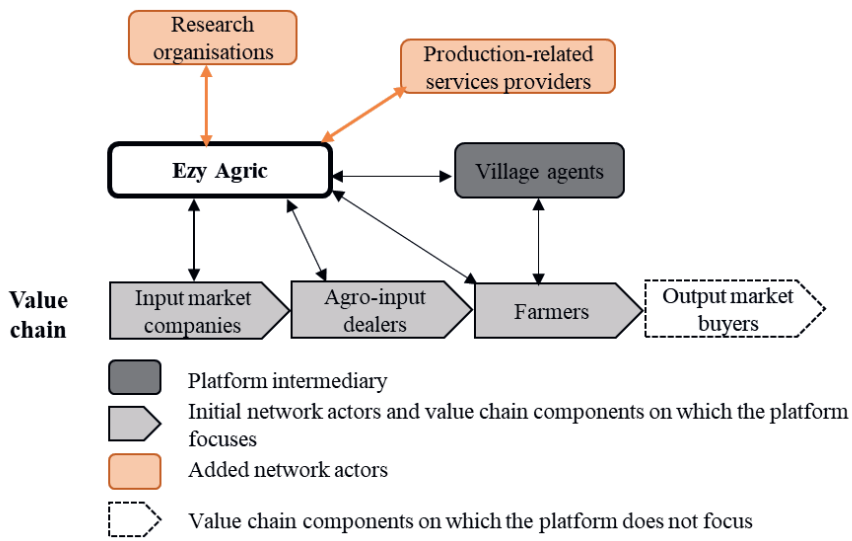


Figure 2.4 Market positioning of the Ezy Agric app

With its market positioning and the services it offers, Ezy Agric co-creates value for its actor network in four ways. First, it allows agro-input suppliers to sell a variety of inputs while enhancing farmers' access to the needed inputs. Second, the platform now offers research

institutions an outlet through which to communicate their research-based knowledge to a wider farming community, with more than 80,000 farmers profiled (at the time of this study) as receiving extension services from the app, supported by village agents. Third, the use of a two-way communication channel involving a smartphone-based app allows farmers to access inputs and production information, as well as to photograph their farms in order to receive timely advice on diseased or affected plants. Such a mechanism enhances interactions and problem-solving for farmers.

Finally, using village agents as intermediaries between the platform and farmers provides a human face in offering registration support, on-the-spot advisory services and last-mile delivery of inputs and production-related services to farmers. As Director 2-2 noted, '*...we earn on a commission basis; the more orders farmers make, the more commission we get from the agro-input suppliers, which we also share with the agents*'. Commissions earned by village agents on inputs and services purchased through the platform incentivise them to provide support services that enhance farmers' access to and use of inputs. As we observed, however, the commission system for remunerating village-based agents was inadequate to maintain them in their roles. More than four of the village agents we contacted had abandoned their roles, citing low levels of facilitation.

As indicated by our results, additional services resulting from the change in the platform's positioning improved the awareness of farmers concerning the benefits of inputs and how to use them. Information gathered from field interviews suggests that farmers' use of inputs improved when they received production information and other related services provided by the app. For instance, Farmer 2-1 noted, '*We knew we could get inputs from the app, but using them was a challenge. With information on the app, we can now use the inputs correctly in the garden*'. In addition, Farmer 2-3 indicated that '*...some of these inputs require one to know how to measure land and apply them, which was a problem, and now we have land-mapping services*

which we can use to know how much of the inputs to use'. As stressed by Farmer 2-1, '*I planted the improved seed I bought from the app after knowing how much to plant in my land acre without wasting the seed*'.

As illustrated by the quotations from the farmers presented above, additional services enhanced the use of inputs by farmers due to the improved knowledge on inputs and related services they had accessed from the app. These findings are consistent with observations made in farmers' fields, which revealed gardens planted with improved maize and bean varieties. While access to production knowledge improved farmers' use of better farm practices, such improvements were also influenced by the low capital required for farm practices. As indicated by Farmer 2-4, '*We now know how to use these practices, and it is easy for us because they don't require much money*'. As shown by observations made in farmers' fields, farmers usually planted in rows to ease weeding and clear garden boundaries in order to control weeds.

While the coordination of various services by the platform increased the use of inputs by some farmers, uptake decisions were still constrained by limited access to microcredit, the unaffordability of smartphones and the high cost of internet data required to access and use the app. In addition, it was observed that using a smartphone app made farmers dependent on the village agents to order inputs and other services. This is because many farmers did not own a smartphone, and those who did, could not navigate the interface or could not afford internet access. The company recognises these challenges and plans to revise its strategy accordingly. As noted by Director 2-1. '*...we are in discussion with bigger banks on providing microcredit to farmers, we also know that produce markets are key for farmers to gain from their farm production and invest in inputs, so we are now looking into how to bring output buyers onto the app*'. In so doing, the platform is moving towards incorporating output markets and coordinating the entire value chain.

2.4.4 Input Information Provider (M-Omulimisa)

Founded as an agritech company by two individuals in 2014 to provide agriculture-related services, M-Omulimisa initially positioned itself between research organisations and farmers to address the production knowledge gap among farmers. Learning from the experiences of farmers, especially with regard to changing weather patterns, M-Omulimisa added the Agriculture Insurance Consortium (AIC) in 2016 through a broker partnership to help farmers manage agricultural risks related to weather shocks while earning commissions from the sale of agro-insurance. At the time of the study, the platform had just expanded its network to include a microcredit institution (Microfinance Support Centre) and various input companies to complement its production-related knowledge in order to stimulate farmers' access to and use of inputs. As recounted by Director 1-1, '*...[we] partnered with Microfinance Support Centre to help farmers access inputs on credit and remove the problem of limited cash flow for farmers*'. The platform thus started by focusing on one point of the uptake barriers and moved to address a variety of uptake barriers, as shown by the orange-shaded boxes and arrows in Figure 2.5.

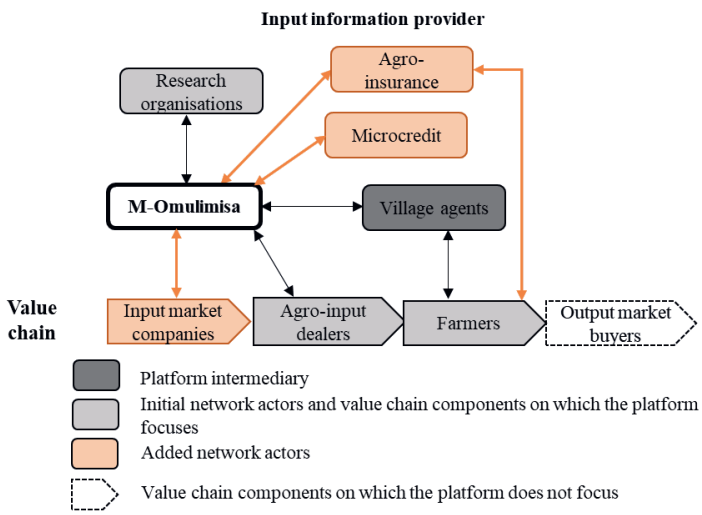


Figure 2.5 Market positioning of M-Omulimisa

M-Omulimisa provides customised agronomic information to farmers using simple mobile phones through the Unstructured Supplementary Service Data (USSD) code to bridge farmers' gaps in knowledge and information concerning inputs. In addition, the platform aggregates the input demands of farmers to help input suppliers plan and stock the inputs required by farmers. Consistent with the changes in its market system positioning, the platform now provides additional services, including highly subsidised weather-index-based crop insurance to individual farmers, accessed and paid through a mobile money wallet. Furthermore, the platform now manages a low-interest micro-loan scheme based on farmer groups. By the time of the study, the platform had registered more than 20,000 farmers receiving various ICT-based agriculture services, including e-extension, weather-index-based crop insurance, agricultural-input loans and input delivery.

Results from key-informant interviews revealed that the platform co-creates value for its actor network in five ways. First, it offers an outlet for research institutions to communicate their research-based knowledge to a wider farming community than would be possible using face-to-face services. One of the platform's research partners confirmed this finding, highlighting the platform's role in scaling agricultural technologies among farmers.[1] Second, the two-way communication channel using a user-friendly, simple-phone-based USSD code enables farmers to seek and receive on-the-spot extension advice cost-effectively and non-time-consumingly. For example, as Farmer 1-2 indicated, '*...we can ask and get responses on our phones without travelling to access it*'.

Third, by aggregating input demand and managing the microloan scheme, the platform provides farmers with access to inputs on low-risk credit. At the same time, it provides agro-input dealers

[1] https://n2africa.org/sites/default/files/Uganda%20Annual%20Country%20Report%202020 18.pdf

with better forecasts for the inputs demanded by farmers, thus offering them the opportunity to expand their input sales. Fourth, the platform shields the risk of defaults on loan repayments and insurance payments, helping the microfinance institution and insurance company reach many farmers with their insurance and credit products. Fifth, using village agents puts a human face on the platform's operations. These agents assist farmers (especially those who cannot use their own phones) with registration, on-the-spot advisory services, microloan applications and last-mile delivery of inputs. Their role is incentivised through commission. As indicated by Village Agent 1-2, '*When input loans are approved and inputs delivered, we are able to earn a commission from each group that has received input loans, although it's not enough for the work we do*'.

The provision of customised production information by SMS increased the farmers' use of better farm practices (e.g. timely planting and row planting), in response to the recommendations provided by the platform. As Farmer 1-3 explained, '*because of the information we get, we conduct our farm operations in time and use improved farm practices*'. Interestingly, the improved use of better farm practices could also have been influenced by the low cost of capital required to use them. In addition to using better farm practices, farmers became more aware of improved seed varieties and fertilisers due to the platform's input information and extension advisory services. For instance, Farmer 1-1 noted, '*Because of the information we get from M-Omulimisa, we now know what inputs to use to increase our yields*'. Similar findings were observed in M-Omulimisa's project progress report for 2018, indicating that farmers' knowledge of inputs had increased because of production information shared through mobile phones.[2]

[2] www.m-omulimisa.com

Furthermore, while production information increased awareness of input technologies, integrating input microloans as a complementary service boosted the use of inputs. As Farmer 1-4 indicated, '*Most of us have started using the improved seed because of the input loans we get through M-Omulimisa*'. This sentiment was shared by Village Agent 1-1: '*We see that the use of improved seed by farmers is increasing due to input loans accessed through M-Omulimisa*'.

Whereas introducing a group-based micro-loan scheme improved the farmers' use of inputs, its coverage remains low. In addition, the long application processes limit access to only a few farmers. M-Omulimisa plans to change its credit-access strategy to address the bureaucratic application processes. Director 1-1 explained, '*...but discussions are underway for digitalising the whole process to quicken access to these loans*'. Similarly, the platform plans to develop an app that will facilitate direct access to inputs and outputs by farmers, thereby improving input and output linkages. As noted by Director 1-1, '*We also plan to develop an app that can allow individual farmers to order and pay for their own inputs directly, and to access various produce buyers on the app*'. The platform is thus moving towards output markets and the coordination of the entire value chain.

2.4.5 Case comparison

In this section, we compare the cases based on the platforms' overall strategies to improve farmers' uptake of agricultural input technologies. We do this by exploring similarities and differences in market positioning, services provided, and co-created value, and how these variations drive smallholders' uptake of agricultural input technologies (see Table 2.5). We also explore the platforms' expected strategic changes in order to investigate their outlook on the coordination of diverse actors, service linkages and value co-creation in the further improvement of the uptake of input technologies by farmers.

Market system positioning

All of the ICT platforms included in this study sought to solve barriers that affected farmers' uptake of input technologies by positioning themselves at different intersections within the market system: between buyers and farmers (Farmgain Africa and Kudu), between agro-dealers and farmers (Ezy Agric); and between research organisations and farmers (M-Omulimisa). Learning from their own experiences and realising that farmers' input use could not be solved by focusing exclusively on one point of the barriers, some platforms started to co-evolve by moving from their initial positioning towards positions where they could solve the various barriers to uptake. The input market-based platforms changed their market positioning from information access to input linkages and vice versa.

Although we did not observe a similar change in positioning for the output-market platforms, they are still planning to move in the future based on their expected strategic changes. The changes in the market positioning for the ICT platforms support the increasing notion that farmers' uptake of input technologies cannot be solved by focusing *exclusively* on the coordination of inputs or the provision of information relating to inputs. Solving the uptake barriers faced by farmers thus requires an integrated value-chain approach in which both input and output markets and related services (including financing) are addressed simultaneously.

Services provided by the platforms

The services provided by the ICT platforms are consistent with their market-system positioning, including the changes in positioning that some of the ICT platforms had made. For instance, the input-information provider added the management of the group-based input microloans to its range of services, while the input-market coordinator added customised production information. The addition of such services demonstrates that, as service ecosystems, ICT platforms are adaptive in nature, changing with the constraints, needs and opportunities existing

within the market system. Such changes largely eliminated barriers that hindered farmers from adopting production-increasing technologies.

Table 2.5 Case comparison

Concepts	Output-market coordinator (Kudu platform)	Output-information provider (Farmgain Africa)	Input-market coordinator (Ezy Agric app)	Input-information provider (M-Omulimisa)
Market-system positioning	• Explicitly positioned between output-market buyers and farmers • No actors added	• Explicitly positioned between output-market buyers and farmers relating to several market stakeholders • No actors added	• Initially positioned between farmers and agro-input suppliers to address farmers' limited access to inputs • Later added other actors to solve the production-knowledge gap concerning the use of inputs	• Initially positioned between research institutions and farmers to solve farmers' production knowledge gap • Later added other actors to complement product knowledge and stimulate farmers' access to and use of inputs
Services provided	• Continued to provide services within its initial market positioning	• Continued to provide services within its initial market positioning	• Started with services that enhance farmers' access to inputs • Added other services in line with its market positioning	• Started with services that enhance farmers' access to production knowledge • Added other services in line with its market positioning
Value co-creation activities	• Farmers and buyers can sell and buy farm produce cheaply. • Farmers get better prices due to the absence of market intermediaries. • Earning opportunities for village agents	• Reaches farmers through NGOs (subscribers) • Uses produce dealers to collect quality data • Both farmers and NGOs make informed decisions regarding production, marketing, and agricultural interventions, respectively. • Earning opportunities for data collectors	• Initially offered agro-dealers an avenue for selling various inputs, while farmers access needed inputs on-demand • Earning opportunities for village agents through commission With the change in positioning: • Offers research institutions an outlet to communicate their research-based knowledge • Immediate access to production information by farmers. • Farmers access production-related services	• Initially offered an avenue for research institutions to communicate research-based knowledge while reaching farmers through a cost-effective and time-efficient two-way communication channel With the change in positioning: • Farmers access low-cost agro-insurance and low-risk input credit while shielding the microfinance institution's loan repayment risk • An avenue for the agro-insurance company, microfinance institution and input companies to sell to a wider coverage of farmers • Earning opportunities for village agents through commission
Uptake of input technologies	• Limited improvement in farmers' use of improved seed and farm practices • Lack of input linkages and credit facilities largely hinders the use of inputs.	• Limited improvement in farmers' use of improved seed only and no improvement in the use of better farm practices • Dependence on intermediary organisations affects effective access to information.	• Initial positioning led to low increments in farmers' use of inputs and better farm practices. • Change in positioning increased input use and led to major improvements in using better farm practices. • Lack of access to credit, high internet costs and use of smartphones largely hinder the use of inputs.	• Initial positioning led to limited improvement in farmers' use of inputs and increased their use of better farm practices. • Change in positioning increased farmers' use of inputs boosted by input loans. • The use of inputs is still limited by low input loan coverage and lack of linkages to output markets.
Expected strategic changes	• Addition of input linkages • Movement towards input markets	• Development of an app to make information more accessible • Integration of fertiliser prices • Movement towards input markets	• Addition of output market linkages and microcredit • Movement towards output markets	• Deeper integration of the input loan scheme, with plans to digitise the service in order to create efficiency and reach more farmers • Development of an app that facilitates communication and access to inputs and outputs • Movement towards output markets and coordination

Value co-creation activities

Integrating resources from several actors is one of the value co-creation activities in which all platforms were engaged. For example, NGOs played a role in exchanging market information, creating awareness and providing extension-advisory services to farmers. Similarly, the use of intermediaries (e.g. village agents and market scouts) allowed the platforms to have an on-site presence and a human face to increase interaction with farmers and other actors while providing insight into the needs and challenges of the actors within their networks. Such insight enhanced the efficiency with which the provision of services was aligned with these challenges and needs while providing earning opportunities for intermediaries (either through commission or wages), thereby contributing to youth employment in the country.

The use of a two-way communication channel by the input-information provider and input-market coordinator allowed farmers to interact directly with the platforms and to seek on-the-spot advice concerning emergent challenges (e.g. pests and diseases). Such interactions enhanced joint problem-solving and reduced the risk of downtime to solve problems in the market, thus enabling farmers to make informed production decisions. Such a mechanism suggests that these platforms obtained new insights from the market that allowed them to add value for farmers, as evidenced by their changes in market positioning.

The provision of on-demand access to information and other services by the output-market coordinator, input-market coordinator and input-information provider enhanced timely production decisions by farmers, as compared to the case of the output-information producer, which involved access to information on a weekly basis. In addition, the use of preferred local languages by the input-information provider enhanced the farmers' interaction with and understanding and use of information, as compared to cases in which English was the only medium of exchange. Similarly, the use of simple phones by the output-market coordinator and input-information provider improved the platforms' usability for farmers, compared to the

platforms with less accessible technologies (e.g. smartphones and email). This suggests that using ICT tools and languages based on the needs and capabilities of farmers enhances decisions concerning the uptake of inputs.

Uptake of agricultural input technologies

Our findings demonstrate that agronomic information provided by the input-market cases (M-Omulimisa and Ezy Agric) enhanced the uptake of improved farm practices that do not require a financial investment. In contrast, improvements in the uptake of inputs that do require capital (e.g. seeds and fertiliser) did not occur until the input-information provider added low-risk input microloans. On the other hand, the output-market cases (Farmgain and Kudu) improved farmers' use of improved varieties of seeds that were in high demand in the market, but had no effect on the use of other inputs (e.g. fertiliser) or on the use of improved farm practices. The latter improvements did not occur until other organisations complemented the platform with information on such practices. In addition, in the input cases (M-Omulimisa and Ezy Agric), the change in the market system positioning of platforms to address various challenges faced by farmers also enhanced their uptake of agricultural inputs over time, as compared to the platforms that remained at their initial positions (Farmgain and Kudu).

Expected strategic changes

While improvements in the use of inputs and farm practices could be observed across several cases, uptake barriers remained in both input and output markets. This made it necessary for ICT platforms to adapt their strategies to solve these barriers. Albeit at varying speeds and points of integration, all of the ICT platforms in this study were moving towards the same model of value-chain coordination to bring on board both input/output actors and supporting services. Moreover, our findings indicated that incentivising intermediaries (e.g. village agents), who play a crucial role in actor networks, remains a challenge requiring attention from the platforms.

The four cases in this study illustrate different strategies that ICT platforms use to improve the uptake of agricultural inputs by farmers. Based on this analysis, we outlined the pathways that ICT platforms take to do this (Figure 2.6). As evidenced by their expected strategic changes, all of the ICT platforms had begun departing from their initial positioning in the market to converge towards becoming future coordinators of the value-chain ecosystem. These ICT platforms are expected to adopt an integrated value-chain approach to providing related services.

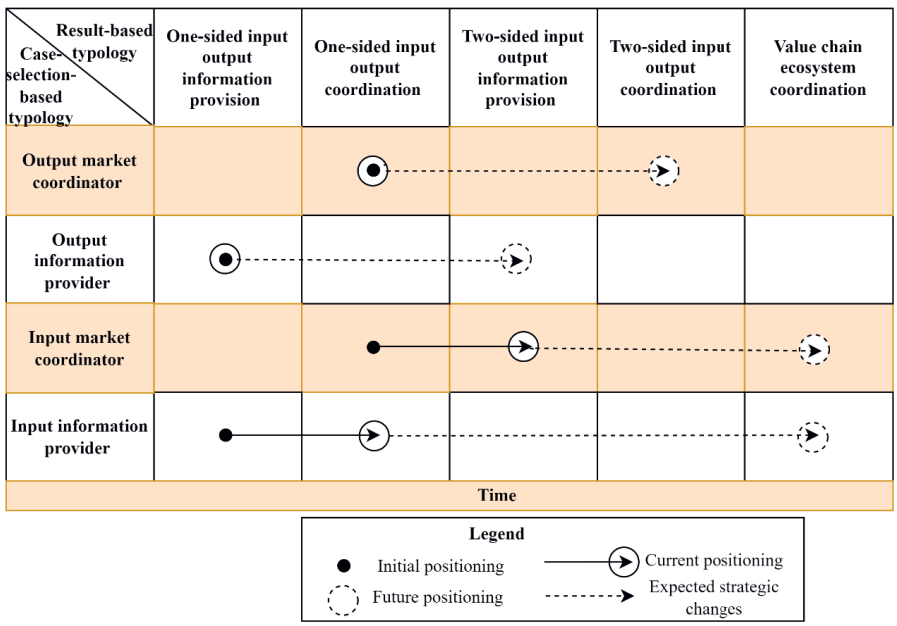


Figure 2.6 Pathways for ICT platforms in improving the use of agricultural-input technologies by farmers

2.5 Discussion And Implications

We started this study by selecting four distinct types of ICT platforms to investigate how the different ICT approaches lead to improved uptake of agricultural-input technologies by smallholder farmers. As demonstrated by our findings, however, ICT platforms are not

restricted to their original strategies, as evidenced by their dynamic positioning within the market system, their services and the value they co-create in order to improve the use of input technologies by farmers.

These results suggest that, although there are different points of departure for the development of ICT platforms in smallholder agriculture, the endpoints are likely to be the same if they are to address the challenges faced by smallholders. The strategic changes that the ICT platforms made as they departed from their initial positioning to converge towards becoming value-chain coordinators indicate that ICT platforms recognise that farmers face a wide variety of uptake barriers that should be addressed simultaneously.

Our findings logically connect to several lines of literature. As indicated by previous research on value chains, improving the use of inputs by farmers requires linking to both input and output markets simultaneously in order to resolve the barriers to uptake (Lambrecht and Ragasa, 2018; Mishra and Dey, 2018). To this knowledge, our findings add that this insight apparently implies that, sooner or later, ICT platforms stand to gain by changing their roles, positioning and activities. As such, they go through a learning process—as emphasised by the literature on organisational learning—thus suggesting that new insights lead to changes in organisational forms, strategies and practices (Santa and Nurcan, 2016). Through such processes, ICT platforms evolve into new roles, as discussed in the literature on human evolution (Seabright, 2010; Wilson, 2020). In addition to suggesting that ICT platforms learn and evolve to new roles, an evolutionary perspective on ICT platforms suggests that, if they learn too slowly, such platforms may be shaken out by others that are quicker in developing the competencies required by their new roles.

2.5.2 Practical implications

The current study has three primary implications for ICT platform managers, policymakers, development partners and other organisations seeking to improve access to and use of

agricultural technologies for smallholder farmers. First, ICT platforms can stimulate learning and induce dynamic responses regardless of how they began. They should learn from each other and adapt their strategies to create greater impacts on farmers' uptake of input technologies, thereby benefitting the entire agricultural sector. A platform that avoids change or learns too slowly risks becoming redundant within the network. This study envisages the creation of business ecosystems that focus on the co-creation of value through the co-production service offerings that provide the competitive advantage that ICT platforms need in order to stay in business. Those in need of such an advantage should broaden the range of services they offer, acquire new skills and knowledge, and reduce costs by engaging in cost-sharing collaborative arrangements with other actors within the market system.

A second implication of our study is related to the network perspective on which it is based, which encompasses interventions relating to information provision and coordination. This perspective is broader than those adopted in many educational programmes for agribusiness managers. Our study thus warns that an overly narrow disciplinary perspective can lead ICT platforms to overlook important market developments and avoid taking on coordination roles that could potentially increase their impact. In other words, learning to coordinate requires a disciplinary basis that should be taught effectively in educational programmes for managers of ICT platforms, as well as throughout the value chain.

Third, to accelerate development towards platforms that encompass the entire value chain, platforms could join forces through mergers and acquisitions and/or form an industry organisation that facilitates learning and harmonisation. This implication is particularly applicable to countries with relatively dense networks of ICT platforms, like Uganda. An industry organisation could help manage the learning processes across the various ICT platforms in order to create new innovations (Cerchione et al., 2016; Gorry, 2016) and work towards leveraging resources and knowledge exchange (Hernández-Chea et al., 2021).

2.5.3 Limitations and Direction for Future Research

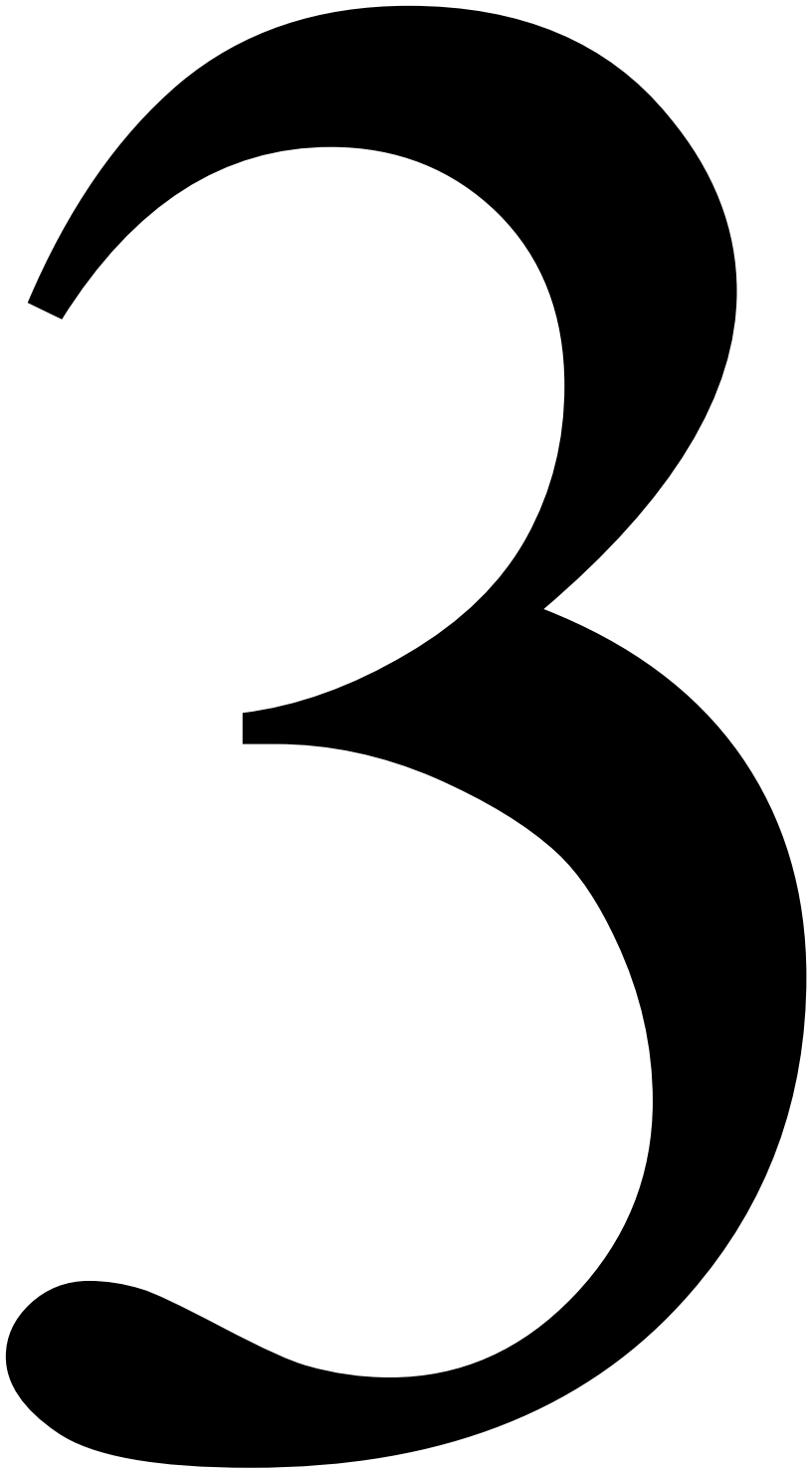
The insights from our study should be considered in light of its limitations. First, while our results are fairly consistent across the different cases, the pattern that we find in our study is based on one case for each archetype. As such, these findings may be interpreted as theoretically, but not empirically generalisable (Yin, 2009). Second, our data were gathered in Uganda, a country with one of the highest numbers of ICT platforms in Africa. Replications in other countries with fewer platforms are likely to find less interaction between platforms and slower learning processes. As such, the patterns revealed in our study may take longer to become identifiable in other contexts, if they appear at all.

Future research may also generate more formal evidence of relationships between ICT platforms and smallholders' uptake of production technologies. In our study, we addressed such effects only in a qualitative manner. More formal studies assessing different pathways could further test these effects while incorporating important insights from the current study. Finally, future studies could examine the perceptions of smallholders of the ICT services provided to them. Our study showed that learning on the part of ICT platforms regarding orientation towards users (farmers) is essential to stimulating uptake of input technologies. As such, there may be many micro-level barriers (e.g. interface design and service marketing) that impede ICT platforms from helping to stimulate uptake, but that may be overlooked by managers who consider only strategic aspects, as discussed in the current study.

2.6 Conclusion

This study explores the impact of the strategies of different ICT platforms on the uptake of agricultural input technologies by smallholder farmers. The results show that to overcome barriers in the uptake of input technologies by farmers, ICT platforms are moving away from an exclusive focus on information provision to the coordination of the value chain, as well as from input to output and vice versa. They are thus moving towards covering the entire value

chain by adapting their positioning within the market system to integrate additional services and actors. The findings further highlight that ICT platforms that learned from experiences and adapted their original positioning claimed more success in improving farmers' uptake of inputs than those that remained at their initial positioning. In their roles as value-chain coordinators, ICT platforms can contribute to the development of the value chain and the uptake of production technologies by smallholder farmers in Africa.



Chapter 3

Actor needs in ICT platforms for smallholder agricultural value chains - A case in Uganda

This chapter is submitted as: Connetie Ayesiga, Esther Ronner, Peter Ebanyat, and Paul T.M. Ingenbleek. Actor needs in ICT platforms for smallholder agricultural value chains - A case in Uganda.

Abstract

Information and communication technology (ICT) platforms are often seen as an effective way to organise and coordinate smallholder-based agricultural value chains. According to empirical evidence, however, most current ICT platforms are technologically oriented, and they tend to neglect users' needs in the design of ICT services. When platforms do consider the needs of users in their design, they tend to focus solely on the needs of smallholder farmers whilst largely neglecting those of other actors within the value chain. Based on focus group discussions and interviews, this study explores ICT service needs and preferences for interface design features for smallholder-based value chain actors to derive potential synergies, trade-offs, and solutions based on the case of the M-Omulimisa ICT platform in Uganda. While findings show that many value chain actors have similar needs for ICT services, some needs and preferences for interface design features differ between actors and, in some cases, they even contradict each other. in light of these contradictions, ICT platform managers must first prioritise needs that cut across all value chain actors and make trade-offs concerning whose needs they consider most important. This study provides practical implications for ICT platforms to keep all value chain actors on board and contribute to the development of smallholder-based agricultural value chains.

Keywords: ICT4D, smallholder-centred design, digital innovations, ICT services, synergies, trade-offs, agriculture, Africa

3.1 Introduction

In the past decade, large-scale investments in the Information and Communication Technology (ICT) infrastructure in sub-Saharan Africa have profoundly enhanced access to and use of mobile phones and internet amongst smallholder farmers (WorldBank, 2018). This has led to the development of ICT platforms in smallholder agriculture (Wyche and Olson, 2018). In the smallholder agriculture context, ICT platforms refer to mobile and web-based digital bases that integrate multiple interfaces and applications such as Short Messaging Service (SMS), video, and audio for different users, including farmers and input suppliers (Kieti et al., 2021). By offering different applications, ICT platforms provide opportunities for improving the efficiency of smallholder-based agricultural value chains (Heeks and Bukht, 2018; Smidt and Jokonya, 2022a). As a part of these efforts, increasing emphasis is being placed on the roles that ICT platforms could play in improving access to and the use of agricultural inputs among smallholder farmers, thereby contributing to solutions for increasing farm productivity and food production for the growing population in Africa (World Bank, 2017; McGuire & Sperling, 2016).

The existing literature has identified potential benefits of ICT platforms with regard to strengthening the use of agricultural inputs by smallholders. As argued by Foster and Graham (2017), ICT platforms enhance farmers' access to low-cost and real-time information on agricultural inputs and farm practices, thereby increasing awareness about and the use of agricultural inputs. Several authors indicate that ICT platforms enhance farmers' access to value chain services, including micro-loans, extension services, insurance, and output markets, thereby increasing opportunities for access and use of agricultural inputs (Cole and Fernando, 2016; Deichmann et al., 2016; Orr, 2018). Other studies, such as conclude that ICT platforms could help overcome spatial barriers and reduce transaction costs, which subsequently increases

farm profits that smallholders could invest in agricultural input technologies (Graham, 2019; Krone and Dannenberg, 2018).

Despite these potential benefits, the uptake of ICT platform services amongst smallholders remains low. According to existing evidence, even many farmers sign up for ICT services, no more than 30% actively use them (Goedde et al., 2021; Krell et al., 2021; Tsan et al., 2019). The literature suggests two main reasons for these low usage rates. First, many farmers are unable to use the ICT services, due to low literacy (Ayim et al., 2020; McCampbell et al., 2021a; Munthali et al., 2018); limited innovation capabilities, due to a limited focus on the market (Tindiwensi et al., 2020); a lack of awareness about the services offered by the platforms (Kieti et al., 2022); and/ or the inability to afford (smart)phones or internet access – which are relatively expensive in low-income countries (Matto, 2018). Second, once users have accessed the ICT services, some are likely to abandon them if the design does not meet their expectations (Kieti et al., 2022). The literature on ICT for development (ICT4D) attributes the latter to platform designs that reflect the technical interests of the platform itself or of its donors, rather than those of the platform users (McCampbell et al., 2021a; Smidt and Jokonya, 2022b; Steinke et al., 2021).

Several studies addressing the design challenges of ICT platforms have focused largely on the needs of farmers for information and knowledge relating to ICT services. For instance, Chiputwa et al. (2022) conducted workshop sessions to collect agrometeorological information and forecast indicators from farmers and codesign a digital interface tool that meets the needs and expectations of the users. Agyekumhene et al. (2020) used multi-stakeholder and focus group discussions to identify the challenges and needs of smallholders to design a smartphone-based farm monitoring app that overcomes literacy and language barriers. In addition, Ortiz-Crespo et al. (2020) elicited feedback from farmers and extension agents in Tanzania to create

an automated hotline that provides farmers with access to a set of pre-recorded messages that address their need for information on sustainable intensification.

One common feature shared by the studies mentioned above is that they focus on the design of a single set of services for a single group of users. At the same time, however, ICT platforms in smallholder agriculture and the platforms' economy at large typically requires more complex designs for a variety of ICT services intended for multiple interdependent clients in the network. For the smallholder context, these clients include value chain members (e.g. input providers, output buyers, and, perhaps, microfinance and insurance providers). These actors can all make use of and add to the platform's information base. They may also extend the function of the platform from information provision to allow farmers to make input purchases and offer their produce for sale. The design of such typical platform services has yet to be addressed in the literature. Such knowledge is nevertheless important and relevant, as neglecting the needs of value-chain actors may lead them to withdraw from platforms, thus creating gaps in other services that ICT platforms can provide, and ultimately undermining the very existence of the platforms.

In this study, we explore the needs of farmers and other key actors in smallholder-based value chains with regard to ICT services. To this end, we adopt a user orientation, as derived from the New Service Development (NSD) process (Lindh and Nordman, 2018). Given that access to and the use of ICT services depends in part on interface design features (Agyekumhene et al., 2020; Coggins et al., 2022; Krell et al., 2021), we also explore preferences for various features of ICT interface design. More specifically, we investigate potential synergies and trade-offs between the needs and preferences of various actors and propose solutions for these trade-offs. Our study was guided by the following research questions: (I) What are the needs and challenges faced by various value-chain actors with regard to ICT services? (II) Which preferences do value-chain actors have with regard to ICT interface design features? (III) Which

synergies and trade-offs can be identified in service needs of value-chain actors, as well as in their preferences for ICT interface design features? (IV) What do these synergies and trade-offs imply for smallholder-based agricultural ICT platforms with regard to the design of their ICT services?

This study contributes to the literature on the use of ICTs amongst smallholders in three ways. First, previous studies have focused largely on integrating the needs of smallholder farmers into the design of ICT services (e.g. Gbangou et al., 2020). Our study extends this literature by showing how ICT service design can deliberately integrate the needs of other actors within the value chain as well. Second, this study identifies synergies and trade-offs in the needs of various actors within the smallholder value chain with regard to ICT services, as well as in their preferences for ICT interface design features. This generates insight into important aspects of services and interface design features that developers of ICT platforms should consider when redesigning their platforms to address challenges faced by a variety of actors within the value chain. Third, the study explains how the design of ICT services can entail trade-offs between the needs and preferences of value-chain actors. The insights generated by this study could help managers to design their platforms in order to increase the use of ICT services amongst smallholder farmers and other value-chain actors in Uganda and elsewhere.

The remainder of the paper is organised as follows. In the next section, we present the relevant background of the study. We then provide an overview of the methods and results, followed by the implications of the results and our conclusions.

3.2 Background

3.2.1 Challenges in smallholder-based agricultural value chains in sub-Saharan Africa

Smallholder-based agricultural value chains are composed of smallholder farmers and other independent actors, including input suppliers for seeds and fertilisers, small-scale aggregators

(buyers), wholesalers/traders, extension agents and service providers, such as microloan banks and, in some cases, insurance companies (Agyekumhene et al., 2020). Several authors have highlighted the many challenges within smallholder-based value chains in sub-Saharan Africa that could explain the persistent low rates of productivity at farm level. These challenges include drastic variations in weather conditions, which affect farm production and the produce supplies that are marketed (Nhemachena et al., 2020; Vaughan et al., 2019); the inadequacy of services provided by both public and private extension systems, which fail to cover all farmers, who are often widely dispersed (Munthali et al., 2018); and poor access to agricultural inputs and technologies.

Furthermore, there are often few input suppliers and output buyers (e.g., Ingenbleek et al., 2013). Even when they are present, they are likely to have difficulty reaching farmers, due to the high operating costs resulting from poor road infrastructure (Mishra and Dey, 2018). Moreover, poor infrastructure (including digital infrastructure) tends to limit the access of farmers to information and markets for inputs, outputs, credit and other production-related services and resources (Brown et al., 2018). Such market conditions can marginalise farmers by significantly increasing the cost of production and making farming unprofitable (Gereffi and Fernandez-Stark, 2016; Kilelu et al., 2017b), reducing investments in input technologies by farmers. Moreover, the activities of actors within the value chain (e.g. production, marketing, addition of value) are often uncoordinated, with information gaps and lack of transparency in markets (Aggarwal et al., 2018; Agyekumhene et al., 2020; Goedde et al., 2019). This creates market uncertainties for both buyers and sellers, resulting in a lack of produce markets and low income for smallholder farmers. Given their upstream position, these farmers are more vulnerable to exploitation by better-informed value-chain actors, such as intermediaries and agro-dealers (Orr, 2018).

As argued by several studies, ICT platforms within the agriculture sector could address some of these challenges in an efficient way. For instance, Deichmann et al. (2016) argue that ICT platforms can eliminate asymmetries in agricultural information and increase production knowledge through new ways of providing extension services (e.g. delivering production messages through mobile telephony). As demonstrated in studies by Foster and Graham (2017) and Krone and Dannenberg (2018), ICT platforms can eliminate existing market barriers by linking farmers to buyers and input suppliers in a cost-effective and time-effective manner. Furthermore, studies by Campion (2018) and Abdullahi et al. (2021) highlight how ICT platforms can empower smallholder farmers to access better financial services and take better farm decisions. Other studies have concluded that ICT platforms can provide customised financial products that meet the distinct needs, preferences and capabilities of farmers (GSMA, 2020; Joiner and Okeleke, 2019; Steinke et al., 2021).

3.2.2 Identification of needs and preferences for ICT services

To identify needs and preferences for ICT services that are aligned to the challenges faced by actors within the value chain, we draw on the service-design literature, which provides a foundation for designing service innovations in collaboration with users (Segelström, 2013). According to Wetter-Edman et al. (2014, p. 109), service design involves understanding the experiences of users and using this information to systematically improve the attributes and features of the services offered, thus resulting in successful new services. Such design thinking has led to the use of user-driven and participatory approaches to innovations in service development (Wetter-Edman et al., 2018).

One example of a user-driven approach is ‘user-centric design’, which guides the design of services that match the needs and context of users. Within the context of smallholder-based value chains, smallholder-centred design could be regarded as a specific case of the user-centric design approach that places the perspectives of smallholders and the actors with whom they

interact at the centre of service design (Graham, 2019; Steinke et al., 2021). In this regard, two aspects of design appear central to a user-centric design approach: (1) understanding the needs of value-chain actors for ICT services that address their challenges; and (2) identifying preferences for interface design features that enable actors to access and use ICT services.

While needs for ICT services logically stem from the challenges experienced by actors within the value chain, different actors may develop different preferences for such services. As defined by Beatty (1981), a need is the measurable discrepancy existing between a present and a desired situation, as asserted by the person who is affected. Preferences derive from the higher favour that users assign to particular available options for meeting their needs (Green et al., 2004). Deriving the service needs of actors requires interacting with and engaging all actors within the value chain in order to understand the challenges they face (Trischler et al., 2018) and to increase the relevance and value of such ICT-based services (Macken-Walsh, 2019). As posited by Jacobs et al. (2019), the involvement of users throughout the design process builds their capacity and increases their sense of ownership of the services designed. In addition, Barakabitze et al. (2017) report that involving users in the design process can have a positive effect on the use of ICT services within the rural community. The integration of a deep understanding of the user into the design or adaptation of ICT-based services could accelerate the commercialisation of services and broaden their adoption (Steinke et al., 2021).

3.2.3 The role of interface design features

Despite the critical necessity of addressing the ICT service needs of actors within the value chain, the ICT4D literature discusses the importance of considering interface design features to enabling users to access service innovations (Agyekumhene et al., 2020; Coggins et al., 2022; Krell et al., 2021). Interface design features refer to hardware and software (e.g. voice, icons, text support, phone type, operating system, language) that enable users to access and use the services provided (Ahmed et al., 2019). It has been argued that the involvement of users in

interface design can improve the fit between interface design features and the service needs of users (Kitsios and Kamariotou, 2020; Saurabh and Dey, 2021), and it could potentially generate important insights into the type of interface design that would be most desirable and that would best meet the service needs of users (Ojasalo et al., 2015). This is because, even if ICT services are well-designed, their optimal use depends on the user-friendliness and usefulness of the interface design (Costopoulou et al., 2016).

Although it is crucial to integrate the challenges, needs and preferences of all actors to the design of widely accepted ICT services, similarities or differences across actors with regard to the desired services and interface design features could potentially lead to synergies and trade-offs (Edward Freeman, 2010; Freeman, 1984). Within the context of this study, synergies refer to derived similarities in needs that may benefit all actors and enhance the use of ICT services. In contrast, trade-offs refer to antagonistic situations involving the exchange of one thing in return for another (Cord et al., 2017). In the case of ICT-based services, trade-offs require decisions to be made between alternatives that cannot be achieved at the same time (Turkelboom et al., 2015). For instance, one actor may need data to fulfil specific goals, whilst another may be reluctant to share such information, due either to a lack of understanding with regard to the purpose of the ICT services and the interconnectedness of actors along the value chains or to genuine privacy concerns. If they are not addressed in the design, such decisions may result in changes in attitudes towards or perceptions of the use of ICT services by actors (Deng et al., 2016), thereby affecting usability and, ultimately, the potential contribution of the ICT platform to the development of smallholder-based value chains.

3.3 Methods

3.3.1 Study approach and context

We conducted a qualitative study to explore the needs and preferences of actors within the smallholder-based value chain with regard to ICT services from within the context of their

business environments. This method allowed us to elicit in-depth and holistic insights into the challenges faced by value-chain actors in relation to ICT services (Ritchie & Lewis 2003). The study was conducted within the context of an ICT platform in Uganda known as M-Omulimisa (meaning: mobile extension). Uganda is a particularly suitable context for this study, given its increasing ICT development, as evidenced by the increase in investments in telecommunication networks and the availability of affordable mobile phones (Panel, 2019). As a result, 60% of all Ugandans have access to mobile phones (UCC 2018). Because of these ICT developments, donations and private investments have resulted in the development of ICT platforms to reach farmers with agricultural services (Tsan et al., 2019), with over 38 agriculture-related ICT platforms existing at the time of study (GSMA, 2020).

Amongst the increasing population of ICT platforms in Uganda, M-Omulimisa stands out, as it has adopted a business-ecosystems approach to reach out to other actors within the value chain (e.g. agro-insurance companies, microcredit organisations and related service providers) to address the many challenges faced by farmers. To address these challenges, the platform started by providing extension information, and it has evolved to coordinating the access that farmers have to inputs, microloans, agro-insurance (using village agents who support farmer registration), on-site advisory services and the last-mile delivery of inputs and production-related services. In addition, the platform has interacted with farmers in the design of its current ICT services, and it is now considering the inclusion of other actors to co-create value and improve access to and the use of its services amongst all value-chain actors in what could be referred to as 'experience-led evolution'. To this end, the platform offers a context that generates valuable insights into the needs and preferences of actors within the value chain.

3.3.2 Data collection

We conducted focus group discussions (FGDs) with farmers and key-informant interviews (KIIs) with other value-chain actors to derive in-depth insights into the challenges, needs and

preferences of these actors with regard to ICT services and interface design features. Our objective was to investigate synergies and trade-offs. The FGDs yielded insights into the experiences and contextual information of smallholders and helped to identify their needs and preferences (Yin, 2013). The KIIs with buyers, input suppliers, village agents and non-governmental organisations helped us to derive individual insights specific to the roles and services they provide, in addition to learning the unique perspectives emerging from their environments with regard to the design of ICT services (Krueger, 2014). Collecting data from various types of actors helped to validate differences in the responses from the various categories of actors. In all, we conducted 12 FGDs with farmers and eight KIIs interviews with other value-chain actors.

To guide the FGDs and KIIs, an interview guide was developed (following Yin, 2013), based on the study concepts derived from our conceptual background, and covering major questions of interest specific to the category of respondents (Table 3.1). The questions were designed (1) to investigate the challenges that participants perceived within the value chain and (2) to elicit the needs and preferences of participants with regard to ICT services and interface design features. These insights helped to identify potential synergies, trade-offs and solutions. The questioning sequence started with an introductory question intended to facilitate free, open dialogue amongst participants, as recommended by Krueger (2014). Once the respondents were comfortable with the topic and had settled into the discussion, several transitional, key and closing questions were asked. During the initial and subsequent interviews, we applied the guide with flexibility, incorporating unanticipated questions that needed further probing as we went along.

Table 3.1 Study concepts with example questions used with key informants and smallholder farmers

Concepts	Example questions
Challenges faced within the value chain	What challenges do you currently face in your farming or in your business activities? How do these challenges affect your production/business? Which options are available for resolving some of the challenges? Is there a way in which ICT platforms could resolve your challenges? If yes, in what ways?
Service needs	Have you ever registered for M-Omulimisa? If yes, what type of services do you receive from the platform? Do you face any challenges in accessing the platform? What types of services do you require from the platform to resolve your challenges and improve your production/service delivery/business across the value chain?
Preferences for interface design features	How would you like to access such services from the platform? How often would you want to access the services? In which languages do you prefer to interact with the platform? Which other features would you like to have that are not mentioned above?

To select participants for the FGDs, we focused on rural and peri-urban areas whose farming communities had access to value-chain services provided by the M-Omulimisa platform. While farmers may be reached through ICT services, it remains a challenge to reach them with inputs and to collect outputs from more remote areas. For this reason, we excluded communities in remote areas where transport and distribution systems were absent, and we included only farmers whose communities could be reached by supply chains. To determine the farmers to be included in the study (i.e. rural and peri-urban), expert opinions were sought from the M-Omulimisa platform and its partner—World Vision, a non-governmental organisation that has worked in Northern Uganda for more than three decades. It was decided to designate farmer groups located beyond 35 kilometres of the main markets/roads or administrative towns as rural and to designate those within a radius of 35 kilometres as peri-urban. In each of the selected rural and peri-urban areas, we then purposively selected farmer groups (Patton, 2015) within which to recruit respondents with experience in ICT services.

To identify cross-cutting challenges, needs and preferences, as influenced by the contexts of farmers (e.g. proximity to markets, main roads, shops for inputs), we selected farmer groups from the selected rural and peri-urban geographical locations. This resulted in six mixed groups of all farmers (three from rural and three from peri urban). To identify challenges and needs specific to the vulnerable groups, which may not arise when they are part of the larger groups, we selected some groups of farmers consisting of young adults, women and older people (Table 3.2). This resulted in three additional groups for young adults, two additional groups for women and one additional group for older people, all of which were distributed across the rural and peri-urban locations. The use of similar categories of farmers across the different geographic locations and group types enhanced the reliability and validity of the insights obtained (Yin, 2013). Each focus group included 8–12 participants.

Table 3.2 Brief descriptions of focus group participants

FGD type	Residence type	Age group	Number	Location
Women FGD 1	Peri-urban	22-52	8	Barr subcounty, Lira
Women FGD 2	Rural	27-61	9	Aromo subcounty, Lira
Mixed FGD 1	Peri-urban	24-64	10	Agali subcounty, Lira
Mixed FGD 2	Peri-urban	20-58	8	Barr subcounty, Lira
Mixed FGD 3	Peri-urban	22-62	10	Agali subcounty, Lira
Mixed FGD 4	Rural	26-69	9	Aromo subcounty, Lira
Mixed FGD 5	Rural	19-58	10	Aromo subcounty, Lira
Mixed FGD 6	Rural	25-60	9	Aromo subcounty, Lira
Young adults FGD 1	Peri-urban	19-31	9	Agali subcounty, Lira
Young adults FGD 2	Peri-urban	23-34	9	Barr subcounty, Lira
Young adults FGD 3	Rural	17-35	10	Agwenge subcounty, Lira
Older people FGD 1	Rural	48-68	10	Agwenge subcounty, Lira

To compare and obtain reliable insights from key informants, we selected two value-chain actors from the same category (i.e. input suppliers, produce buyers, village agents, NGOs) across the network of value-chain actors interacting with the ICT platform (Figure 3.1), resulting in a total of eight KIIs (Table 3.3). The questions used with key informants were similar to the questions and study concepts presented in Table 1, adapted according to the

respondents' roles within the value chain, with the objective of learning how ICT platforms could support their roles.

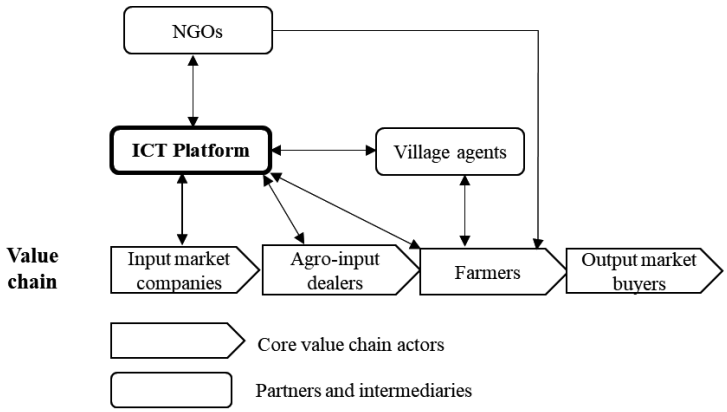


Figure 3.1 Network of actors within the value chain

The discussions and individual interviews of all focus groups were recorded with an audio recorder, after obtaining consent from the participants. A translator knowledgeable about the specific contexts, including the locally spoken languages (Ingenbleek et al., 2013) served as an interpreter to translate the questions asked by the main researcher to the focus group participants, and to translate their responses back to the main researcher. Study participants were mobilised with the help of M-Omulimisa village agents and the field team.

Table 3.3 Brief descriptions of key informant interview participants

Category	Name of actor	Respondent Identification	Role	Years in role
Input suppliers	MK agro input dealer shop	Agro input dealer	Owner	5 years
	Alito joint cooperative	Seed supplier	Cooperative chairperson	8 years
Output buyers	AgriNet	Cereal and grain legumes buyer	Director	13 years
	Mukwano	Oilseed processor	Operations manager	20 years
Village agents	Lincoln Obua	Village agent 1	Village agent	3 years
	Alex Okello	Village agent 2	Village agent	2 years
NGOs	Goal Uganda	NGO 1	Dynamic programme manager	7 years
	Sasakawa Africa 2000	NGO 2	Livelihood, ICT manager	6 years

3.3.3 Data analysis

Data from the FGDs and KIIs were transcribed verbatim using a computer and coded qualitatively using ATLAS.ti data-analysis software (Woods et al., 2016a). To explore challenges, needs and preferences of ICT-based actors with regard to ICT services and interface design features, we analysed the transcripts in a series of steps. The first step involved a thorough reading and re-reading of the transcripts to become familiar with the dataset (Ezzy, 2013). To identify the needs and preferences of the various actors with regard to ICT services, we first explored the value-chain challenges faced by the actors using the key study concepts in the first round of coding. This helped us to identify the contextual and holistic challenges, thus leading to the first-order codes for 'value chain challenges' (see Figure 3.2 for coding structure).

In the second step, we identified needs for ICT services, as emerging from the challenges, given the tendency of needs to arise from the ways in which value-chain actors understand the challenges they encounter within the value chain. This generated insight into the actors' needs that could be solved by ICT platforms, along with their preferences for ICT interface design features, thereby fulfilling the ICT service needs identified for each category of value-chain actors. These insights were grouped together into the second-order themes of 'ICT service needs' and 'preferences for ICT interface design features' (Figure 3.2). Once the coding was finalised, we checked the ICT service needs and preferences for ICT interface design features to identify similarities and differences between actors. This yielded insight into 'synergies and trade-offs regarding ICT service needs, and synergies and trade-offs regarding preferences for ICT interface design features' (Figure 3.2).

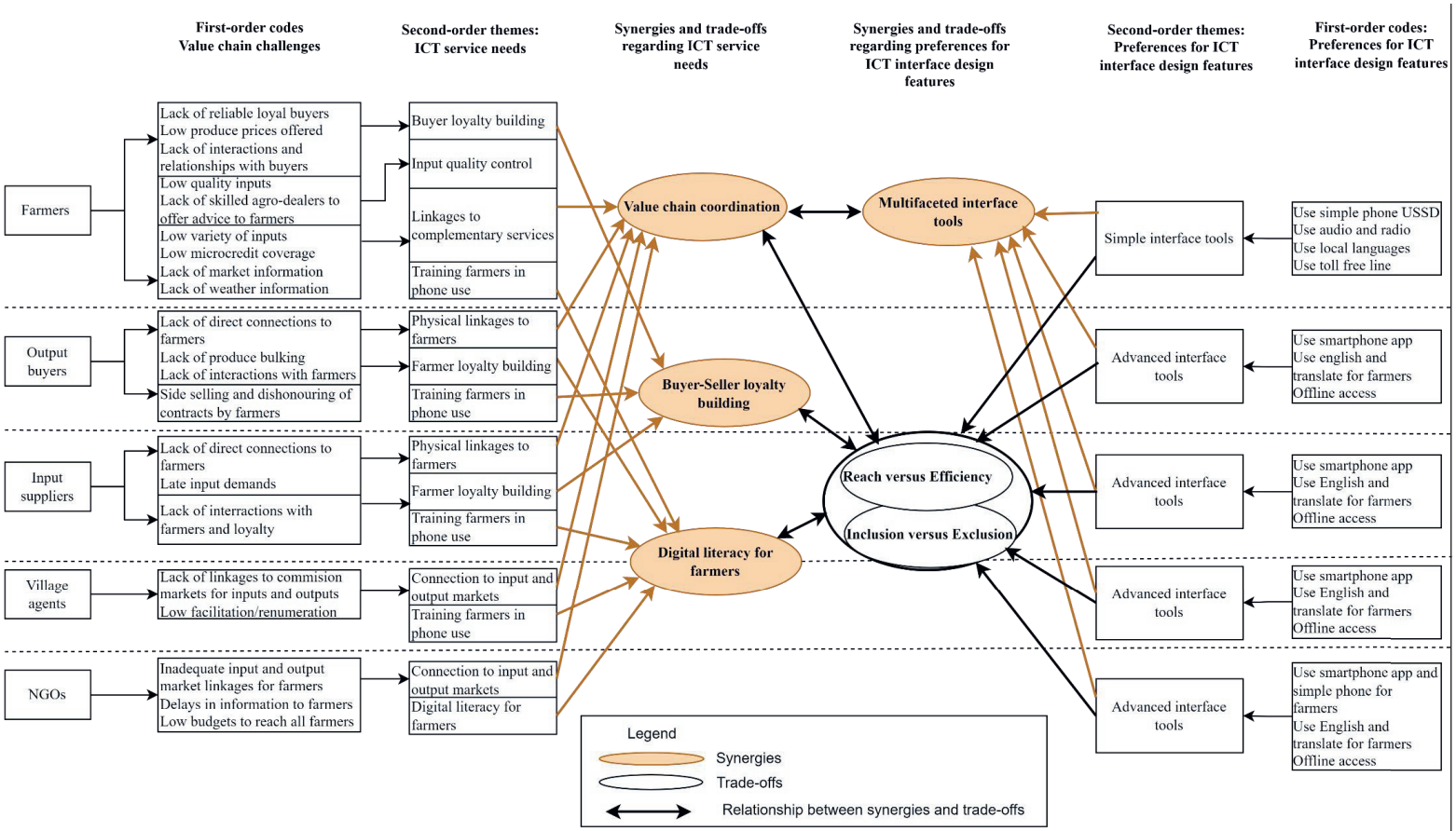


Figure 3.2 Coding structure and interpretation

3.4 Results

Our empirical analysis focused on exploring value-chain challenges faced by various actors within the value chain and on identifying their needs and preferences for ICT services and interface features, with the objective of gaining insight into synergies, trade-offs and solutions. In the following sections, we describe the findings (supported by illustrative quotations) and present the identified challenges and needs for ICT services, followed by the preferences for interface design features for each value-chain actor.

3.4.1 Farmers' challenges, ICT service needs and preferred interface design features

Based on the results from FGDs, the main challenge for smallholder farmers is a lack of key value-chain services to complement the extension services they receive, which are crucial to make the value chain work. These complementary services fall into four broad categories: (1) access to output markets, (2) access to a broad range of inputs, (3) access to microloans for all farmers and (4) access to additional information (e.g. on output markets, weather and extension services) (See quotations in Table 3.4). For instance, farmers either sold their produce at low prices to any available intermediaries due to uncertainties with regard to larger buyers (Women FGD 1 and FGD 2) or lost money through market search due to the high transport costs associated with moving from one place to another (Young adults FGD 1). Because of these challenges, farmers indicated the need for ICT platforms to connect them to produce buyers, in order to increase their farm income, thereby enabling them to invest in better inputs.

Farmers lacked access to a range of inputs, including seeds, fertilisers, pesticides, post-harvest equipment, storage facilities and related services (e.g. spraying) (Mixed FGD 1, Mixed FGD 3). The lack of access to post-harvest equipment and storage facilities affected produce quality, thereby attracting low prices (Mixed FGD 3). Moreover, many farmers considered the quality of inputs to be poor, with poor seed-germination rates (Mixed FGD 5). Uncertainty concerning the quality of agricultural inputs discouraged farmers from investing in improved

inputs. Notably, farmers indicated the need for ICT platforms to connect them to a broad range of inputs for most of the crops they grow, including fertilisers, pesticides, post-harvest equipment and storage facilities. Furthermore, ICT platforms should integrate a quality-control mechanism, including connecting farmers to verified agro-input dealers (Mixed FGD 1). Quality assurance for inputs would enhance the farmers' trust in the ICT services, as well as in their usability.

With regard to credit access, results from the FGDs indicate that, apart from a few farmers who had accessed microloans for improved seeds (Young adults FGD 3, Older people FGD 1), the majority of farmers lacked access to credit for their agricultural activities (Women FGD 2, Mixed FGD 5). The lack of credit prevented farmers from investing in the inputs required in order to expand their farming activities. The participants expressed a need for ICT services to fully integrate microloans for a broad range of inputs that could easily be accessed by all farmers through farmer-friendly processes that would eliminate delays in accessing inputs.

Farmers lacked information on deviations from the known rain patterns and longer dry spells within the seasons (Older people FGD 1), and agronomic information was limited to a few target crops—soybeans and maize—thus relatively ignoring other crops (Older people FGD 1, Mixed FGD 2, Women FGD 1). Furthermore, farmers were not aware of the presence of various produce buyers and prices within their localities (Young adults FGD 1, Mixed FGD 6). To address these challenges, farmers expressed a need for ICT platforms to provide localised weather alerts to inform farm activities, agronomic information targeted to most of the crops that are grown, and output market information to ensure competitive prices and greater farm profits.

Table 3.4 Illustrative quotations from farmers' challenges, needs for ICT services and preferred interface design features

Needs and preferences	Quotations
Complementary services	**Outputs:** 'Right now, we don't have dependable buyers, and we rely on local traders who cheat us and give us low prices'. (Young adults FGD 1) we need connections to buyers within our localities. This would help us not waste money and time looking for somewhere else to be able to sell our produce'. (Young adults FGD 1) '...This is something we need help with, because we try to produce, but who would we sell to if we used improved seeds? Most local traders just take advantage of us, because we have no other options'. (Female FGD 2) **Inputs:** 'We would also like to get all inputs from the platform, such as seeds, pesticides and fertilisers. They could be bundled up together with the post-harvest handling equipment as loans for easy access'. (Mixed FGD 3) 'We get poor germination, particularly for soybean seeds in some farmers' gardens, pointing to either batch problems or something else'. (Mixed FGD 5) 'Some agro-dealers sell fake inputs. The platform should link us to dealers who are verified to sell good-quality inputs; otherwise, it's the farmers who are losing'. (Young adults FGD 1) **Microloans:** 'For instance, in this village, only one group was able to get the input loans, and only for seeds, leaving out most farmers. Even then, the input loans should have come with all inputs needed by the farmers. For now, we may get seeds, but the seeds need fertilisers'. (Mixed FGD 4) **Information:** 'We incur losses due to long dry spells or the late onset of rains'. (Older people FGD 1) 'We also grow other crops, like beans, sunflowers and tomatoes, and we need information on them. Sometimes, one crop fails and another works better and, this way, we balance the income from our farms'. (Mixed FGD 2) 'Information on buyers within our surroundings, along with prices and linkages to markets within our localities. This would help us not waste money and time looking for somewhere else to be able to sell our produce". (Young adults FGD 1)
Buyer loyalty	'If you look at last season, some soybean buyers came around to buy and promised to come back, but they never did, we were only left with only these traders who offer very low prices, and we had no choice'.(Female Women FGD 1) 'These buyers just set the prices without listening to our woes and, if we don't agree to their prices, they don't buy our produce, leaving us with no one to buy our produce'. (Mixed Group 2). 'If the platform can could help us interact more with these buyers and agro-input agro-dealers, it would help improve our relationships and trust with them'. (Mixed FGD 4)
Digital literacy	'...but we would need to be trained to use the phones; sometimes we see text messages coming from M-Omulimisa but, because we do not know to proceed in order to get more information, we end up ignoring the messages'. (Mixed Group 3).
Simple interface tools	'I think that what works for us farmers is the simple phone that we have through SMS, because you can store it on your phone and refer to it later'. (Young adults FGD 1) 'Even audio could work for those farmers are too busy to read'. (Mixed FGD 3) '…using the radio could also work, because it reaches many farmers, and some announcements could be shared, especially in the evening, when farmers are back at home'. (Young adults FGD 2) 'Our local language (Luo) is preferred, and the good thing is that we all speak same language, and this would make it easy to use the platform'. (Older people FGD1)

In addition to the lack of complementary services, a second main challenge that farmers mentioned was their disappointment with their previous connections to produce buyers. They

reported rarely interacting with produce buyers and being unaware of prevailing market prices offered by different buyers, which forced them to sell their produce to random local traders at low prices. This suggests the presence of underdeveloped buyer-farmer relationships, which undermined any chance of buyer loyalty. According to the participants, this was manifested during the marketing season when buyers offered low prices (Female FGD 1, Young adults FGD 3), simply walked away or dismissed the concerns of farmers (Mixed Group 2). To overcome these problems, farmers suggested using ICT platforms to enhance interactions between them and other actors (e.g. buyers and input suppliers), in order to create trust and build loyalty (Mixed FGD 4). This would help build stronger relationships and prevent similar issues in the future (see Table 3.4 for supporting quotations).

A third challenge related to digital literacy. Most of the farmers in the FGDs indicated that they were reluctant to use ICT services due to illiteracy and limited training in the use of mobile phones (Mixed FGD 3). Consequently, the farmers—most of whom owned simple-feature phones—did not use their phones to access agriculture-related services, as they perceived difficulties in navigating the interface (Women FGD 1). For this reason, they expressed a need for ICT platforms to train them in using mobile phones to access and use the ICT services provided.

Finally, to fulfil the ICT service needs mentioned above, farmers preferred ICT platforms to focus on easy-to-use mobile phone interface tools, like USSD codes, audio messages and a toll-free line available to assist with additional inquiries concerning interactions with value-chain actors (Mixed FGD 3). In addition, farmers favoured radio programmes for crucial activities, such as announcing the start of the buying seasons, stating the location of buying centres and providing weather forecasts for wider coverage (Young adults FGD 2). The farmers also expressed a preference for local languages as a means of communication, thereby enabling those with lower levels of education to utilise the ICT services.

3.4.2 Agro-input suppliers' challenges, ICT service needs and preferred interface design features

The KIIs demonstrated that agro-input suppliers lacked physical connections to farmers, which limited their potential customer base (Agro-input dealer, seed supplier), notwithstanding the low input sales (see Table 3.5 for illustrative quotations). As a result, agro-input dealers were unable to provide services that were not related to products, such as advising farmers on the proper use and application of agrochemicals (a role currently played by the platform's village agents). To address these challenges, agro-input suppliers expressed a need for ICT platforms to connect them directly to farmers and expand their customer base. Such connections would result in increased input sales and benefits for agro-input suppliers, in addition to improving their participation in the value chain and their utilisation of ICT services.

Table 3.5 Illustrative quotations on input suppliers' challenges, needs for ICT services and preferred interface design features

Needs and preferences	Quotations
Physical connections to farmers	'There have not been arrangements to widen our business reach, with no direct connections between us and farmers'. (Seed supplier) 'If we can't get farmers to buy our inputs, then there is no benefit'. (Agro-input dealer)
Payment services	'In this way, the platforms could also process payments to us (the input providers) through mobile money, without farmers coming to us'. (Agro-input dealer) 'In fact, through such an app, we could also have deposits and bookings for seeds made, because…for example, for seeds, demand is high, and we do not want to keep it for long, because it could go bad, and we would incur losses'. (Seed supplier)
Advanced interface tools	'For us, a smartphone is easy: orders can come through an app, and we deliver, because such a technology would provide for efficient order processing'. (Agro-input dealer). 'I prefer English, because it is easily used to navigate; maybe farmers could have it translated, I don't know, but pictures of inputs could help farmers make a choice'. (Agro-input dealer). 'English becomes easy to manage but, with technology, they need to find ways of making both the smartphone and simple phones work together'. (Seed supplier)

Agro-input suppliers also recommended that ICT platforms should incorporate input orders and payment/pre-payment services, which could entail the management of seed pre-payments during the marketing season, when farmers have cash, rather than during the planting season, when they are cash constrained. Furthermore, integrating a mobile-money payment system could provide a simpler way of processing and tracking payments, in addition to reducing

transport expenses for farmers. These services could enhance the overall usability of the ICT services amongst both agro-input suppliers and farmers.

To fulfil the needs mentioned above, agro-input suppliers expressed a preference for using advanced interface tools (e.g. smartphone apps) that could enable farmers to buy inputs directly while enabling agro-input suppliers to reach more farmers efficiently (Table 3.5). The use of a smartphone app could also allow for the integration of payments and order tracking, as well as real-time communication and feedback between farmers and agro-input suppliers, thereby increasing the efficiency of the supply chain. Furthermore, the agro-input suppliers expressed a preference for the English language as the medium of communication (Agro-input dealer). They nevertheless acknowledged the need for the platform to incorporate farmer-friendly features and local languages in order to cater to the diverse capabilities of farmers and improve their access to ICT services, as stated by both the agro-input dealer and the seed supplier.

3.4.3 Output buyers' challenges, ICT service needs and preferred interface design features

As with the input suppliers, results of the KIIs indicated that output buyers also lacked physical connections to farmers (Cereal and grain legumes buyer, Oilseed processor), which hindered interactions and service exchange between them (Table 3.6). While output buyers do have the potential to finance some value-chain activities, our findings indicate that coordination is still a challenge. More specifically, buyers indicated that, although they have only limited connections to farmers, they are expected to buy produce from them as part of their involvement in the platform (Oilseed processor, Cereal and grain legumes buyer). Individualised operations with widely dispersed farmers increase transaction costs for output buyers, which discourages their participation and cooperation in value-chain activities. To derive more benefits from ICT services, output buyers expressed a need for direct connections to farmers, as well as the need

to incorporate produce bulking and crop-yield predictions in order to reduce transaction costs (Cereal and grain legumes buyer, Oilseed processor).

Table 3.6 Illustrative quotes from buyers' challenges, needs for ICT services and preferred interface design features

Needs and preferences	Quotations
Physical connections to farmers	'The main challenge with ICT platforms is connecting with farmers for produce marketing'. (Cereal and grain legumes buyer) 'If [the platform] could connect us directly and not simply provide prices but actual connections to the farmers that could lead to transactions, it would be easier for us (as buyers) to reach the farmers'. (Oilseed processor) 'The platform can monitor the volumes and location of this produce'. (Cereal and grain legumes buyer)
Farmer loyalty	'We provide extension support services as well as seeds, but when it comes to buying the produce, farmers don't remember how much we have invested in supporting their production, and they end up selling to other buyers, just because of a small price increment, like SHS20'. (Oilseed processor) '…but in the end, we never get the produce. How can you come back? Tell me how you can keep coming when you are not sure the farmers will have produce for you'. (Cereal, grain legumes buyer) 'If we could get a scheme to explore rewards that could keep farmers loyal, it would help'. (Oilseed processor) 'Farmers need to know why they are doing business with us, what is required, and basic minimum information on how to keep time, records, bulk and negotiate prices'. (Cereal and grain legumes buyer)
Advanced interface tools	'For us to be helped in terms of efficiency, an app is better; farmers can upload their bulk produce, and we will pick it'. (Oilseed processor) 'The use of an app is fine. Like this, we can update our price information frequently and also get alerts about the farmers' bulked produce'. (Cereal, grain and legumes buyer) 'But for us, we prefer smartphones, and English is best for such operations. The local language can be used by farmers with the platform, but we prefer English'. (Oilseed processor)

Output buyers also experienced a lack of loyalty from farmers, which hindered their ability to establish beneficial connections with them. In the past, output buyers provided support services to farmers (e.g. pre-financed inputs and extension advisory services). According to our results, however, farmers often breached their agreements with buyers and sold their produce to other buyers—a practice commonly referred to as 'side-selling' (Cereal and grain legumes buyer, Oilseed processor). Side-selling by farmers left output buyers frustrated, and it discouraged from fulfilling their roles in the value chain. To build trust and loyalty between farmers and output buyers, the output buyers suggested that ICT platforms could facilitate continued interactions between them through relevant ICT interfaces, as well as physical meetings.

Furthermore, output buyers expressed a need for ICT platforms to provide farmers with training in digital literacy and business skills, including bulk marketing, to enhance their capacity to use their phones to access ICT services and manage their business relationships (Cereal and grain legumes buyer).

To fulfil the needs mentioned above, output buyers preferred advanced interface tools (e.g. smartphone apps) to improve the expected produce-market connections between the platform, buyers and farmers (Cereal and grain legumes buyer, Oilseed processor). Unlike simple-feature phones, an interface based on a smartphone app could track expected production and bulking processes, thereby enabling produce buyers to plan their field operations. Furthermore, buyers preferred using English as a medium of communication to streamline business operations into ICT services without the need for translation (Cereal and grain legumes buyer, Oilseed processor).

3.4.4 Village-based agents' challenges, ICT service needs, and preferred interface design features

According to the KIIs, village-based agents (VBAs) receive inadequate remuneration for their work, due to a lack of connections to input suppliers and produce buyers (Table 3.7). Despite the expectation that VBAs would earn commissions from the sale of inputs and produce supplies to buyers, such value-chain connections were absent (Village agent 1). The lack of connections to input and output markets made VBAs reliant on facilitation from the platform, which was perceived as inadequate. To address this challenge, ICT platforms should fully integrate VBAs into their ICT services, in order to enable linkages to commission markets for inputs and outputs. Furthermore, to ensure successful connections between VBAs and input and output markets, ICT platforms should train farmers on how to use their phones to access ICT services (Village agent 1). Digital literacy would improve the farmers' use of ICT services and benefit all the actors within the chain.

Table 3.7 Illustrative quotations on Village agents' challenges, needs for ICT services and preferred interface design features

Needs and preferences	Quotations
Connection to input and output markets	'...for us (as village agents), the platform needs to think of how it can connect us to buyers and input suppliers, so that we can earn more commission'. (Village agent 2) 'Our earnings are not clear, because the services from which we are to earn are not integrated into our activities. Right now, our facilitation is based only on loans received by farmers' groups, which are not enough'. (Village agent 1)
Digital literacy for farmers	'Many farmers do not know how to use the platform, and they are therefore not able to use the services provided through the platform, which places pressure on us to move from one farmer to another to help them'. (Village agent 2) 'For farmers to benefit from ICT services, they need more training in the use of mobile phones'. (Village agent 1)
Advanced interface tools	'For the work we do, a smartphone is better, as we can use it advise farmers, as well as to connect agro-input dealers to farmers for ordering and delivery'. (Village agent 1)

To fulfil the needs mentioned above, the results indicate that VBAs prefer using advanced interfaces (e.g. smartphone apps) to establish direct connections with farmers, input suppliers and produce buyers, as well as to track farmers' input orders and plan for input delivery (Village agent 1). In addition, smartphone tools could enable farmers to post their produce offers for timely pick-up by village agents or buyers (see quotations in Table 3.7), whilst also reducing transaction costs related to transporting farm produce by either farmers or buyers (Village agent 2).

3.4.5 Non-governmental organisations' challenges, ICT service needs and preferred interface design features

Agriculture-based NGOs aim to increase the income of farmers through the promotion of agricultural innovations, as well as through capacity building for farmers and extension agents. In the interviews, NGOs noted that they faced high operating costs for mobilising and training farmers in different value-chain segments. Moreover, although local government departments could support implementation of the activities of NGOs, they often perceived NGOs as funders and expected facilitation, thus tending to limit collaboration. The NGOs therefore expressed a desire to partner with ICT platforms to implement some of their activities (e.g. to enhance

farmers' access to production information and to provide connections to input and output markets in a timely and cost-effective manner).

Findings from the interviews indicate that the current lack of coordination amongst value-chain actors limits farmers' access to value-chain services, and especially to input and output markets, which in turn affects the expected farmer-level impacts of NGOs. To overcome these challenges, NGOs suggested that ICT platforms should coordinate the entire value chain and enable farmers' access to all actors and services within the value chain, including extension information, physical linkages to input and output markets, and other related services (NGO 1 and 2). This could help overcome barriers faced by farmers and enable NGOs to reach more farmers and create more impact efficiently.

Furthermore, to enable farmers to make full use of ICT services, ICT platforms should provide digital-literacy trainings (NGO 1, NGO 2). While farmers may use mobile phones for social communication, navigating codes and keywords to access ICT services requires additional skills (NGO 2), without which access to and use of ICT services may be limited.

To meet the needs mentioned above, NGOs preferred advanced interface tools that are compatible with both simple-feature phones and smartphones, to cater to all categories of farmers and value-chain actors using the platform to provide services to farmers (Table 3.8). For instance, a smartphone interface could enable audio-video tools to support field diagnostics, cater to illiterate farmers, and help to identify pests and diseases (NGO 2), thus addressing on-farm challenges. Furthermore, NGOs preferred offline engagement for extension advisory services, especially in areas where internet connectivity is weak and costly (NGO 2).

Table 3.8 Illustrative quotations on NGO's challenges, needs for ICT services and preferred interface design features

Needs and preferences	Quotations
Coordination of the value chain	'We would like them to add more strength on markets, post-harvest handling and other services. We would like to have a value-chain-based ICT platform where everything along the chain can be found'. (NGO 2)
	'Coordination between input suppliers and ICT firm remains a challenge. This needs to be streamlined so that all partners are fulfilling their roles in enhancing access to inputs amongst farmers'. (NGO 1)
Digital literacy	'We know that using USSD code is easy, but we can't assume that for farmers who did not go to school. In fact, training farmers in business skills could be part of this training as well, so that they will be able to negotiate with other value-chain actors and have a say with regard to their produce'. (NGO 2)
	'...train farmers in the use of phones. I think we assume that, once we send information in a text, farmers will know what to do'. (NGO 1)

3.5 Synergies and trade-offs in the needs and preferences of actors

The most profound synergetic need expressed by all actors is the need for ICT platforms to coordinate the entire value chain, thereby enhancing the delivery of relevant value-chain services for mutual benefits (Table 3.9). Such mutual benefits could emerge as ICT platforms transform value-chain processes by facilitating connections between the demand for and supply of agricultural markets (inputs, outputs, microcredit and associated services) across actors within the value chain (Chuang, Wang & Liou, 2020). Previous studies have suggested that ICT service design should encompass the needs of all value-chain actors and help to bridge spatial barriers (Krone and Dannenberg, 2018; Liverpool-Tasie et al., 2020; Smidt and Jokonya, 2022a). This view is supported by our research. Based on our findings, the integration of transaction-management systems (e.g. order processing and payments for inputs and outputs) could help to bridge spatial barriers in smallholder-based value chains by reducing transaction costs and enhancing the efficiency of service delivery, thereby increasing the value of ICT services.

Three other synergetic needs were identified with regard to optimising ICT-coordinated value chains: (1) building loyalty between farmers and business actors (e.g. buyers); (2) conducting digital literacy trainings for farmers; and (3) designing multi-faceted platforms. Fostering loyalty between farmers and business actors (e.g. buyers) is crucial for correcting market uncertainties to ensure smooth and efficient value-chain interactions and service delivery (Lajoie-O'Malley et al., 2020). For instance, facilitating information exchange and interactions between buyers and farmers could improve trust and result in strong buyer-seller relationships amongst business actors (Lajoie-O'Malley et al., 2020; Liverpool-Tasie et al., 2020). In addition, the use of contractual agreements between buyers and farmers can remove uncertainties related to the timely supply of inputs, the timely purchase of farmers' outputs and commitment to produce prices that have been promised. Furthermore, incentives through loyalty interventions and business-skills training (including bulk marketing) could improve farmers' commitment to and capacity for managing business relationships effectively.

The lack of digital literacy amongst farmers impedes their access to ICT services (McCampbell et al., 2021a). To address this challenge, we agree with recommendations from other studies that training and re-training farmers in using mobile phones is crucial (Abdullahi et al., 2021; McCampbell et al., 2021b), as are awareness campaigns led by ICT platforms and other stakeholders, including governmental entities and telecommunications companies (Girma and Kelil, 2021). We argue that digital literacy for farmers offers synergistic benefits to all actors, as it optimises interactions, connections and service delivery amongst all actors within the value chain, thereby improving the use of ICT services.

With regard to multifaceted interfaces, our study highlights the need for integrating the needs and capacities of different actors by paying particular attention to social and cultural disparities, capabilities and business goals (e.g. language, literacy and efficiency requirements). To date, digital services have largely focused on making agricultural information and knowledge

accessible, whilst offering solutions that connect farmers to resources, including markets. Such efforts have been based on the use of simple-feature mobile phones that use USSD codes (Abdulai et al., 2023). In light of the increasing availability of mobile phones, the internet and emerging technologies (e.g. big data analytics; see (Wolfert et al., 2017), the results of our study emphasise that investments in ICT services should be concentrated on multi-faceted platforms for both simple-feature and smartphones, thus catering to all actors.

Whereas all actors participating in our study agreed that the ICT-service needs discussed above are important for ICT platforms to consider, our results also identify trade-offs that ICT platforms must balance. One challenging trade-off for ICT-platform developers has to do with the choice between efficiency and reach, given the differences in preferences for ICT interface design features. On one hand, farmers prefer simple phone tools (e.g. SMS, USSD) and audio, which are easy to use and overcome illiteracy, in addition to increasing participation and the impact of ICT services. On the other hand, other value-chain actors prioritise capability and computational power to support efficient operations across different actors, which leads them to prefer internet-enabled smartphones and the use of English as a medium of communication. These divergent preferences thus pose a choice for ICT developers: either they can reach many farmers and create more impact by using simple-feature phones, or they can prioritise efficiency within the value chain and reach a more limited number of farmers, but abide by the needs of the other actors within the value chain.

Another trade-off relates to the choice between inclusion and exclusion. The preference of farmers for local languages is driven by a sense of identification and belonging, which can stimulate inclusion and participation in ICT-based value chains. While the preference for English by other actors could facilitate collaboration amongst various value-chain actors and stakeholders, without disrupting their reporting structures, the use of English may impede the farmers' access to ICT services and exclude their participation in ICT-based value chains

(Misaki et al., 2018). As a result, ICT platforms must take decisions concerning which languages to incorporate into ICT services in order to create impact across the value chain.

Table 3.9 Key insights and design implications for synergies and trade-offs

Synergies and trade-offs	Key insights	Description	Design implications
Synergies	Value chain coordination	All actors expressed a need for the platform to coordinate the value chain from production to marketing to increase the delivery of relevant services across all actors.	To enhance benefits for all actors, ICT platforms should integrate connections to various actors and services within the value chain. This includes managing orders and payment processes to avoid transaction costs related to in-person service exchange.
	Loyalty building	Actors expressed a need for the platform to create a trust-building mechanism to improve business relationships.	ICT platforms should co-create value through a loyalty-building scheme that harmonises business relationships and enhances trust and loyalty amongst actors within the value chain.
	Digital literacy for farmers	All actors collectively expressed a need for targeted and continued digital-literacy trainings to help farmers use mobile phones and access ICT services..	Training farmers to use mobile phones could optimise ICT-based interactions, connections and service delivery across actors, resulting in a successful ICT-coordinated value chain and improving the use of ICT services.
	Multifaceted interfaces	All actors agreed that there are a variety of interface needs: simple interface tools for farmers and advanced interface tools for other actors. This will require ICT platforms to integrate both types of interface tools in order to cater to all actors.	ICT platforms should integrate tools for both simple-feature phones and smartphones, customised to different languages, duration and timing of access (on-demand, online and offline) in order to include all categories of actors.
Trade-offs	Reach versus efficiency	The preference of farmers for simple-feature phone tools may increase the platform's reach amongst farmers, whilst the preference of other actors for internet-enabled smartphones could increase efficiency in value-chain operations, albeit with low reach amongst farmers.	ICT developers should integrate multi-faceted tools that align with the diverse challenges, needs and preferences with regard to enhanced access and use of ICT services amongst all actors within the value chain. This would eliminate the need to choose between using simple-feature phone tools to reach many farmers with inadequate value-chain services and using smartphone tools to create efficiency within the value chain while reaching few farmers who are able to access and use smartphones.
	Inclusion versus exclusion	The preference of farmers for local languages could increase participation in the use of ICT services, whilst the preference of other actors for English could increase collaborations with various actors and stakeholders within the value chain.	ICT platforms should integrate different language options to achieve maximum participation and collaboration between all actors, thereby enhancing access to needed value-chain services and consequently increasing the usability of ICT services.

3.5.1 Theoretical implications

This study contributes to the smallholder literature on use of ICTs by demonstrating the importance of involving users in the design process, in order to create ICT services that correspond to their needs, preferences and capabilities (Kitsios and Kamariotou, 2020; Magesa and Jonathan, 2022). Within the context of smallholder-based agricultural value chains, a user-oriented design approach has helped to identify synergies and trade-offs in service needs and interface preferences that can shape the design or re-design of existing ICT services, in addition to improving agricultural value chains in sub-Saharan Africa. User participation could help to bridge gaps between design and reality, resulting in more inclusive and better-suited service innovations (Ortiz-Crespo et al., 2020; Steinke et al., 2021). As also emphasised by our results, however, user involvement should go beyond simply involving farmers, and extend to include other core actors within the value chain (e.g. buyers, input suppliers, microfinance institutions), in order to design services and interface tools that match the challenges, needs and preferences of a variety of actors. This would create a balance between user preferences, technological feasibility and economic feasibility (LaFond and Davis, 2016), thus reducing the digital divide and leading to responsible design (Van der Burg et al., 2019).

To improve the coordination of ICT-based value chains, ICT platforms should orient themselves towards the needs of a variety of actors, in addition to mobilising and allocating resources (skills and financial) to create value for all. The benefits of market orientation for businesses have long been discussed (Narver & Slater, 1990; Kohli & Jaworski, 1990): firms that focus on understanding their customers create superior value resulting from the consistent adaptation of strategies towards the needs of customers. Understanding the needs of actors within the value chain requires constant interactions and engagement to share information and commit to actions that benefit all actors (Mukhtar and Azhar, 2020). By coordinating the entire value chain from production to marketing and by aligning value-chain services with the needs

of all actors, ICT platforms could promote the use of ICT services amongst their customers, which subsequently benefits all actors within the value chain.

3.5.2 Practical implications

The results of this study have practical implications for the managers, owners and funders of ICT platforms, as well as for input and output market companies, NGOs and policy-makers. To encourage actor participation in ICT-based value chains and to enhance the use of ICT services amongst all actors, this study has three important implications for the design of ICT services. First, managers, owners and funders of ICT platforms should prioritise solutions that resolve challenges that cut across the various actors to enhance mutual benefits. Solutions that are related to the creation of efficiency in the business processes of actors and that support their decision-making. Examples include production, marketing processes (produce bulking and pickup alerts; price information), inputs and credit connections.

Second, ICT platforms should develop multi-faceted interfaces that integrate tools for both simple-feature phones and smartphones, customised to different languages, types of access (on-demand, online and offline) and the capabilities of different actors. Such interfaces could also cater to the preferences of different actors with regard to information access (e.g. through SMS, audio and video). Multi-faceted interfaces could bring on board all actors within the value chain without the need for trade-offs and decisions concerning whose interface preferences are to be considered most important.

Third, to enhance ICT-based services, the knowledge-management literature highlights the fact that ICT platforms serve as innovation intermediaries who play multiple roles, including demand articulation, network building, knowledge brokering (Kilelu et al., 2011). To play these multiple roles, ICT platforms must develop their capacity in terms of human resources, as well as the capacity of those on whom they rely to provide this range of services (e.g. village agents). Such capacities are required for knowledge management and the development of business

models that take into account logistical arrangements for the delivery of inputs and outputs with a quality-assurance mechanism. Developing the capacity of ICT platforms and their agents could ensure that the information that is disseminated is of good quality and relevance, and that it is thus reliable.

In collaboration with NGOs and input and output companies, ICT platforms should design loyalty-building interventions that could enhance buyer-seller relationships, increase transparency and build trust, thereby enhancing the use of ICT services amongst both categories of actors. Such interventions should enhance transparency and the exchange of credible information (e.g. bulking alerts and price information) in order to enable timely produce delivery and pick-ups, in addition to mitigating conflicts. To address loyalty constraints and low prices for farmers, our study highlights the crucial role that ICT platforms can play in creating value for all actors. For instance, ICT platforms could develop business models that enhance access to input and output markets, with loyalty incentives for some volume thresholds. Such incentives could increase market certainty for farmers while reducing the costs of operation costs for buyers, who could ultimately offer a premium price for farmers' produce. This could improve relationships and trust between the parties, thus improving the use of ICT services as well.

3.6 Conclusion and direction for future research

This objective of this study was to investigate synergies and trade-offs in needs and preferences for ICT services amongst a variety of value-chain actors by focusing on perceived value-chain challenges, needs and preferences of various actors with regard to ICT services and interface design features. While ICT platforms are regarded as silver bullets in facilitating and fostering agricultural value-chain connections in a cost-effective manner, the results of our study indicate that such coordination mechanisms remain a lengthy process, requiring the consideration of and alignment with a variety of actors, as well as with their needs and preferences. As indicated by

our study, the realisation of ICT-based value-chain development hinges on the equitable fulfilment of the needs of all actors within the value chain, and not only those of smallholder farmers. Given that our results are based on a single case study, we invite future research on this subject, which could contribute insights into the relevance of eliciting the needs and preferences of all actors within the value chain in the process of designing and re-designing ICT services. Our results also indicate that multi-faceted interfaces that integrate the design interface preferences of various actors with loyalty interventions are crucial to enhancing access to and the use of ICT services across all value-chain actors. Future research is needed in order to collect empirical evidence on the impact of our recommendations.

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Disclosure statement.

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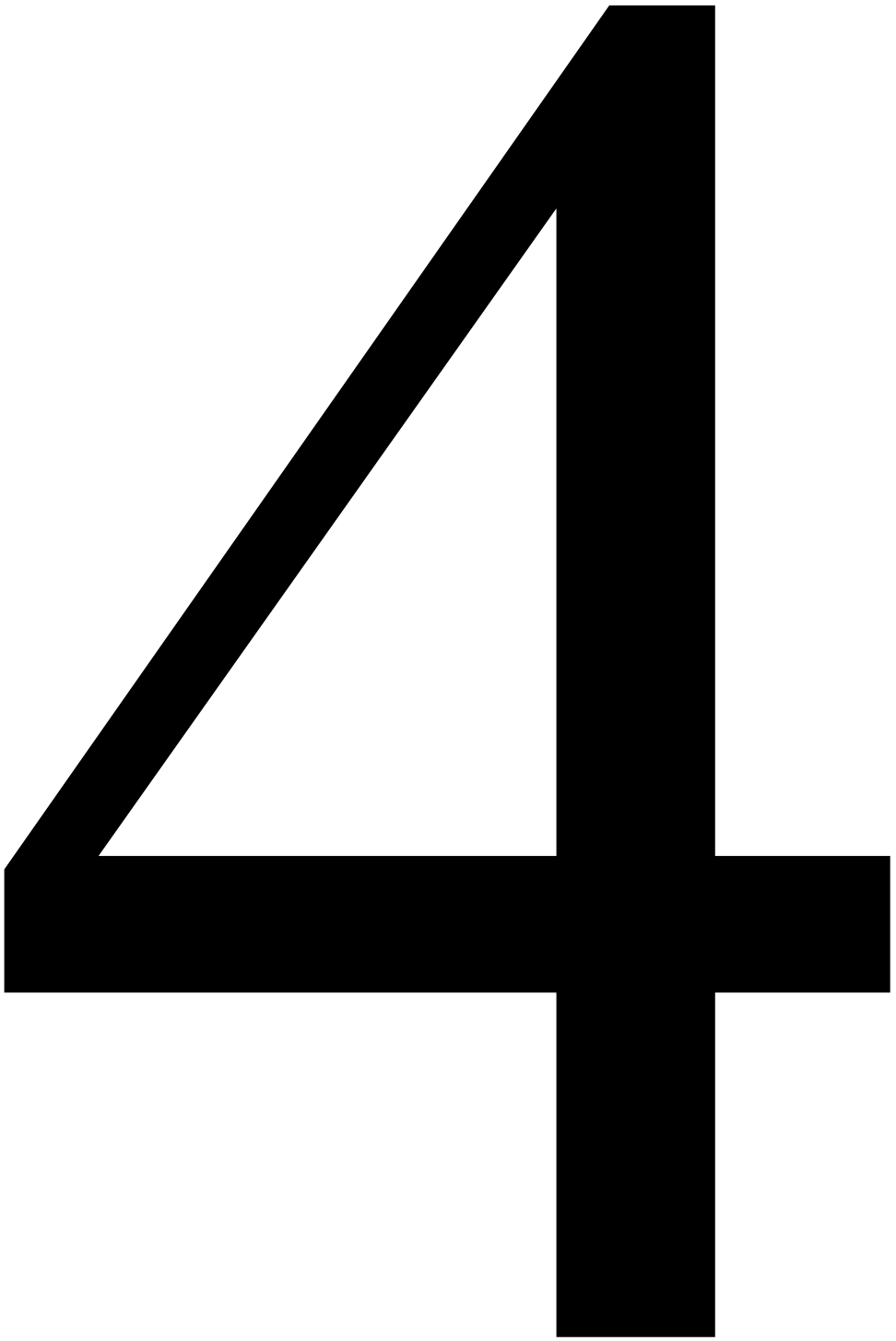

Chapter 4

Effect of Information and Communication technology-based loyalty incentives on farmers' use of agricultural inputs and productivity: Evidence from a field experiment in Uganda

This chapter is to be submitted as: Connetie Ayesiga, Esther Ronner, Peter Ebanyat, Ken Giller, and Paul T.M. Ingenbleek. Effect of Information and Communication Technology-based loyalty incentives on farmers' use of agricultural inputs and productivity: Evidence from a field experiment in Uganda

Abstract

To address low yields and contribute to food security in sub-Saharan Africa, policy-makers encourage smallholders to use productivity-enhancing agricultural inputs. Yet rates of use of such inputs remain disappointing, among others, because farmers are uncertain whether buyers willing to pay for the improved outputs will come to make a purchase. Loyalty incentives that encourage farmers to use the inputs and promise commitment from buyers may help to overcome such uncertainty. This study, therefore, examines the effects of loyalty incentives shared by an Information and Communication Technology (ICT) platform on farmers' use of agricultural inputs and soybean yields using survey data from 234 farmers in Northern Uganda. The results indicate a significant (P<0.001) influence of financial and non-financial loyalty incentives on farmers' use of improved seed and fertiliser compared with no incentives. Average soybean yields significantly increased above the control (619 kg ha^{-1}) by 525, 747 and 854 kg ha^{-1} for non-financial, financial, and a combination of financial and non-financial incentives, respectively. Our results suggest that loyalty incentives are effective in increasing the adoption of productivity-enhancing inputs to increase yields in smallholder farming, thereby advancing the knowledge on loyalty interventions for sustainable intensification of agricultural production and technology adoption through ICTs.

Keywords: ICT platforms, ICT4D, output market access, technology adoption, producer-buyer relationship, sub-Saharan Africa.

4.1 Introduction

The demand for food is growing globally due to population growth, growing incomes and rapid urbanisation. In Africa alone, food demand is projected to double by 2050 (FAO, 2017; Van Ittersum et al., 2016), yet production remains low due to dependence on rain-fed smallholder agriculture, declining soil fertility and decreasing farm sizes (Lowder et al., 2021). The central tenet of improving food production is using sustainable agricultural practices such as improved seed cultivars, organic and mineral fertilisers, crop rotations with legumes, and other related technologies. Yet, the uptake of these technologies remains low among smallholders in sub-Saharan Africa (Macours, 2019a; Stevenson et al., 2019). One factor contributing to farmers' low uptake is limited access to output markets and, more generally, the uncertainty that smallholders face trying to sell their harvested produce. Such output market uncertainty discourages farmers from investing in productivity-enhancing inputs (Aker and Ksoll, 2016; Simtowe et al., 2019b; Suri and Udry, 2022).

Output market uncertainty often stems from the lack of trust and loyalty between farmers and produce buyers (Agyekumhene et al., 2020). While farmers cope with risks of absent buyers and disappointing prices (Agyekumhene et al., 2020; Barnes et al., 2021), buyers struggle with low quantities and quality due to side-selling and dishonouring contractual agreements (Bold et al., 2017; Chavas and Nauges, 2020; Dubbert, 2019). Furthermore, side-selling by smallholder farmers hinders their power to bargain better prices from other buyers (Meemken and Bellemare, 2020; Sebhatu et al., 2020), affecting their incomes to invest in inputs. As a consequence, output market uncertainty leads to lower investment in inputs and associated farm practices, and consequently to lower farm productivity and a less-than-optimal contribution to reducing food security. Vice versa, enhancing loyalty between farmers and output buyers will overcome output market uncertainties, and increase uptake of inputs and practices as well as crop yields (Dubbert et al., 2023; Ton et al., 2018).

The relationship marketing literature suggests loyalty interventions as instruments to strengthen market relationships (Agarwal and Mehrotra, 2018; Viswanathan et al., 2022). A loyalty intervention is a system of integrated, structured and personalised marketing actions that offer loyal customers a wide range of financial and/or non-financial incentives (Bombaij and Dekimpe, 2020; Steinhoff and Palmatier, 2016). While the impacts of loyalty incentives in relationship marketing literature show positive effects on behavioural loyalty measures in hospitality and other businesses (Liu and Ansari, 2020; Viswanathan et al., 2017) , such loyalty incentives have not been widely applied in smallholder agricultural systems.

Within the existing literature, some studies have looked at incentives within contract farming and examined their effects on the quality of outputs (Hoffmann et al., 2023; Saenger et al., 2013; Treurniet, 2021), input choices in shared output arrangements (Burchardi et al., 2019), yields, incomes and welfare (Arouna et al., 2021; Bellemare, 2018; Otsuka et al., 2016). These studies have looked at contracts within the traditional face to face arrangements between farmers and buyers. As such arrangements come with high transaction costs and are difficult to enforce in the institutional context of smallholders (Macchiavello and Morjaria, 2021). Studies on loyalty incentives within a relational context, beyond the context of contractual obligations and enforcement, are to the best of our knowledge absent. This absence is logically explained by the fact that sharing the information on loyalty incentives among many small and dispersed farmers, is still a burdensome and costly effort. The growing presence of agriculture-related Information and Communication Technology (ICT) platforms in sub-Saharan Africa that can reach farmers efficiently through SMS-messages (c.f., Larochelle et al., 2019; Mohammed and Abdulai, 2022; Van Campenhout et al., 2021), offers however, new opportunities for communicating loyalty incentives.

This study aims to test whether an ICT-coordinated loyalty intervention with an assured produce market creates a change in farmers' use of agricultural inputs, and consequently improves crop

yields, in the context of soybean farming in Northern Uganda. Specifically, we: 1) Assess effects of financial and non-financial loyalty incentives on farmers' use of agricultural inputs, and 2) Assess effects of financial and non-financial loyalty incentives on farmers' soybean yields. Our research contributes to the existing literature in three ways. First, by focusing on loyalty, this study introduces a new perspective to the growing body of literature on enhancing the uptake of agricultural technologies and practices among smallholder farmers (e.g., Ronner et al., 2016; van Heerwaarden et al., 2018; van Vugt et al., 2018; Vanlauwe et al., 2019). Second, the study shows positive effects of an ICT-coordinated loyalty intervention on farmers' uptake of agricultural inputs and farm productivity in an empirical study conducted in Uganda. Third, the study distinguishes between two different types of loyalty incentives, financial and non-financial incentives, and shows that the effects are generalizable across the two types.

4.2. Background

4.2.1 The role of loyalty incentives in agricultural value chains

A growing body of research has examined the impact of improved agricultural inputs such as seed and fertilisers on the productivity of soybean smallholder farmers. For example, Tufa et al. (2019) and van Vugt et al. (2018) show how the use of improved seed varieties significantly increased soybean yields on smallholder farms in Malawi. Likewise, Ronner et al. (2016) showed that P-fertilizer and rhizobium inoculants increased smallholders' soybean yields in northern Nigeria. Similar increases in soybean yields were reported in farmers' fields in northern Uganda due to P-fertilizer and rhizobium inoculants use (Mirriam et al., 2022), with positive effects of fertiliser use in combination with no tillage reported in Ghana (Buah et al., 2017). Despite the benefits of these productivity-enhancing technologies, smallholders' adoption remains low (Ehiakpor et al., 2021; Macours, 2019a) due to, among others, the limited access to information and linkages to input and output markets (Brown et al., 2017; Muoni et al., 2019).

In general, farmers have limited access to quality inputs (Khonje et al., 2018; Mukhtar and Azhar, 2020). Even if they can obtain quality inputs, access to buyers that are willing to pay for the improved farm outputs remains a challenge. As such buyers are sourcing from many small and dispersed smallholders they face high transaction costs due to poor infrastructure and limited institutional support (Aker et al., 2016; Kilelu et al., 2017b; Krone and Dannenberg, 2018). Buyers also cope with uncertainty about the produce quality and quantity that farmers can offer, because they can't be certain that farmers have access to the necessary inputs and, if they do, whether farmers decide to purchase and apply them (Dubbert, 2019; Dubbert et al., 2023). Farmers therefore often sell their improved produce to middlemen or local traders at low prices (Aggarwal et al., 2018; Aker et al., 2016; Krone and Dannenberg, 2018). Thus, the lack of quality inputs and buyers that are willing to pay for the improved outputs result in low incomes earned by farmers which in turn forms a negative self-reinforcing loop that further constrains farmers' use of agricultural inputs and productivity (Barnes et al., 2021).

Improving farmers' use of agricultural technologies requires proper coordination of the value chain such that farmers can access and are informed about inputs as well as buyers (Chavas and Nauges, 2020). In a value chain coordination process, input providers coordinate the deliveries to smallholders to ensure that a target group of farmers can access all important inputs (Kilelu et al., 2017a). It further ensures that when farmers use the inputs to improve their produce, buyers are actually present to make them an offer for the improved quality and/or quantity (Reinker and Gralla, 2018). Value chain coordination thus removes market uncertainty for the farmers. The crucial next step is then to inform the smallholders that the market situation has changed and to persuade them to participate by purchasing and using the inputs (Minkoua Nzie et al., 2018; Minten et al., 2016). So called loyalty incentives may help to achieve this.

4.2.2 Loyalty incentives

Loyalty incentives are any kind of compensation that is given to an individual before or during a transaction with the goal of changing their attitude and behaviour towards the company or business giving the incentives (Keh and Lee, 2006). In the context of smallholders, attitudes and behaviour are changed to usage of the inputs and practices that are preferred by the output buying company. To date, loyalty incentives for smallholders have only been offered as part of contract farming arrangements (Arouna et al., 2021; Bellemare, 2018). Implementing loyalty incentives through contracts comes, however, with high transaction costs to reach individual farmers or farmer groups through extension or buyer agents. With the rapid development of ICT platforms in agricultural value chains, implementation of loyalty incentives is becoming more feasible (Purohit and Thakar, 2019). ICT platforms – are digital tools on which multiple interfaces and applications are integrated for users (Baryamureeba, 2004; Zahedi and Zahedi, 2012), including farmers and other value chain actors (Aker et al., 2016; Orr, 2018). ICT platforms can play an important role as they can easily communicate the loyalty incentives and stimulate a change of behaviour among farmers (Purohit and Thakar, 2019).

The literature distinguishes two types of loyalty incentives: financial and non-financial. Financial incentives are defined as rewards in a transaction that includes cash such as discounts, bonuses, or upgrades (Lilien, 2016; Viswanathan et al., 2017). For example, Omar et al. (2015) found that financial incentives attracted individuals to a company and raised their commitment and loyalty to the same company (Agarwal and Mehrotra, 2018; Erbschloe, 2017). Non-financial incentives are rewards in a transaction that do not include cash such as recognition, gifts, privileges, and special treatment (Brashear-Alejandro et al., 2016). Financial and non-financial incentives may also be combined (Lee et al., 2015; Lilien, 2016), because individuals may be attracted by different types of incentives (Alshurideh et al., 2020; Bombaij and Dekimpe, 2020; Brashear-Alejandro et al., 2016; Chen et al., 2021).

In this study we used both financial and non-financial loyalty incentives, together with interactions and relationship building between farmers and the buyer, to create a certain market outlet for farmers. Moreover, the loyalty incentives could only be obtained above a certain sales threshold to the buyer, which we expected to translate into increased use of agricultural inputs among farmers, to increase their produce volumes to sell to this buyer. We hypothesized as follows:

H1: Financial (price bonus) and non-financial (tarpaulins) incentives will have a positive effect on farmers' use of agricultural inputs compared with the control.

The two types of incentives aimed to cater to different types of farmers. On the one hand, in the context of smallholder farmers, non-financial incentives such as gifts for recognition might be fitting in an informal, not fully monetized economy in which people generally exchange favours. For instance, Melnyk and Bijmolt (2015) found that, adapting non-financial incentives to individuals' needs confers pride of being recognised, which increases their commitment and loyalty (Brashear-Alejandro et al., 2016). Tarpaulins as non-financial incentives were therefore expected to attract farmers to the loyalty programme to ease threshing and winnowing of their soybean grain to increase quality and earn better prices. Financial incentives, on the other hand, would appeal to farmers who have a certain level of access to output markets but are longing for better value (prices) from produce buyers. Price bonuses as financial incentives were therefore expected to attract farmers' enrolment in the LP to earn more from their production. As a result, both non-financial and financial incentives may appeal to different types of farmers, but are expected to have the same effect on input use. Hence, we hypothesised as follows:

H2: There is no significant difference in use of agricultural inputs among farmers receiving financial incentives (price bonus), compared to farmers receiving non-financial incentives (tarpaulins).

The loyalty incentives were expected to enhance farmers' use of inputs, to increase farmers' crop yields to meet the expected volumes to supply to the buyer. Several studies indicate significantly improved crop yields due to the uptake of improved seed varieties and/or fertilisers for crops such as maize, legumes, and other cereals (Martey et al., 2019; McArthur and McCord, 2017; Nurgi et al., 2023). For soybean specifically, improved seed varieties, fertilisers and the use of rhizobium inoculants (rhizobia bacteria responsible for fixing nitrogen from the atmosphere in symbiosis with legumes, applied to legume seeds at planting) are expected to increase crop soybean yields (van Heerwaarden et al., 2018; van Heerwaarden et al., 2023; Vanlauwe et al., 2019). Hence, we hypothesized:

H3: Financial (price bonus) and non-financial (tarpaulins) incentives will have a positive effect on farmers' soybean yields compared with the control.

Figure 1 shows the loyalty incentives and their expected outcomes based on the theoretical and conceptual underpinnings described above. Although loyalty incentives are expected to enhance farmers investments and use of inputs, a number of external and internal factors my influence the outcome. Several meta-analyses conducted across African countries (Fadeyi et al., 2022; Feyisa, 2020; Guo et al., 2020; Ruzzante et al., 2021) conclude that the main factors enhancing adoption of agricultural technologies among smallholder farmers in Africa include; age of the household head, education level, household size, farm size, access to extension services, land size, land tenure, access to credit, and distance to markets (inputs and outputs), and organization membership. In this study, we included household head's characteristics such as gender, age, education; household characteristics such as household size, phone, credit access, location (remote/peri-urban etc.); farm characteristics such as farm size, land tenure security; farm environment conditions such as distance to all-weather road, distance to agro-input shops, distance to output markets). These factors are included in the analysis as control variables to

explore to what extent these variables affect the relationship between the loyalty incentives and the outcome variables.

From the conceptual framework described above, the loyalty intervention offers price bonus and tarpaulins as financial and non-financial incentives to farmers, that can be earned in the future during the marketing season. We expected these incentives to result in increased investments in inputs, to increase produce volumes to supply to the output buyer, influenced by household and farm (environment) characteristics (**Figure 4.1**). In turn, the loyalty intervention would improve the relationship between farmers and buyers, reducing market uncertainties on both sides, and serving as an incentive for both parties to continue their relationship in future.

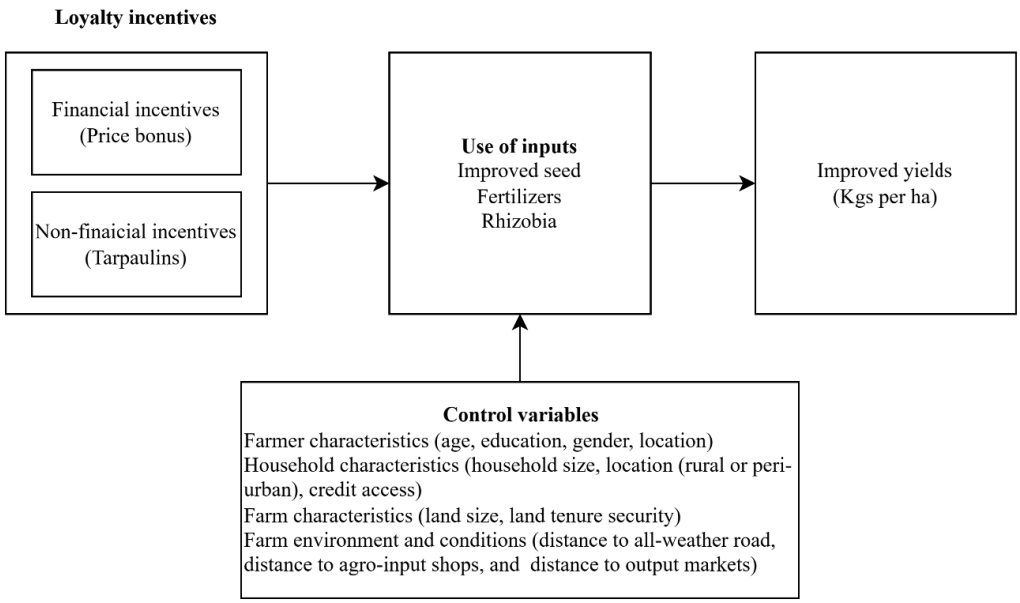

Figure 4.1 Conceptual model

4.3. Methods

4.3.1 Study context

We test our hypotheses in the context of a loyalty intervention offered through an ICT company called M-Omulimisa (www.m-omulimisa.com), implemented with soybean farmers in Lango sub region, Northern Uganda. Soybean production provides opportunities for farmers in this region to improve their incomes and nutrition, as soybean is a relatively cheap protein source. Soybean contributes to enhanced soil fertility for other crops through its ability to fix nitrogen from the atmosphere (Franke et al., 2018; Giller et al., 2011; Vanlauwe et al., 2019). In addition, soybean farmers in Lango sub-region were part of previous project interventions, including the N2Africa project in which soybean production increasing technologies were disseminated to farmers through the M-Omulimisa ICT platform. These technologies included improved soybean varieties, phosphorus fertilizers such as triple super phosphate (TSP) and single super phosphate (SSP), and rhizobium inoculants.

At the time of study, the M-Omulimisa platform facilitated farmers with soybean production information, linkages to input suppliers and access to input loans in collaboration with a government microfinance institution, particularly for improved seed. The existing ICT platform provided a suitable context to test the impact of financial and non-financial loyalty incentives on farmers' use of agricultural inputs.

4.3.2 Experimental design

We implemented a cluster randomized controlled trial in which 45 farmer groups (clusters) selected from the M-Omulimisa ICT platform database were randomly assigned to treatment groups. The selected farmers groups were those who had access to production information on soybean technologies and linkages to input providers and access to credit through the microloan scheme. The use of independent and geographically village-level dispersed farmer groups (clusters) helped to avoid contamination across treatment groups. All the farmer groups were

located in the Lango sub region, with similar geographical features, production conditions, income levels, culture and language.

The 45 clusters were randomized to four treatments namely (i) Financial incentives (cash bonuses only). (ii) Non-financial incentives (tarpaulins only) (iii) Both financial + non-financial incentives (both cash bonuses and tarpaulins) (iv) Control (no incentives). All information on the loyalty intervention was communicated through the ICT platform. Farmers in the treatment groups interacted with the buyer through physical meetings and through buyer agents to enhance trust and market certainty. Farmers in the control group only received general information on the presence of the buyer in the area via SMS (Appendix 1). All groups received production information on soybean (when to plant, weed, etc., synchronised with the farming calendar) and contacts of input suppliers (Appendix 4.1).

In total, we had n =11 groups for each of the control, financial and non-financial treatment groups while the both financial + non-financial treatment group had n =12 groups. The unequal number of groups resulted from some groups being located in the Eastern region but had been entered wrongly in the M-Omulimisa ICT database as located in the Lango sub region. All information shared to all treatment groups was translated in the Langi local language and sent to the different treatment groups through mobile phones during the second season of 2021 (August to December 2021). All farmers could ask for clarifications about the information shared through the platform or the village agents working with the ICT platform. In addition, the village agents were expected to aggregate farmers' produce for the buyer and earn a commission while reducing the transaction costs for both the farmers and the buyer.

We applied the loyalty incentives to the case of soybean production in Northern Uganda (more detail in section 3.1). The financial incentive comprised a price bonus: farmers would receive a premium price of 0.03 USD for every kilo, if they sold more than 800 kg of soybean to the buyer. Non-financial incentives offered were tarpaulins (used by farmers use to dry their harvest

and improve product quality), to be obtained after farmers sold 800 kg of soybean individually, or 20,000 kg as a group to the buyer.

4.3.3 Sampling and data collection

Although the unit of randomization was a farmer group (cluster), the unit of analysis was the household. To select survey respondents from each of the 45 farmer groups recruited into the LP intervention, we used the probability-proportionate-to-size sampling because of unequal group sizes, and used simple random sampling to select actual household participants for the survey. This resulted into a randomly selected sample of 234 farmers who had grown soybean in the second season to complete the questionnaire.

Data about farmers' use of inputs (improved seed, fertiliser and rhizobia), social demographics, and other variables such as distance to input and output markets, was collected using a cross section survey questionnaire, programmed onto a computer tablet using Open Data Kit (ODK). A 5-point Likert scale was used to measure farmers' use of inputs scoring from 1-Very little extent, 2- Little extent, 3-Neutral, 4-Large extent, 5-Very large extent. In addition, an additional score of "Not at all" was added to reflect non-use of inputs by farmers. The use of a Likert scale served to assess farmers' intensity of using inputs from their own behaviour perspective. Soybean yields were based on farmers estimates, collected in kilograms per acre and translated to kg ha^{-1} during analysis.

Prior to data collection, enumerators were trained covering all aspects contained in the survey questionnaire to ensure understanding of all variables and terms used. The questionnaire was pre-tested among farmers in one of the communities outside the villages covered by this study (Ingenbleek et al., 2013). To collect the data from respondents, consent was requested before we proceeded with the interviews. M-Omulimisa's village agents were used to mobilise the randomly selected farmers. In cases where these farmers were not available during the day of

data collection and a day that followed, other group members were randomly selected to replace them. The interviews lasted between 45 and 60 minutes on average.

4.3.4 Data analysis

Two data analysis techniques were employed. First, a multivariate analysis of variance (MANOVA) in R version 4.2.3 was used to test the study hypotheses of the effects of loyalty programme incentives on farmers' use of improved seed, fertilisers and rhizobia combined (H1), because of more than one dependent variable. To run the MANOVA, we combined the "Not at all" scores with the "Very little extent" score to fit in with the 5-point Likert scale. To account for violations of normality assumptions expected from the Likert-scale data, bootstrapping was conducted to generate a bootstrapped distribution of F-statistics for the MANOVA model. The bootstrapped test yielded the same results as the MANOVA statistic, indicating that our test statistic was dependable. We used a 95% confidence interval for the MANOVA test.

To determine significant differences in medians of the control and treatment groups (H2), the Kruskal–Wallis test for non-parametric data was used, followed by a pairwise comparison to show how the use of inputs (improved seed, fertilisers and rhizobia) was affected by the different treatment groups.

To determine effects of other factors on the relationship between loyalty incentives and outcome variables, we included control variables using the multivariate analysis of covariates (MANCOVA) test at 90% confidence interval, which we assumed to have enough precision about the effect of the control variables on the effect of the loyalty intervention. Secondly, we conducted an ANOVA to test the effects of loyalty incentives on soybean yields obtained by farmers (H3). We used Tukey's HSD test to compare differences in yield between the treatment groups. To determine the contribution of each agricultural input type to soybean yields, we conducted a simple linear regression.

4.4. Results

4.4.1 Effects of financial and non-financial loyalty incentives on farmers' use of inputs

Compared with the control, all treatments had a positive effect on the combined use of improved seed, fertilizer and rhizobial inoculants $F(9, 690) = 8.4782$, $p < 0.001$; Pillai's Trace = 0.2987 (Table 4.1a); partial $\eta p2 = 0.10$, a large effect size (Cohen 1988, p.368). The bootstrap results show that the true population mean of 8.4782 falls within the confidence interval of 15.042 and 16.517 at 95% (Table 4.1b), and therefore confirms the Pillai's Trace results. Thus, hypothesis 1 which predicted a positive and significant effect on farmers' input use by financial and non-financial incentives compared to control is supported.

Table 4.1a & b MANOVA results summary for the effect of the loyalty incentives on use of inputs (a) and Boot statistics results (b)

a)

Summary MANOVA

	df	Pillai approx	F	num df	den df	P value	
(Intercept)	1	0.99591	18515.3	3	228	< 0.001	***
Treatment	3	0.29872	8.4782	9	690	< 0.001	***
Residuals	230						

Significance. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

b)

	Boot statistics					Boot Confidence Intervals (95%)	
	R	original	bootBias	bootSE	bootMed	Lower	Upper
1	1000	8.4782	-7.4798	0.39453	0.93849	15.042,	16.517)

If we consider the use of improved seed, fertilisers and rhizobia individually, all treatments had a positive effect on the use of improved seed and fertilizer. About one third of the farmers who received a combination of both financial and non-financial incentives used improved seeds to a 'large extent', and 12% to a 'very large extent', compared with 41% to a 'very little extent' in the control group (Figure 4.2). For fertilizers, 6% of farmers who received a combination of both financial and non-financial incentives were 'neutral' in their use of fertiliser, and 11% used

fertilisers to a 'little extent', compared with 98% who scored 'very little extent' in the control group (Figure 4.2).For rhizobial inoculants, although the MANOVA test statistic showed significant differences across treatment groups on farmers' use of improved seed, fertilizer and rhizobial inoculants combined, our results showed absolute numbers of households using rhizobial inoculant were very small (Figure 4.2).

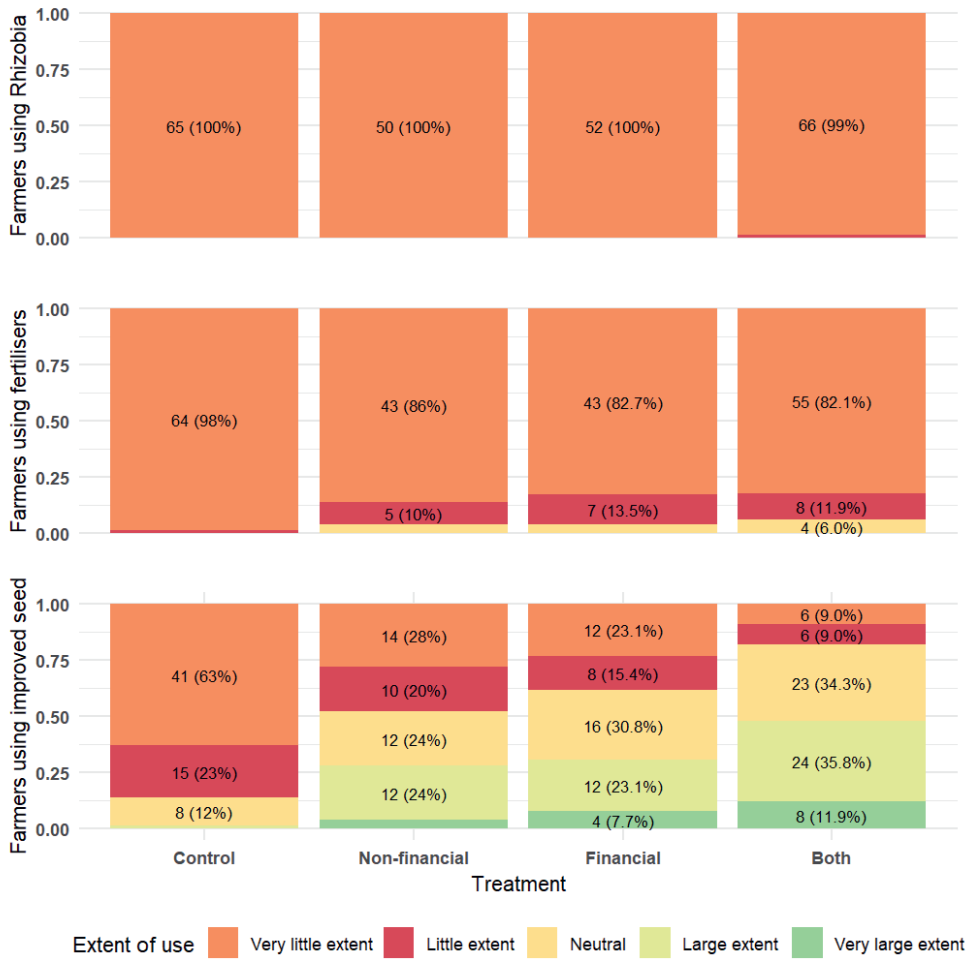

Figure 4.2 Percentage of respondents using improved seed, fertilizer and rhizobia across control (*n = 65*), non-financial (*n =50*), financial (*n =52*), both financial and non-financial (*n = 67*)

The post-hoc test results confirmed that for the use of improved seed and fertilizer, the control group was significantly different from all treatment groups (Table 4.2). Although the combination of both financial and non-financial treatment was significantly different from the non-financial treatment, it was not significantly different from the financial treatment. This means that the financial incentives could have attracted farmers to use improved seed more than the non-financial incentives in the treatment with both financial non-financial incentives.

For fertilizer use, similarly, significant differences were only found between the control and financial treatment, and between the control and the combination of both financial and non-financial treatments (Table 4.2). For rhizobia, the post hoc test results showed that the differences between the control and treatment groups were not significant with $p > 0.05$ (data not presented).

Our results from the pairwise comparison showed that use of improved seed was statistically different between farmers who received non-financial incentives alone and those who received a combination of both financial and non-financial incentives, and between farmers in the control and those who received financial incentives alone. In the use of fertilisers, statistical differences were observed between farmers in the control and those who received financial incentives and between farmers in the control and those who received a combination of both financial and non-financial incentives. There were no significant differences observed between farmers who received financial incentives alone and those who received non-financial incentives alone in the use of both improved seed and fertilisers. Therefore, hypothesis 2 predicting no significant differences in use of agricultural inputs among farmers receiving financial incentives, compared to farmers receiving non-financial incentives is supported.

Table 4.2 Pairwise comparison between treatment groups across the use of improved seed and fertiliser

	Pairwise comparison MANOVA				
	Response variables	**Group1**	**Group2**	**P.adj**	**P.adj.signif**
1	Improved seed	Control	Financial	0.00	****
2	Improved seed	Control	Non-financial	0.00	****
3	Improved seed	Control	Both	0.00	****
4	Improved seed	Financial	Non-financial	0.83	ns
5	Improved seed	Financial	Both	0.06	ns
6	Improved seed	Non-financial	Both	0.00	**
7	Fertilizer	Control	Financial	0.04	*
8	Fertilizer	Control	Non-financial	0.10	ns
9	Fertilizer	Control	Both	0.01	**
10	Fertilizer	Financial	Non-financial	0.99	ns
11	Fertilizer	Financial	Both	1.00	ns
12	Fertilizer	Non-financial	Both	0.93	ns

Significance level codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

With the control variables added in our MANCOVA, we found that phone ownership of the household head ($p < 0.1$) and area planted with soybean ($p < 0.05$) had a significant effect on farmers' use of improved seed, fertilizer and rhizobial inoculants combined (**Table 4.3**). However, the effects sizes were very small with Partial Eta Squared; ηp2 at 0.03 and 0.004 for phone ownership of the household head and land size located to soybean production, respectively.

Table 4.3 MANCOVA summary results of effects of the loyalty incentives controlling for covariates

	Mancova summary results						
	Df	**Pillai**	**Approx F**	**num df**	**den df**	**P values**	
Treatment	3	0.31546	8.5391	9	654	0.000	***
Age	1	0.010765	0.7835	3	216	0.504	
Location (peri-urban or rural)	1	0.014219	1.0386	3	216	0.378	
Education	1	0.005421	0.3924	3	216	0.765	
Gender	1	0.023965	1.7678	3	216	0.156	
Household size	1	0.003438	0.2484	3	216	0.866	
Phone ownership of house hold head	1	0.030488	2.2642	3	216	0.081	.
Area planted with soybean	1	0.043702	3.2904	3	216	0.021	*
Loan access for soy	1	0.010852	0.7899	3	216	0.500	

Distance to agro input shops	1	0.002319	0.1674	3	216	0.918
Distance to output markets	1	0.001918	0.1384	3	216	0.936
Land use rights	1	0.021953	1.6161	3	216	0.186
Distance to all weather road	1	0.005617	0.4067	3	216	0.748
Residuals	218					

Significance level codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

4.4.2 Effects of financial and non-financial loyalty incentives on farmers' yields.

The average yields per treatment were; 619 kg/ha for the control, 1146 kg/ha for the non-financial incentives, 1465 kg/ha for the financial incentives, and 1475 kg/ha for a combination of both financial and non-financial treatment groups. Results from a one-way ANOVA (Table 4.4**)** revealed that there was a statistically significant difference in soybean yields between the treatment groups [$F(3, 230) = 45.71$, $p < 0.001$]. Our results indicated that farmers who used more productivity enhancing agricultural inputs had on average higher yields due the loyalty incentives. Thus, hypothesis 3, predicting a positive and significant effect on farmers' yields by financial and non-financial incentives compared to control is supported.

Table 4.4 Anova model results showing effects of treatments on soybean yield

Anova model summary						
	Df	Sum Sq	Mean Sq	F value	P value	
Treatment	3	30512650	10170883	45.71	0.000	***
Residuals	230	51175441	222502			

Significance level codes: '***' 0.001

Tukey's HSD Test for multiple comparisons showed that the mean value of soybean yields was significantly different between at least two treatment groups (Figure 4.3, Table 4.5). These differences were significant between all treatment pairs, except between the financial and both financial and non-financial ($p < 0.99$, 95% C.I. = -216.34, 234.87) treatment groups.

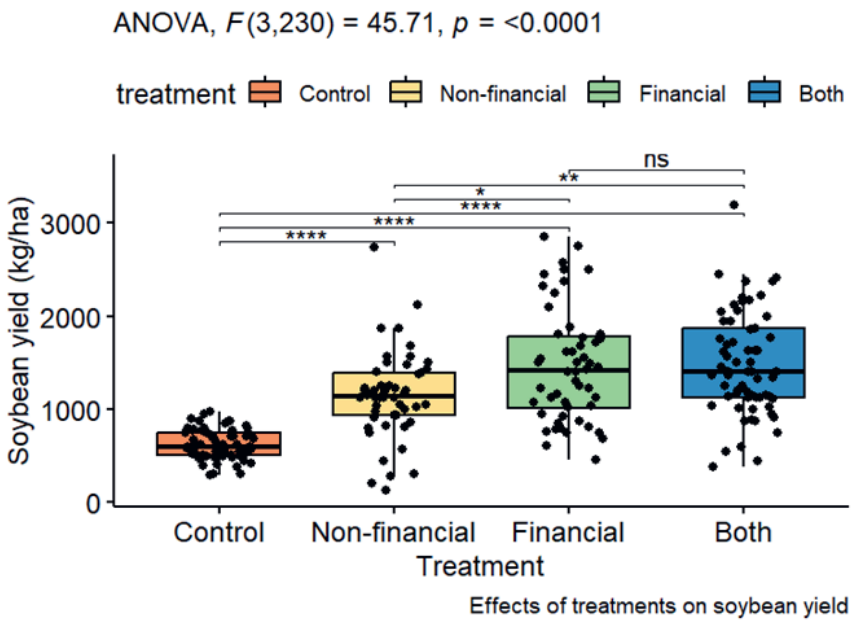

Figure 4.3 Farmer-reported soybean yields (kg/ha) in the control and different treatment groups

Table 4.5 Tukey's HSD test showing multiple comparisons between treatment groups

Tukey pairwise comparison results				
Treatment	Difference	Lower	Upper	P adj
Non-financial-Control	526.79261	297.16528	756.42	0.00
Financial-Control	846.39229	619.27463	1073.51	0.00
Both-Control	855.65666	643.13206	1068.18	0.00
Financial-Non-financial	319.59968	77.81446	561.385	0.00
Both-Non-financial	328.86406	100.73171	556.996	0.00
Both-Financial	9.264375	-216.34167	234.87	1.00

Although the treatments increased farmers' use of agricultural inputs, our results from simple linear regression showed that yield increments were mainly influenced by use of improved seed ($p < 0.001$) and not use of fertilizer (Table 4.6). This is because few farmers used fertilizer and, the extent of use was low even among those farmers who used fertilizer (Figure 4.2).

Table 4.6 Effects of improved seed and fertilizer to yield increments

	Coefficients				
	Estimate	Std Error	t value	P values	
Intercept	462.86	94.1	4.919	0.00	***
Improved seed	260.45	26.79	9.722	0.00	***
Fertilizer	35.12	76.67	0.458	0.647	

Significance level codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Adding fertilizer together with improved seed led to increased yields in the financial and a combination of both financial and non-financial but not in the non-financial treatments (Figure 4.4 A). Furthermore, as the extent of use of inputs increased, soybean yield increased in the financial and in the combination of financial and non-financial treatments (Figure 4.4 B).

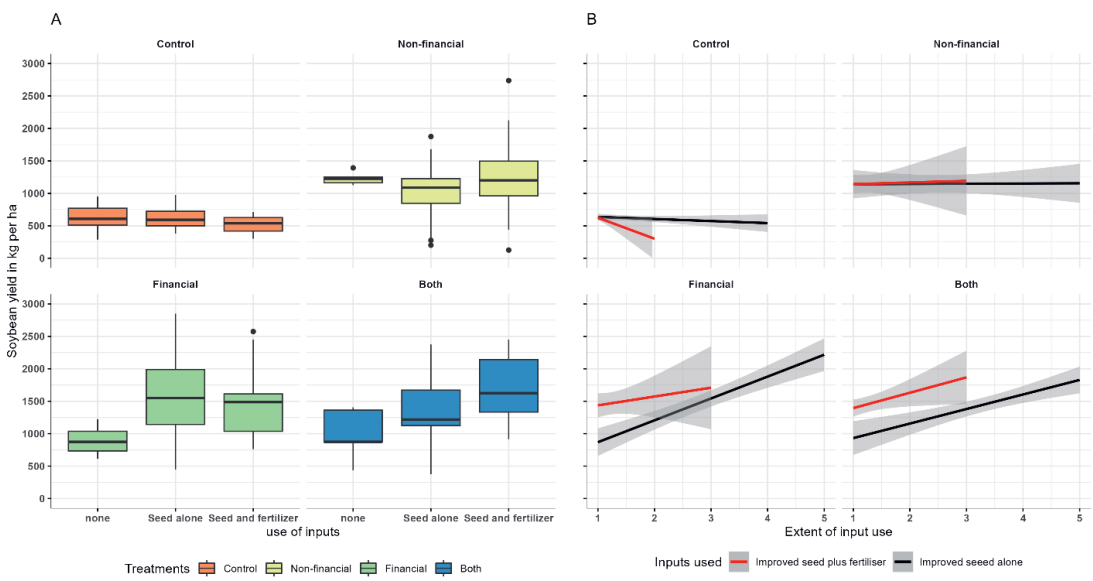

Figure 4.4: A) Box plots of input use on soybean yield across the control and treatments. B) Likert scale effects of extent of use of each input type on soybean yield.

4.5. Discussion

The purpose of this study was to assess the effects of financial and non-financial loyalty incentives on smallholders' use of agricultural inputs and resulting crop yields. Our results show that financial and non-financial incentives communicated through mobile phones significantly influenced farmers' use of agricultural inputs (improved seed and fertilizers), and consequently increased farmers' yields.

While our findings show large effects of the treatments on the use of improved seed compared with the control, there were only small differences between the financial and non-financial treatment groups, and the financial and a combination of financial and non-financial treatment groups. As hypothesised, the evidence indicates that farmers are more likely to use agricultural inputs if they expect loyalty incentives, from an assured buyer. These findings are consistent with findings by studies on marketing incentives in contract schemes. For instance, Hoffmann et al. (2023) investigated the effect of a modest food safety premium on semi-subsistence farmers' investment in a food safety technology in Eastern Kenya. The authors found that a 5% market premium for produce that met the associated regulatory standard increased doubled maize farmer's investment in the food safety technology. Treurniet (2021) found that an individual price bonus incentive focusing on compositional quality improved the quality of milk among Indonesian dairy farmers. Saenger et al. (2013) showed positive effects of both a higher penalty for low quality milk and a bonus for high quality milk on dairy farmers' use of inputs in Vietnam.

Our study extends the relational marketing strategies to crop farming, particularly for smallholder farmers, and demonstrates how loyalty interventions can help buyers differentiate themselves through competitive price offers to enhance farmers' loyalty (Brashear-Alejandro et al., 2016) and stimulate smallholder uptake of agricultural inputs. Our results show that market uncertainty resulting from a lack of access to market information (available buyers and

prices) affects farmers' use of agricultural inputs, as seen from the control groups. Furthermore, our results suggest that interactions and relationship building with the buyer in addition to loyalty incentives communicated through the ICT platform could have increased farmers' market certainty (Ola and Menapace, 2020), stimulating their investments in productivity enhancing agricultural inputs.

Although our findings indicate effects of loyalty incentives on fertilizer use, large differences were only observed between the control and financial treatments, and between the control and the combination of both financial and non-financial treatments. These results suggest that financial incentives appeared to be more attractive than the non-financial. Despite the wide demonstration of productivity enhancing incentives of phosphorus fertilizers (e.g. TSP) among farmers in the region, the lack of access to such types of fertilizers, the high investment costs, the risk of weather shocks, and the variability in response and profitability (Ronner et al., 2016; van Heerwaarden et al., 2023) could have limited farmer's use.

We were unable to test hypothesis 1 for rhizobia, as few farmers used rhizobial inoculants. Despite efforts in previous projects to enhance awareness on rhizobial inoculants and their benefits in soybean cultivation (Van Heerwaarden, 2017), the supply chain has not been developed and inoculants are not available in local shops in rural Uganda (Vanlauwe et al., 2019). Rhizobial inoculants are produced at a small scale by Makerere University and not widely-distributed, hindered by the lack of effective distribution networks (Ronner et al., 2016), Vanlauwe et al., 2019). This finding was also echoed by (Brown et al., 2017) who find that uptake of maize-legume agricultural inputs among farmers in Africa was hindered by unreliable input market infrastructures, failing to meet the input needs of farmers.

Although the effects were small, phone ownership and area planted with soybean increased farmers' use of agricultural inputs. For area planted with soybean, these findings are consistent with some studies on different crops who found that an increase in land allocation for a

particular crop, including soybean, enhanced farmers' use of agricultural inputs (Anang et al., 2021; Danso-Abbeam and Baiyegunhi, 2018). These results indicate that farmers with a large area planted with a crop give more priority to that crop, and are inclined to invest more resources in that particular crop. Hence, as soybean production is regarded a profitable venture in the study area, farmers who allocate more land to soybean are expected to intensify their investments in agricultural inputs to enhance their yield gains. The effects of phone ownership by the household head on use of inputs indicate that phone access and ICT platforms can enhance farmers' access to information and capacity to use it to invest in agricultural inputs (Aker and Ksoll, 2016).

The increases in yield as an effect of the increased use of inputs were influenced by the use of improved seed rather than by fertilizer, due to the limited use of the latter. Although few farmers used fertilisers, our results showed that adding phosphorus fertilizer to improved seed positively influenced yields, in line with Van Heerwaarden et al. (2023), Ronner et al. (2016) and Ulzen et al. (2018). Furthermore, our study showed that soybean yield increased with a larger self-reported extent of use of inputs. Despite the beneficial effects of improved seed and phosphorus fertilizers on soybean yield, (physical) access to such agricultural inputs remains a challenge in many countries in sub-Saharan Africa (Sheahan and Barrett, 2017; Bold et al., 2017). There are various reasons for this, including lack of credit to pre-finance the inputs, poor quality inputs available, and lack of physical linkages to agro-input dealers. While farmers could get an input loan in our experiment, only a few farmer groups accessed the loan due to low coverage of the scheme and bureaucratic and non-digitalised application processes.

From the above discussion, this study draws the following practical implications. First, market certainties related to produce markets in combination with (financial) loyalty incentives emerge as a strong stimulant for farmers' use of inputs in this study. These results show that farmers' access to output markets linkages with competitive prices are necessary for enhancing farmers'

investment in agricultural inputs. However, farmers' use of inputs will only increase when these inputs are easily available. Overall, our results suggest that, in addition to improved output market linkages, addressing the low use of inputs and low yields among smallholder farmers necessitates improving farmers' physical linkages to inputs through input loans, quality inputs within their localities and knowledge about the benefits and use of the inputs.

Second, business models for input markets such as fertilizer and rhizobial inoculants need to be redesigned to allow greater access by farmers in rural areas. Future research should establish the effects of output market-based loyalty program incentives within established logistical arrangements for fertilisers and rhizobial inoculants. Such research findings would be relevant for policymakers and value chain stakeholders interested in enhancing uptake of technologies to develop smallholder-based value chains.

Third, while further studies of use of fertilisers and rhizobial inoculants are needed within established logistical arrangements, the increasing use of improved soybean seed varieties in Uganda is evident. Since the launching of N2Africa project in Uganda in 2014, use of improved seed varieties released by Makerere University has expanded resulting in availability of certified and quality declared seed in most rural areas of northern Uganda. Furthermore, efforts of the ICT platform to disseminate soybean technologies has continued even after the project end with linkages to improved seed through micro loans now available to rural farmers, and a growing local demand for soyabean for poultry feed and exports to neighbouring Kenya. If input and output markets are coordinated to enable access by smallholders, increased use of inputs for improved soybean production is to be expected.

4.6. Conclusion

This study assessed the effects of financial (price bonus) and non-financial (tarpaulins) incentives, delivered through an ICT platform, on the use of productivity enhancing inputs and yields among soybean farmers in Uganda. The results indicate that the loyalty incentives enhanced farmers' use of agricultural inputs (improved seed and fertilizers) and soybean yields, as farmers were incentivised to increase their produce volumes for the buyer. Furthermore, our study shows that ICT platforms have the potential to mitigate uncertainties related to output markets (produce buyers and prices) by enabling access to timely and accurate market information, which enhances farmers' investments in agricultural inputs. Although information on inputs, output market, and expected loyalty incentives enhanced farmers' use of inputs, availability of required inputs remains a barrier to more widespread use of inputs among smallholder farmers.

Acknowledgements

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Disclosure statement

We have no competing interests to declare.

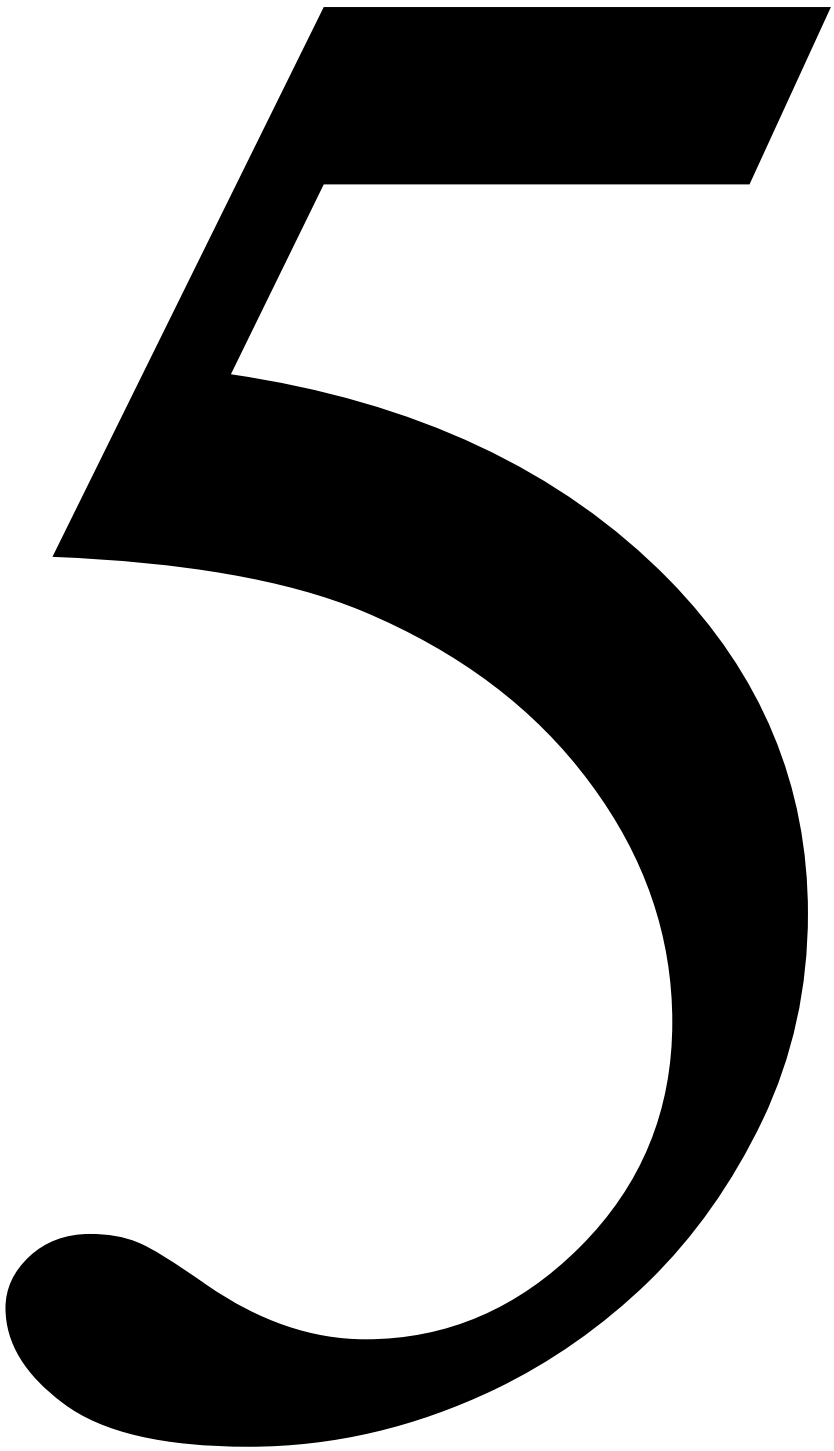
Appendix 4.1 Loyalty intervention information sent to individual farmers across the treatment and Control groups

	Financial	Non-Financial	Financial + Non-financial	Control
1st set	Dear (farmer name), as you plan to plant for the new season, m-Omulimisa has brought on-board a new company called "focal buyer" to ensure that, you have a market for your soybean at the end of season. "focal buyer" will offer you a guaranteed competitive price for your soybean. Peter from m-Omulimisa.			
	To ensure you benefit from this competitive price offered by "focal buyer", we recommend that you use improved production inputs such as improved seed, fertilisers and inoculants. To purchase, contact Denis 0778200390 for seed, Ogwang Isaac on 0781796669 for fertilisers.			
	For an additional improvement in your yield, we highly recommend to use good farming practices such as timely planting and ap propriate spacing, row planting, timely weeding, among others in addition to improved inputs. Send queries to 0800219999 for more information.			
	Because soybean is an important crop as a cheap protein source for humans and animals, we are delighted to partner with you by ensuring you have a good market for your soybean so that those who are not able to grow it, can equally benefit from its protein source _"focal buyer"			
	To show our commitment to this partnership, we are keen to sign contracts with you as farmer groups as a guarantee to buy your produce at end of season. "focal buyer" staff will be in touch during the season to make sure you get the best quality harvest. We (m-Omilimisa) are in this together _Paul "focal buyer"			
	We as "focal buyer", guarantee a price bonus of 100 shs per kilo if you deliver 20 tonnes of soybean or more as a group at the end of season _"focal buyer".	We as "focal buyer", guarantee to reward a tarpaulin for each member of the group that will supply 20 tonnes of soybean or more _"focal buyer".	We as "focal buyer", will offer a price bonus of 100 shs per kilo and tarpaulins for each member of the group that delivers 20 tonnes of soybean or more _"focal buyer".	
2nd set	Hello xxxx (farmer name) To maximise your yields and be able to earn the price bonuses of 100 shs per kilo offered by "focal buyer", you are reminded to use good farming practices such as timely planting and appropriate spacing, row planting, timely weeding, etc. _m-Omulimisa.	To maximise your yields and be able to earn the gift rewards of tarpaulins offered by "focal buyer", you are reminded to use good farming practices such as timely planting and appropriate spacing, row planting, timely weeding, etc. _m-Omulimisa	To maximise your yields and be able to earn the price bonuses of 100 shs per kilo and gift rewards of tarpaulins offered by "focal buyer", you are reminded to use good farming practices such as timely planting and appropriate spacing, row planting, timely weeding, etc. _m-Omulimisa	To maximise your yields, you are reminded to use good farming practices such as timely planting and appropriate spacing, row planting, timely weeding, etc. _m-Omulimisa
3rd set	As the time for harvesting nears, we remind you to exercise good practices such as harvesting only ripe plants and drying your produce on a tarpaulin to improve the quality and marketability of your produce and be able to earn the	As the time for harvesting nears, we remind you to exercise good practices such as harvesting only ripe plants and drying your produce on a tarpaulin to improve the quality and marketability of your produce	As the time for harvesting nears, we remind you to exercise good practices such as harvesting only ripe plants and drying your produce on a tarpaulin to improve the quality and marketability of your produce and be able to earn the price bonuses of	As the time for harvesting nears, we remind you to exercise good practices such as harvesting only ripe plants and drying your produce on a tarpaulin to improve

	price bonuses of 100shs per kilo offered by "focal buyer". _m-Omulimisa.	and be able to earn gift rewards of tarpaulins offered by "focal buyer". _m-Omulimisa.	100shs per kilo and gift rewards of tarpaulins offered by "focal buyer". _m-Omulimisa.	the quality and marketability of your produce. _m-Omulimisa.
4th set	The buying season is here, as "focal buyer", we are ready to buy your soybean produce. Our bulking centres are located at ....., ... Contact us on			
	As you bring your produce to the bulking centre, make sure our buying agents record your name, produce supply and your group name, in order for your group to be awarded bonus points that will earn you the offered price bonuses of 100 shs per kilo if your group brings 20 tonnes and above of soybean produce. _"focal buyer"	As you bring your produce to the bulking centre, make sure our buying agents record your name, produce supply and your group name, in order for your group to be awarded bonus points that will earn you the offered gift rewards of tarpaulins if your group brings 20 tonnes and above of soybean produce. _"focal buyer"	As you bring your produce to the bulking centre, make sure our buying agents record your name, produce supply and your group name, in order for your group to be awarded bonus points that will earn you the offered price bonuses of 100 shs per kilo and gift rewards of tarpaulins if your group brings 20 tonnes and above of soybean produce. _"focal buyer"	
	To earn your price bonuses, make sure you receive a supply card indicating your ID number, quantity of produce supplied and the name of your group. _"focal buyer"	To earn your gift rewards of tarpaulins, make sure you receive a supply card indicating your ID number, quantity of produce supplied and the name of your group. _"focal buyer"	To earn your price bonus and gift rewards of tarpaulins, make sure you receive a supply card indicating your ID number, quantity of produce supplied and the name of your group. _"focal buyer"	

Appendix 4.2 Demographics of respondents

Treatment	N	Age	Education (years)	Household size	Gender	
					Male	Female
Control	65	30.7	8	5	55	10
Financial	52	31.8	8	5	45	7
Non-financial	50	31.2	8	5	39	11
Both	67	39	8	5	59	8



Chapter 5

Marketing Innovations in Rural Markets in Emerging Economies: Strengthening Loyalty through an ICT Platform in Uganda

This chapter is to be submitted as: Connetie Ayesiga, Esther Ronner, and Paul T.M. Ingenbleek. Marketing innovations in rural markets in emerging economies: Strengthening loyalty through an ICT platform in Uganda

Abstract

The growing presence of mobile phones in distant rural areas of emerging economies opens new opportunities for marketing innovations in agricultural, rural markets. The development of smallholder-based agricultural value chains is, in that respect, particularly important to enhance the production of sufficient food for rapidly growing populations. Historically, integrating widely scattered small-farming communities in value chains has always been difficult because remoteness comes with many barriers that hinder the development of market relationships. We present results from a field experiment on an ICT platform providing loyalty incentives as a relationship-building mechanism between farmers and a buying company in Uganda. Both financial and nonfinancial loyalty incentives appear to positively affect farmers' loyalty intention. Affective and calculative commitment mediate these relationships. The effects appear to be stronger for farmers that have greater trust in the ICT platforms. Pressure from other buyers negatively influences farmers' loyalty intentions, but the effect is weaker than that of loyalty incentives. These findings suggest that loyalty incentives are effective innovations for value chain development in rural markets of emerging economies.

Keywords: Marketing innovations, Value chains, Rural markets, Emerging economies, ICT4D, Buyer competition, Sub-Saharan Africa.

5.1 Introduction

In his seminal work on the fortune at the bottom of the pyramid, Prahalad (2001) already foresaw that Information and Communication Technology (ICT) would have a disruptive impact on rural markets in emerging economies, opening a new technological basis for innovations that could potentially solve persisting problems in these markets. In the past, it has always been difficult to develop rural markets because reaching a sufficient number of farmers with information without exceeding transaction costs was sheer impossible. The rapid dissemination of mobile phones has created new opportunities, including the possibility to reach farmers efficiently through SMS messages or through web-based platforms and applications that provide information and other services (Aker and Ksoll, 2016; Baumüller, 2018) . Prominent examples of platforms that have contributed to market development include e-Choupal, which provides up-to-date marketing and agricultural information to millions of farmers in India (Mukerji, 2020), and M-Pesa, a mobile money system in Kenya that allows farmers to make and receive payments (McBride and Liyala, 2023).

Innovation in rural markets of emerging economies is not only essential to reduce poverty among small-scale farmers but also to ensure that food production keeps pace with the growing and urbanising population (cf. FAO et al., 2020; van Berkum, 2021). The often dispersed agricultural communities are largely integrated with markets through small-scale traders that visit the communities to collect small quantities of agricultural output and resell it to larger traders in more central markets who aggregate it to higher volumes that can be transported to the urban populations (Fafchamps, 2003; Ingenbleek, 2020). This market system has always been vulnerable to disruptions, like bad road conditions preventing traders to travel, shortages of critical inputs like improved seeds and fertilisers, and a scarcity of reliable price information, thus leading to few incentives for farmers to increase the quality and quantity of their production (cf. Khonje et al., 2018; Kilelu et al., 2017a). Developing value chains of input providers,

smallholder farmers and output buyers, and thereby creating more stable relationships, is increasingly suggested to solve this problem (e.g., AGRA, 2017; De Brauw and Bulte, 2021). In such value chains, input providers invest in developing and distributing farm inputs and output buyers in the collection and purchase of harvests at fair prices. Consequently, everyone benefits: uncertainty and risks for farmers to invest in their production reduce, for the input providers, a more stable market emerges, and the output buyers can expect higher quantity and quality. The growing food demand and increasing food prices, however, bring many new traders to the rural areas, offering farmers short-term, attractive prices (Shiferaw et al., 2015). This further undermines the delicate relationship development process and the emergence of stable value chains that can continue to innovate and invest in food production in an upward cycle.

ICT platforms may be in the right position to deal with this problem by extending their services to farmers with interventions in relationship development. The marketing literature offers many insights into loyalty incentives that can foster relational exchange (e.g., Liu and Ansari, 2020; Viswanathan et al., 2017; Wang et al., 2016). Like most marketing literature, the insights from the loyalty literature are, however, developed particularly in consumer market contexts in high-income economies(Burgess and Steenkamp, 2006). As such, there is a paucity of research on loyalty incentives in rural contexts in emerging economies. With ICT platforms now providing opportunities to reach farmers with incentives that encourage them to make long-term planting and marketing decisions, studies on this topic are both timely and relevant.

In this article, we examine the impact of loyalty incentives in the rural context of soybean farming in Northern Uganda. Specifically, we address the questions of whether loyalty incentives in this context indeed strengthen farmers' loyalty to output market buyers, whether the effects occur with both financial and non-financial incentives, whether and which type of commitment explains the relationships, and whether the effects are moderated by farmers' trust in the ICT platform and the pressure from other buyers. Uganda is a particularly suitable context

because while the rural area fits all the typical characteristics of rural areas in emerging economies, it also has one of the highest number of ICT platforms in sub-Saharan Africa (GSMA, 2020) and high penetration of mobile phones (UCC, 2018).

In doing so, our article adds to the emerging literature on innovation in rural markets of emerging economies. The existing literature on innovation at the bottom of the pyramid has mostly focussed on urban markets, with limited attention for co-creation between companies and people living at the bottom of the pyramid (BOP) (Kolk et al., 2014). The relatively few studies in marketing that look at rural sectors of emerging economies tend to focus on hindrances to market integration, like market orientation (Ingenbleek et al., 2013; Kwaramba et al., 2022) and marketplace literacy (Teklehaimanot et al., 2017; Viswanathan et al., 2021). More precisely, our study makes the following contributions to this literature. First, it shows that loyalty incentives offered through an ICT platform have a positive effect on farmers' loyalty intentions, thereby contributing to the development of stable value chains. In that respect, we also show that the effect of loyalty incentives is stronger than that of perceived pressure coming from other traders entering the region. Because the innovation requires active contributions from farmers, value chain partners, and the ICT platform, it is also a process of co-creation at the BOP.

Second, our study shows that the effect is generalisable across financial and non-financial incentives, though, as we show, both types of incentives stimulate different types of commitment (calculative and affective, respectively), which helps to explain why the loyalty instruments eventually influence loyalty intentions. Thirdly, our study shows that the effects of loyalty incentives are contingent on a trusted ICT platform environment, suggesting that relationships in the value chain are strengthened more effectively when the new ICT institutions are also trustworthy. The remainder of this article is structured as follows: the next section presents the background on innovations in rural markets and loyalty incentives, followed by a

section on the conceptual model and hypotheses. After presenting the methodology, the results are presented, followed by a discussion and implications for theory and innovation management in private companies and rural development policy, before finishing with a conclusion.

5.2 Background

5. 2.1 Innovation in rural markets of emerging economies

While the large cities in emerging economies are increasingly becoming centres of innovation (cf., Cohen, 2006; Duranton, 2015), innovation is often less self-evident in rural areas. Most important innovations in food production in emerging markets occur in the so-called peri-urban areas surrounding the cities, where more intensive forms of agricultural production are adopted (Orsini et al., 2013). Agricultural economists have, however, pointed out that such innovations in peri-urban areas are unlikely to provide enough food to the rapidly growing cities (Barrett, 2021; O'Hara and Toussaint, 2021). Others have therefore pointed out that integrating smallholder producers from remote rural areas into the food system is also essential for food provision to urban areas, pro-poor development, women empowerment, and other humanitarian reasons reflected in the Sustainable Development Goals (Fan and Rue, 2020).

Dissemination of innovation to remote rural areas is, however, difficult, given the dispersion of farming communities in more remote areas and the deprivation of basic resources (Viswanathan et al., 2012). The road infrastructure in these areas remains poor, hampering farmers' access to information and markets for inputs, outputs, credit and other production-related services and resources due to high operating costs (Mishra and Dey, 2018). There are often few inputs suppliers and output buyers (e.g., Ingenbleek et al., 2013), and exchange is mostly community-based with producers selling to either local buyers or traders connected to marketplaces elsewhere (Adekambi et al., 2015; Adekambi et al., 2018).

Research on subsistence marketplaces has shown that people living in resource-deprived contexts, develop coping strategies relying on social relationships with others (Viswanathan et al., 2019; Viswanathan et al., 2012). In rural areas, the social fabric of communities helps to achieve a larger scale and efficiency and to share practices between actors, leading to a more uniform quality and joint marketing (Venugopal and Viswanathan, 2017, 2019; Viswanathan et al., 2014). Within such joint marketing arrangements and reliance on social networks, innovation is not absent. Work on jugaad innovation (improvised or makeshift solution using scarce resources) has highlighted the typical characteristics of innovation processes that are driven by a shortage of productive resources compensated for by inventive ideas (Prabhu, 2017; Prabhu and Jain, 2015; Radjou et al., 2012). Authors working on frugal innovation specifically highlight the need to focus on essential attributes of products so that products can become more affordable and be repaired more easily (Adomako et al., 2023; Levänen et al., 2022). That way, they also fit the typical conditions of rural areas. The rapid dissemination of mobile phones in rural areas in some emerging economies can, in that way also be seen as a frugal innovation that had a transforming impact on the rural areas (Knorringa et al., 2016).

Building on the spread of mobile phones, the rapid development of mobile-based ICT platforms is a potential game changer in rural agricultural markets (Baumüller, 2018). Mobile-based ICT platforms offer new ways to reach smallholders with SMS-based services such as information on markets, prices, weather forecasts and tailor-made extension advisory services in a time and cost-effective way (Aker and Ksoll, 2016; Baumüller, 2018). This is especially important given that smallholder farmers are often dispersed with relatively low purchasing power, and relatively few companies present to provide inputs to farmers and to purchase their outputs (Ingenbleek et al., 2013). The two-way interactive communication mechanism enabled by ICT platforms provide opportunities for previously unconnected buyers to reach smallholder farmers (Sklyar et al., 2019) and potentially contributes to strengthening relationships (Tong et

al., 2020; Vieira et al., 2019). Strengthening relationships through ICT platforms, however, requires that both farmers and buyers benefit from their interactions in a way that farmers access produce markets at fitting prices and buyers get the needed produce volumes. To achieve this, relationship building interventions such as loyalty incentives may help. Hence, advancing the potential to expand loyalty interventions among the base of the pyramid actors in rural areas.

In short, while mobile-based ICT-platforms clearly have the potential to overcome structural disadvantages associated with rural areas in emerging markets, concrete marketing interventions are needed to bring their potential to real impact. With absence of stable market relationships being an important barrier hindering progress, ICT platforms can be used to implement loyalty incentives among farmers with the aim to relationships with output buyers.

5.2.2 Conceptual framework

The dependent variable in our study is farmers' loyalty to a buying company. Loyalty is a field of knowledge that is well-developed within marketing. It was in particular popular in the late 1990s and early 2000s (e.g., Dick and Basu, 1994; Oliver, 1999), but also more recently it is a topic of investigation (Wolter et al., 2017; Ziliani, 2019). We draw on ideas from this line of literature to study how relationships between farmers and farm-output buyers in rural markets of emerging economies can be strengthened. Loyalty refers to the degree to which an individual exhibits intentions to and repatronise a loyalty object, and possesses a positive attitudinal disposition toward the loyalty object (Oliver, 1997).

The existing literature accordingly classifies loyalty into two components: attitudinal and behavioural (e.g., Dick and Basu, 1994). While attitudinal loyalty measures the degree to which an individual prefers and affectively likes a loyalty object over another (Zeithaml et al., 1996), behavioural loyalty reflects behavioural intention or actual action of repeated patronage (Bolton and Lemon, 1999; Mittal and Kamakura, 2001). In our research context, where the challenge is to strengthen value chain relations through farmers' planned sales decisions to a particular

buying company, the focus is on the behavioural aspects of loyalty. We define loyalty to a buying company therefore as farmers' planned intention to supply their farm produce to a specific buying company.

To strengthen farmers' loyalty, this study develops specific loyalty incentives to create value to a transaction between farmers and a specific output buyer to drive farmers' commitment, and lead to loyalty (see the conceptual framework in Figure 5.1). Studies in the loyalty literature taking a trust-commitment perspective, argue that loyalty emerges through commitment, satisfaction and trust (Garbarino and Johnson, 1999; Morgan and Hunt, 1994; Palmatier et al., 2007). Satisfaction and trust are derived from an individuals' past experiences with the loyalty object (Morgan and Hunt, 1994; Oliver, 1999). In our research setting, we instead aim to break past routines of disloyalty, thus taking an interventional approach. This approach is propagated by authors advocating that loyalty can be strengthened by specific marketing instruments, so called loyalty incentives that intend to increase commitment towards upcoming transactions (Belli et al., 2022; Lewis, 2004; Steinhoff and Palmatier, 2016). Loyalty incentives are any kind of compensation given to an individual before or during a transaction with the goal of changing their attitude and behaviour towards the company or business giving the incentives (Keh and Lee, 2006).

The literature on loyalty interventions distinguishes different types of loyalty incentives, categorised as economic (monetary) and psychological (non-monetary) incentives (Belli et al., 2022; Dose et al., 2019; Steinhoff and Palmatier, 2016; Viswanathan et al., 2017). Monetary incentives, some argued, were limited in their emotional appeal (Brashear-Alejandro et al., 2016; Viswanathan et al., 2017). They therefore argued that non-monetary incentives like presents as tokens of appreciation for the loyal relationship, can be more effective in some situations or for specific customer groups (Bombaij and Dekimpe, 2020; Steinhoff and Palmatier, 2016; Viswanathan et al., 2017). As the same arguments may also apply to farmers,

we include both monetary and non-monetary incentives in our framework as drivers of commitment.

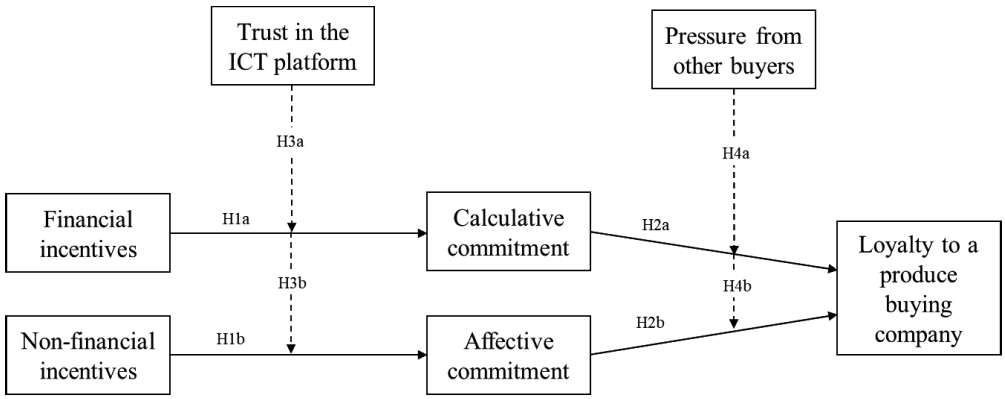


Figure 5.1 Conceptual model

Commitment is defined as "an enduring desire to maintain a valued relationship" (Moorman et al., 1992, p. 316). The commitment literature distinguishes three forms of commitment arising from different motivations (Meyer et al., 1993; Shukla et al., 2016). First, calculative commitment which best describes the attachment status based on cost-benefit evaluations created to maintain relationships (Bansal et al., 2004b; Petzer and Roberts-Lombard, 2021). Second, affective commitment which best describes the emotional attachment created to maintain a relationship derived from feelings of identification and affiliation (Bansal et al., 2004b; Shukla et al., 2016). Third, normative commitment which results from a force or social antecedent that makes an individual feel that they ought to be committed to a certain firm or brand (Allen and Meyer, 1996; Bansal et al., 2004b). Literature suggests that normative commitment is highly correlated with affective commitment with weaker effects (Bansal et al., 2004b; Gruen et al., 2000), so we follow previous authors by not considering it in this study (Meyer et al., 1989; Wang et al., 2020) and to focus on affective and calculative commitment (Geyskens, 1996).

We add two moderating variables to the model, namely trust in the ICT platforms and pressure from other buyers. We draw on trusted environment theory (Grayson et al., 2008) to include the variable trust in the ICT platform. In our context, we define trust in the ICT platform as the trust farmers have in the ICT platform and its agents. In our study context where visits are too costly to reach the widely dispersed farmers, communication of incentives through ICT platforms is virtually the only option. Farmers' trust in the ICT platform can then affect the impact of the loyalty incentives.

We further include a variable on the pressure of other buyers that may moderate the relationships between commitment and loyalty. We define pressure from other buyers as existence of other output buyers trying to achieve produce volumes and market share through attractive offers to farmers. In our study context, fierce competition for agricultural produce results in many traders active in the market that approach farmers with attractive offers but on short term basis (Burke et al., 2019; Dillon and Dambro, 2016). As such, they put pressure on farmers to be disloyal to the focal buying company.

5.2.3 Hypotheses development

Loyalty incentives and commitment

According to the existing literature, loyalty incentives help induce perceived value beyond the actual exchange value, which makes individuals become more committed and loyal to the loyalty object (Fornell et al., 1996; Fullerton, 2003; Zeithaml et al., 1996). For example, Wu et al. (2014) indicate positive relationships between perceived value, commitment and loyalty in terms of purchase intentions in an online shoppers perspective. Kumar and Reinartz (2016) also indicate a relationship between perceived value and commitment, resulting in loyalty behaviour. In this way, loyalty incentives shift customers' perspectives to not only enrol in a transaction but endure a relationship with the firm, and reinforce their loyalty behaviours (Steinhoff and Palmatier, 2016).

In the farming context, this means that farmers do not only enroll to purchase inputs like seeds and fertilizers to produce the quality and quantity of crops that output buyers prefer, but that they also intend to sell the outputs to these buyers at the end of the farming season. Different forms of loyalty incentives in that respect, result in different types of commitment (Johnson et al., 2006; Verhoef, 2003). When the benefits of financial incentives are evaluated to exceed costs, farmers will develop calculative commitment by purchasing and using inputs to produce and sell outputs to the buyer, otherwise, they will not commit (Agarwal and Mehrotra, 2018; Melnyk and Bijmolt, 2015). On the other hand, when the benefits of non-financial incentives foster a sense of belonging and emotional connection, farmers will develop affective commitment (Bombaij and Dekimpe, 2020; Dlamini and Chinje, 2019). Thus, we hypothesize:

H1: (a) Financial/ (b) non-financial incentives have a positive influence on farmers' calculative/affective commitment.

Commitment and loyalty

Commitment is a key component of maintaining long-term relationships between a company and its customers; thus, loyalty is formed and strengthened through commitment (Gustafsson et al., 2005). In other words: if an individual desires to maintain a relationship, we would expect them to be loyal (Burnham et al., 2003; Lam et al., 2004). Both calculative and affective commitment result in different motivations for maintaining relationships (Geyskens et al., 1996; Wetzels et al., 1998). In our study context, farmers with calculative commitment are motivated to maintain relationships based on the economic benefits they can derive from relationship against the alternative options. If farmers perceives that maintaining the relationship will lead to better prices and profits from their farm production, they will be motivated to continue the relationship. For instance, Chiou and Droge (2006) found that individuals with calculative commitment remain loyal because the costs associated with moving to alternatives are evaluated

to be too high or because alternatives are not reliable. Similarly, Raïes et al. (2015) found positive effects of calculative commitment on high brand loyalty.

On the other hand, farmers with affective commitment develop an emotional bond and feel a strong connection to the focal buyer, which motivates them to maintain the relationship to preserve the emotional benefits, even when faced with economic uncertainties. De Ruyter et al. (2001) found that positive effects of affective commitment on influences the intention to continue the relationship because it is perceived as noncoercive resulting in a positive and agreeable exchange atmosphere which builds trust and mutual support. Verhoef et al. (2002) found positive effects of consumers' affective commitment on customer referrals and the number of services purchased, while Chiou and Droge (2006) found a strong effect of consumers' affective commitment on behavioural loyalty intentions.

Following the above arguments, high levels of calculative and affective commitment will therefore make farmers less likely to switch to other competing produce buyers. Thus, we hypothesize as follows.

H2: Farmers' (a) calculative commitment and (b) affective commitment positively influence their loyalty.

The moderating role of farmers' trust in the ICT platform

According to Grayson et al. (2008), a trusted environment in which a set of companies and individuals operate, can have an effect on business relationships. In our study context where communication of incentives occurs through an ICT platform, the ICT platform is an important aspect of the business environment that farmers may out their trust in. We therefore, define trust in the ICT platform as the trust farmers have in the ICT platform and its agents. It cannot be taken for granted that farmers indeed fully trust the platforms because ICT platforms are relatively new, and have not had much time to build trust among smallholders. In the study by

Grayson et al. (2008), individuals are influenced not only by how much they trust a company and its representatives but also by how much they trust the broader context in which the market exchange is taking place. In our context, trust in an ICT platform will affect the relationship between the loyalty incentives and farmers' commitment because the loyalty incentives are communicated through the ICT platform. In our study context, when farmers perceive the ICT platform to be fair and transparent, it enhances their trust and commitment to the focal buyer. On the other hand, if the ICT platform is perceived as unfair, it may diminish farmers' commitment to the focal buyer even with an otherwise trustworthy focal buyer. Hence, trust in the ICT platform moderates the relationship between loyalty incentives (financial and non-financial) and farmers' commitment (affective and calculative). We therefore hypothesize that:

H3: Farmers' trust in the ICT platform positively moderates the relationship between (a) financial incentives and farmers' calculative commitment, and (b) non-financial loyalty incentives and affective commitment.

The moderating effect of pressure from other buyers

While loyalty incentives may enhance commitment and consequently loyalty, the presence of competitors in the business environment can increase or reduce an individual's loyalty behaviour to the firm offering loyalty incentives (Ganesh et al., 2000; Pratt et al., 2022). Liu and Ansari (2020) find that loyalty decisions to loyalty programmes are influenced by the competitive environment. Lam et al. (2010) and Sun et al. (2003) argue that individuals switch to competitors because the value that is offered by an incumbent firm is perceived as lower than that of competitors. We draw on this literature to define pressure from other buyers as existence of other output buyers trying to achieve produce volumes and market share through attractive offers to farmers. If there is more pressure from other buyers, the other buyers will make offers that are also calculatively and/or emotionally appealing. This makes the loyalty incentives offered to the farmers by the focal buyer less unique or less appealing to the farmers. As a

consequence, the relationship between commitment and loyalty will be weaker. Therefore, we hypothesize that:

H4: Pressure from other buyers negatively moderates the relationships between (a) calculative/(b) affective commitment and loyalty.

5.3 Methodology

5.3.1 Study context

We test our hypotheses in the context of a loyalty intervention offered through an ICT platform, M-Omulimisa (www.m-omulimisa.com), implemented with soybean farmers in Lango sub region, Northern Uganda. Soybean production and marketing provides opportunities for farmers in this region to improve their incomes and nutrition, as soybean is a relatively cheap protein source for human and livestock. The quantities that most farmers produce are however relatively small. Hence, an important buying company of soybean produce was looking for ways to increase farmers' production volumes of soybean at marketable quality levels. Due to a high demand for edible oils for human consumption and soybean cake for animal feed, the company is confronted with competition of new traders to bid on farmers' soybean harvests. At the same time, farmers complain about the lack of reliable output buyers and low prices offered by output buyers, which affects their willingness to invest and use productive inputs. The lack of reliable output buyers indicates the lack of producer-buyer relationships which affects both the buyers and farmers in terms of produce volumes and predictability of sales and prices, respectively.

In addition, the Uganda offers the most dynamic agribusiness ICT platform community in sub-Saharan Africa, with over 38 ICT platforms targeting farmers (GSMA, 2020). Most ICT platforms in Uganda facilitate exchange of agricultural information and input and output market prices to farmers. The M-Omulimisa platform facilitates linkages to input suppliers and access

to input loans in collaboration with a government microfinance institution, particularly for improved seed. In these activities, the platform is however also hindered by the weak buyer-seller relationships and is looking for ways to strengthen farmers' access to output markets. As such, the platform provides an excellent context for the focal buyer to test loyalty incentives that address the weak buyer-seller relationships.

Notably the study was influenced by unanticipated contextual changes. Low production due to long drought spell tripled the prices for soybean in the country. Farmers could not match the required quantity threshold due to low production affected by the prolonged dry spells, while the focal buyer was driven out of the market due to high prices offered by its competitors. This had several consequences for the study. First, given that the buying company stepped out, we could not measure loyalty in terms of actual selling behaviour and we therefore relied on intentions to measure loyalty. Second, to assess whether farmers had experienced negative consequences from the loyalty incentives that were offered to them in the planting season and a buying company that was unable to keep these promises representatives from the ICT company and the focal buyer joint the principal researcher of this study at debrief meetings with all the participating farmer groups to ask about their experiences. Farmers indicated that their harvests were affected by the long drought spell but that they had not experienced any negative consequences arising out of the experiment because the high prices paid by other buyers compensated for their lower production levels and the absence of the incentives that were promised to them. Infact, during the debrief meetings, farmers requested that the loyalty arrangements would be continued in the next season During the meetings, plans were developed for the next season to improve the distribution of inputs and credit access with the ICT platform to ensure that farmers can access the required inputs to increase their production in the next season.

5.3.2 Experimental Design

We tested our model and hypotheses with primary data obtained from a cluster randomized trial, implemented through the M-Omulimisa ICT platform. Our experiment consisted of five parts: (1) intervention design, (2) sample recruitment and random assignment of participants into treatments, (3) implementation of the loyalty incentives to manipulate our constructs, (4) sampling for post-treatment outcome measures, and (5) data collection. The timeline of our field experiment is presented in Appendix 5.1.

In the intervention design, the principal researcher designed loyalty incentives in consultation with experts from non-government organisations working with M-Omulimisa, farmer group representatives, and village agents. As a result, a price bonus equivalent to 0.03 USD for each kilo sold in addition to the prevailing market price used by the buyer, and tarpaulins (used by farmers for drying and winnowing their produce grain and improve their produce quality) were included as financial and non-financial incentives, respectively. Both financial and non-financial incentives were promised to farmers if they would supply at least 800 kg of soybean individually or 20,000 kg as a group to the focal buyer.

The experiment included three treatment groups (financial incentives (cash bonuses only), non-financial incentives (tarpaulins only), both financial + non-financial incentives (both cash bonuses and tarpaulins) and a control (no incentives) group. . By including a group that received both incentives we could accommodate for a scenario in which the effects of the loyalty incentives are contingent on one-another and farmers would develop loyalty thus only in response to receiving both incentives.

To inform farmers in the treatment groups about the incentives, they received SMS-messages in the Langi local language on their mobile phones during the second planting season of 2021 (August to December 2021). Farmers in the control group did not receive any information about the loyalty incentives. All farmers, including those in the control group, received general

agricultural information on soybean (among others when to plant, how to weed, and contacts of input suppliers). Such information is often shared by the platform, following the farming calendar (see Appendix 5.2 for detailed information about the loyalty intervention, and timing of information). Farmers could ask for clarifications about the information shared through the platform to so called village agents, who represent the ICT platform in the farming communities and can mobilise, train, enrol, and offer additional face to face advise to farmers.

5.3.3 Sampling, questionnaire development and data collection

45 farmer groups derived from the ICT platform's database were selected for the experiment. All selected farmers groups had for at least two years access to all services provided by the ICT platform (i.e., production information on soybean technologies, linkages to input providers, access to microloans). To minimize chances of contamination, we selected one independent farmer group per village to have farmer groups (clusters) that were geographically dispersed from each other (De Janvry et al., 2017). All the farmer groups were located in the Lango sub region, with no large differences in geographical and production conditions, income levels, culture, and language. The selected 45 farmers groups were randomly assigned to the three treatment group and the control group. In total, we had n =11 groups for the control, financial and non-financial treatment groups while the financial + non-financial treatment group had n =12 groups.

To select households from the 45 farmer groups, a list of the members was used as a sampling frame. We used a simple random sampling technique using an automated process to select the households. The number of respondents selected from a farmer group was proportional to group size with large groups having more respondents. In total, 234 households were randomly selected to complete the questionnaire, distributed across the experimental groups (see respondent demographic in Table 5.1). We tested for differences in the demographics and there were no significant differences between the experimental/control groups. In addition, from each

farmer group, we randomly selected 5 respondents as a reserve list for replacements in case the selected farmers were un available or refused to take part in the survey.

Table 5.1 Respondent demographics

Treatment	N	Age	Education (years)	Household size	Gender	
					Male	Female
Control	65	30.7	8	5	55	10
Financial	52	31.8	8	5	45	7
Non-financial	50	31.2	8	5	39	11
Both	67	39	8	5	59	8

A structured questionnaire was developed in consultation with a research expert who had field research experience in the study area, ensuring translational validity (Ingenbleek et al., 2013). To check for clarity of questions and reduce ambiguity, a pre-test with a preliminary questionnaire was conducted among 40 farmers selected from one of the communities outside the villages covered by this study (Ingenbleek et al., 2013). This allowed to improve the questionnaire further.

Prior to data collection, the questionnaire was programmed onto a computer tablet using Open Data Kit (ODK), and enumerators were trained covering all aspects in the questionnaire to ensure understanding of the interview process, clarity of measurement variables, concepts and administration of the interview process (Ingenbleek et al., 2013).

To identify the selected respondents for the survey, we used the ICT platform's village agents after which research enumerators approached the respondents and requested their voluntary participation before the interviews. All respondents that were approached accepted to be interviewed. In cases where the respondents were not available during the day of data collection and a day that followed, other group members from the reserve list replaced them. The interviews lasted between 45 and 60 minutes on average and the use of a computer tablet helped achieve all responses in such a way that, the enumerator would not proceed to the next question

unless there was a response from the previous question. The data collection was conducted during the marketing season, at the time when the farmers make output sale decisions but before the focal company announced that it wouldn't purchase soy bean in the season. We used phone-based SMS to inform farmers that the focal buyer would not proceed with the buying arrangements due to low produce volumes and high prices. After data collection and at the end of the buying season, debrief meetings with farmers were conducted by the principal researcher together with representatives from the platform and the focal buyer to understand farmers experiences as already indicated in section 3.1.

5.3.4 Construct measurement

A total of five constructs were used in the study as illustrated in Table 1. Four of the constructs' items (affective, calculative, trust and loyalty intention) were identified from previously validated scales and adapted to suit the context of this study. [3]

Loyalty intention was adapted from Johnson et al. (2006) and include the respondents' selling intentions to and recommending the loyalty buyer to others. Trust items were adapted from measures of system trust by Grayson et al. (2008). Their system trust items focused on government regulators while ours focused on the ICT platform as a broader context in which farmers receive the information on the loyalty intervention. The items focused on whether the respondent believes that the ICT platform offers consideration to the respondents before taking actions in terms of the information shared is fair, sincere, honesty and the platform people behind the platform are fair and just. Responses to all construct items were made on 5-point

[3] More specifically, affective and calculative commitment was measured using items adapted from Bansal et al. (2004a) with the following adaptations: Because Bansal, H., Irving, P., and Taylor, S. (2004a). A three component model of customer commitment to service provider. Academy of Marketing Science, 32 (3), 234-250.'s research context was different from ours, we made minor adjustments to item wording. For example, their measures refer to "My Auto Service Company" as the target of commitment, whereas ours refer to the target such as "the focal buyer."

scales Likert scales (1=strongly disagree, 5= strongly agree). For one construct (pressure from other buyers), items were developed following suggestions in the literature (Rossiter, 2002) . We first specified the domain of content that the construct was intended to capture based on the pre-test.

Then we developed indicators that capture those important aspects of pressure from other buyers from the perspective of the smallholder farmers. The items focused on whether and how the respondents faced demands from other buyers to lure them to sell their produce. Responses to the construct items were made on A 5-point Likert scale (1=very little extent, 5= very large extent). To depict the Likert scale length to the respondents in our study context, well measured stick lengths corresponding to the Likert scale were used as a point of reference. **Table 5.2** below presents the descriptive statistics of the constructs while Table 5.3 presents the construct items and sources.

Table 5.2 Descriptive statistics

Constructs	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Calculative commitment	234	1.00	4.57	2.7253	.88473	.783
Affective commitment	234	1.17	4.83	2.7692	.94744	.898
Trust in ICT platform	234	1.57	4.29	3.0971	.62606	.392
Loyalty	234	1.00	4.50	2.9430	.96818	.937
Pressure from other buyers	234	1.00	3.60	2.3718	.48644	.237

Table 5.3: Model constructs and construct validity and reliability

Construct	Items	Descriptions	Loadings	*a*	CR (rho_a)	CR (rho_c)	AVE
Loyalty intentions Adapted from (Johnson et al., 2006)	LI1	I consider the focal buyer to be my first choice to sell my produce.	.827	.916	.919	.935	.704
	LI2	It is very likely that I would sell my produce to focal buyer next season	.873				
	LI3	I would recommend focal buyer to other farmers.	.824				
	LI4	I would only consider selling my produce to focal buyer if they offered higher prices than other buyers.	.836				
	LI5	I would sell my produce to focal buyer again even if other farmers would not.	.837				
	LI6	Other buyers are not able to convince me to sell to them.	.838				
Affective commitment Adapted from (Bansal et al., 2004a)	Af 1	I feel emotionally connected to focal buyer.	.645	.882	.892	.911	.632
	Af 2	I am proud to belong to focal buyer's network	.840				
	Af 3	I feel a sense of belonging to focal buyer's network	.829				
	Af 4	The relationship that I have with focal buyer is something that I really care about.	.793				
	Af 5	I would feel lost if my relationship with focal buyer no longer exists	.804				
	Af 6	The relationship that I have with focal buyer is very much like being with family.	.842				
Calculative commitment Adapted from (Bansal et al., 2004a)	Ca 1	It would be very hard for me to leave focal buyer right now, even if I wanted to.	.672	.868	.874	.899	.561
	Ca 2	My farming would be disrupted if I didn't sell to the focal buyer	.811				
	Ca 3	I feel that I have too few options to consider not selling to focal buyer	.822				
	Ca4	The relationship that I have with the focal buyer deserves my maximum attention to maintain.	.728				
	Ca 5	The relationship that I have with focal buyer is something I intend to maintain	.804				
	Ca 6	The relationship that I have with focal buyer is of less value to me.	.695				
	Ca7	Right now, staying with focal buyer is a matter of necessity as much as desire.	.695				
Trust in the ICT platform adapted from	Tr 1	I can trust the information received on my phone completely	.663	.907	.824	0.863	.514
	Tr 2	I can count on my phone network (dropped)	.781				
	Tr 3	The information received on my phone is truly sincere and honest	.852				
	Tr 4	The connectivity in my area cannot be counted on	.694				

(Grayson et al., 2008)	Tr 5	The information sent to my phone is not accurate	.613				
	Tr 6	The people behind the information shared are fair and just	.673				
	Tr 7	Whenever we get information from M-Omulimisa ICT platform, we know that it is sharing its best judgement.	.663				
Pressure from other buyers Newly developed	PB1	Approach you even though they don't know you	.714	.811	.860	.874	.635
	PB2	Put pressure on you to sell your harvest to them	.743				
	PB3	Offer you higher prices	.888				
	PB4	Encourage you to grow different crops	.830				
	PB5	Offer you gifts to sell to them (dropped)	.714				

The items in the questionnaire consisted of the actual name of the buyer but has been replaced with "focal buyer" for purposes of keeping the object anonymous.

5.3.5 Data analysis

Data were analysed using partial least squares structural equation modelling (PLS-SEM), a causal predictive approach designed to provide causal explanations (Hair et al., 2019). PLS-SEM was used for data analysis due to its unique advantages. First, PLS-SEM is a good technique for studies aiming to test complex relationships between constructs, which was also the case in this study (Sarstedt et al., 2019). Thus, it is a preferred technique for theory testing which fits smaller sample sizes as is the case in our study (Hair et al., 2019). We used four dummy variables for the categories of loyalty incentives financial, non-financial and a combination of both financial and non-financial. The fourth dummy variable (control group) served as our reference category.

5.4 Results

5.4.1. Measurement model

Following Hair et al. (2019), we check the quality of the measurement model on: reliability, convergent validity, and discriminant validity. According to Table 2, Cronbach's alpha and composite reliability values were all greater than the recommended value of .7 (Hair et al., 2019), indicating reliability was achieved. Next, convergent validity was examined by assessing the factor loadings and average variance extracted (AVE). We first inspected the loadings of individual items on their corresponding construct (Fornell and Larcker, 1981). Loadings above .70 are recommended, as they indicate that the construct explains more than 50 per cent of the indicator's variance (Hair et al., 2019), thus providing acceptable item reliability. Items with low loading were eliminated (Trust 2 for trust in the ICT platform construct and PB 5 for pressure from other buyers construct). Then PLS algorithm was rerun, and the results were satisfactory. While some indicator loadings were less than .7, they were preserved since the constructs' composite reliabilities exceeded the acceptable requirement of .7 (Hair et al., 2019). All AVEs were greater than .5 (Table 5.3), ranging from .514 to .704 which indicates that the

construct explains at least 50 per cent of the variance of its items (Hair et al., 2019). The above results indicate that convergent validity was attained in this study.

The Heterotrait-Monotrait Ratio (HTMT) criteria was used to evaluate discriminant validity, the extent to which a construct is empirically distinct from other constructs in the structural model (Henseler et al., 2015). According to Table 5.4, all HTMT values were less than the .85 conservative thresholds (Henseler et al., 2015). Thus, supporting the conclusion that discriminant validity was established.

Table 5.4 Discriminant validity Heterotrait-Monotrait ratio (HTMT)

	Affective	Calculative	Loyalty intention	Pressure from buyers	Trust in ICT platform
Affective					
Calculative	.515				
Loyalty intention	.675	.742			
Pressure from buyers	.244	.214	.373		
Trust in ICT platform	.478	.659	.551	.166	

5.4.1.1 Model fit

The developed model's approximation fit was evaluated using standardized root mean square residual (SRMR), as proposed by (Henseler et al., 2016). While Byrne (2002) recommended that an SRMR of less than .05 is regarded an acceptable fit, other research has shown that the SRMR of a fully defined model can be higher with an SRMR of .08 believed to be appropriate (Henseler et al., 2014). An acceptable SRMR of .075 was calculated for this model. The Bentler-Bonett normed fit index (NFI) was also used to determine the approximate fit of the model (Henseler et al., 2016). According to Singh (2009), an appropriate NFI should be between .6 and .9. The NFI calculated for this study was .753, which was within the specified range. Multicollinearity was checked using the variance inflation factor (VIF) for all items. Results showed all VIFs of individual items were below the threshold of 3.3. Common method bias was

checked using the Harman Single Factor test which was below 50 percent. The above results suggest that there was no common bias problems in this study model (Diamantopoulos et al., 2006; Hair et al., 2014).

5.4.2 Structural model and hypotheses testing

After the measurement of the model's validity and reliability and the overall model fit were adequately confirmed, the Smart-PLS 4 bootstrap approach was applied with a 5,000 samples loop (Hair et al., 2019) to examine the hypothesized relationships as the second step. Bootstrapping was used in a single time to show the direct and indirect effects providing all the requirements (t-values, p-values, path coefficients) (Nitzl et al., 2016). Table 5.5 demonstrate the SEM analysis results below.

Table 5.5 Structural model analysis results

Paths	Coefficients	*t*-statistics	*p-values*	Conclusions
Direct effects path analysis				
Financial -> Calculative (H1a:+)	1.329***	7.057	.000	Supported
Nonfinancial -> Affective (H1b:+)	1.801***	16.471	.000	Supported
Calculative -> LI (H2a:+)	.480***	9.791	.000	Supported
Affective -> LI (H2b:+)	.352***	7.244	.000	Supported
Both -> calculative	1.224***	8.072	.000	Supported
Both -> affective	1.663***	16.240	.000	Supported
Mediation path analysis				
Financial -> Calculative -> L1	.638***	4.701	.000	Supported
Nonfinancial -> Affective -> LI	.634***	6.832	.000	Supported
Both -> calculative -> LI	.588***	5.296	.000	Supported
Both -> affective -> LI	.586***	5.900	.000	Supported
Moderation path analysis				
Trust x Financial -> Calculative (H3a:-)	-.120	.650	.516	Not supported
Trust x Nonfinancial -> Affective (H3b:-)	.016	.145	.885	Not supported
Pressure x calculative -> Loyalty (H4a:-)	.095*	1.859	.063	Not supported
Pressure x affective -> Loyalty (H4b:-)	-.051	.958	.338	Not supported
Pressure -> Loyalty	-.168	3.806	.000	Supported
Trust -> Calculative commitment	.221	2.021	.039	Supported
Trust -> Affective commitment	.058	1.208	.261	Not supported

Note. Significance level (2-tailed): p value < .01 (***); < .05 (**); < .10 (*)

The results shown in Table 5.5 indicate that Hypotheses 1a and 1b predicting positive effects of financial and non-financial loyalty incentives on farmers' calculative and affective commitment, respectively, are supported. These positive effects are indicated by significant and positive coefficients: financial incentives (β =1.329; p <.01); non-financial incentives(β =1.801; p <.01(β =1.224; p <.001). In addition, positive effects of a combination of both financial and non-financial loyalty incentives on calculative (β =1.224; p <. 01) and affective commitment (β =1.663; p <. 01) were also observed. Furthermore, Hypotheses 2a and 2b predicting positive effects of calculative and affective commitment on farmers' loyalty intention, respectively, is supported as indicated by the positive and significant path coefficients: calculative commitment (β = .480; p <. 01) and affective commitment (β = .352; p <. 01).

5.4.2.1 Mediation analysis results

As our model suggests mediation paths from loyalty incentives via commitment to loyalty intention, we also conducted a mediation analysis (Preacher and Hayes, 2008). The study results show a positive mediation effect of calculative commitment from financial loyalty incentives to loyalty intentions (β = .638; p <. 01). In addition, a positive mediation effect of affective commitment from non-financial loyalty incentives to loyalty intentions is observed (β = .459; p <. 01). The results further show positive mediation effects of calculative commitment (β = .588; p <. 01) and affective commitment (β = .586; p <. 01), from a combination of both financial and non-financial loyalty incentives to loyalty intentions.

5.4.2.2 Moderation analysis results

Regarding the moderation results shown in Table 5.5, Hypothesis 3a predicting a moderating effect of trust in the ICT platform on the relationship between financial incentives and calculative commitment is not supported (β = -.120, p>.05). In addition, Hypothesis 3b predicting a moderating effect of trust in the ICT platform on the relationship between non-financial incentives and affective commitment is not supported (β = .016, p > .05). The

moderation effects of pressure from other buyers on the relationship between commitment (affective and calculative) and loyalty intention was also examined. Hypothesis 4a predicting a negative moderating effect of pressure from other buyers on the relationship between calculative commitment and loyalty intention is not supported ($\beta = .095$, $p < .10$).

Furthermore, Hypothesis 4b predicting a negative and significant moderation effect of pressure from other buyers on the relationship between affective commitment and loyalty intention is not supported ($\beta = -.051$, $p > .10$). While we did not find moderation effects, our results show that pressure from other buyers has a negative and significant effect on loyalty intentions ($\beta = -.168$, $p < .01$). In addition, trust in the ICT platform has a positive and significant effect on calculative commitment ($\beta = .221$, $p < .05$, but with no significant direct effect on affective calculative commitment ($\beta = .058$, $p > .05$).

5.5 Discussion

This paper examined the influence of ICT-based loyalty incentives on farmers' loyalty intentions, and the mediating and moderating effects of commitment and pressure from buyers, respectively, in an agricultural rural market context. We find significant positive relationship between loyalty incentives and farmers' loyalty intentions to the focal buyer. While our theory is mostly supported, three results require further discussion.

First, in our moderation analysis we did not find significant effects of trust in the ICT platform on the relationship between loyalty incentives (financial and non-financial) and commitment (calculative and affective), while we expected to find positive effects. A possible explanation could be that the loyalty incentives themselves have strong effects, and are not hindered by the trust in the ICT platform especially in our context where the platform performs it's job quite well and employs village agents who work as intermediaries between the platform and farmers. Thus, as argued by (Grayson et al., 2008) trust in the environment (here the ICT platform) is

not a substitute for individual trust, and that it is necessary for ICT platforms to develop trusting relationships with farmers, as effects could be indirect.

Second, we predicted a negative and significant effect of pressure from other buyers on the relationship between commitment (calculative and affective) and loyalty intention. Our study found instead an indicative positive effect of pressure from other buyers on the relationship between calculative commitment and loyalty intentions, while results on effective commitment were non-significant. For the indicative positive effects on the relationship between calculative commitment and loyalty intention, one explanation is that farmers have had previous negative experiences with other buyers which then lead to a positive effect on the relationship with the focal buyer. In addition, the positive effect on calculative commitment only and not with affective commitment could be due to farmers' rational evaluation of trade-off of risks and benefits from the focal buyer. Hence the need to earn the loyalty incentives help to turn the balance in favour of the focal buyer even when other traders show up in the market.

Overall, the stronger direct effects of pressure from other buyers on loyalty intention indicate that the change in the market structure due to many traders entering the market, leads to change in loyalty intention. Our findings are in that respect consistent with those of Kwaramba et al. (2022) who find that smallholders' market participation is positively associated with the market credibility and financial outcomes, driven by the need to make a profit from their farm production. Thus, business environments can increase or reduce an individual's loyalty behaviour to the firm offering loyalty incentives (Liu and Ansari, 2020; Pratt et al., 2022).

5.6 Implications and conclusions

5.6.1 Theoretical implications

Our study contributes to the emerging literature on innovation in rural markets of emerging economies, particularly to the literature on ICT platforms in rural markets. While the existing

literature focuses mostly on the role of these platforms as information sharers, we show that information sharing can be used to achieve deeper objectives. By sharing information of loyalty incentives, ICT platforms can in fact contribute to the stability of relationships in the increasingly turbulent rural markets. With that, ICT platforms contribute to the development of stable value chains that can increase a stable food supply to meet the growing demand in urban environments.

Given the importance of loyalty incentives in relationship building and loyalty (Ramaswami and Arunachalam, 2016; Yi and Jeon, 2003), our study shows that the loyalty literature can be broadened to the entire new context of rural markets in emerging economies with a high social relevance. This opens new doors for this body of knowledge: it can help to fix market failures in less affluent parts of the world.

Furthermore, the present research conceptualized and operationalized a new construct—pressure from other buyers, a market structure-focus variable which has not been explored in the literature and which is of particular relevance to relationship marketing research in the increasingly turbulent context of agricultural rural markets. Thus, the study helps to understand that, relationship building does not only depend on social factors within the farming communities but also external factors have an impact and should be viewed as dynamic which may alter existing market structures and relationships. This finding aligns with prior findings, linking competitive offerings in the market to loyalty (Kwaramba et al., 2022).

In recent times, the surge in technological advancements in smallholder agricultural market systems have transformed the digital landscape offering opportunities for value chain actors to interact with each other (Sklyar et al., 2019). Our work also demonstrates how output market buyers can leverage digital innovations as a strategic resource to gain competitive advantage (Skarmeas et al., 2016) to implement loyalty instruments that yield loyalty and performance. Our study findings suggest that even within more pervasive face-to-face interactions between

buyers and sellers, ICT platforms are effective tools that can be used to build actor' relationships in a smallholder context because of the availability of mobile phones among farmers.

5.6.2 Practical implications

Our findings have important implications for policy makers, managers of ICT platforms and input and output market companies aiming at innovating in rural markets to develop value chains and contribute to food security in rural areas. First, Policy makers should partner with ICT platforms as potential partners that can stimulate smallholders' food production to increase food security for the growing population. Policy interventions in emerging economies should be centred around providing an enabling business environment and physical infrastructure for the well-functioning of such ICT-based interventions. Such enabling business environment should include ensuring better phone and internet network connectivity and low internet costs for rural farmers as well as better road networks for improved input and output logistical management. This will enhance access and use of ICT based services to improve the productivity of smallholder farmers.

Second, ICT platforms should focus their innovations towards improving actor relationships to build trust and loyalty, if they are to enhance farmers productivity through greater use of agricultural inputs and contribute to food security. Enhancing actor relationships help correct the existing market failures such as lack of access to inputs and output markets, and help reduce transaction costs related to poor infrastructures and dispersed small scale producers, in rural markets in emerging economies. Reduced transactions costs consequently improves actors' gains from the production and marketing of agricultural produce as well as from the provision of related agricultural services.

Third, our study results show that ICT platforms contribute to the functioning of agricultural value chains. Thus, input and output market companies should use available ICT platforms to integrate and strengthen relationships and trust between smallholder farmers and the input and

output market companies. These relationships will enhance access and use of value chain services and actors for improved functioning of rural markets and better incomes across the value chain.

5.6.3 Limitations and future research

Finally, we discuss the limitations and some directions for future research. First, our measure for loyalty focuses on intentions rather than actual behaviour. This is a limitation because while studies in the loyalty literature use intention to predict actual loyalty behaviour, we cannot prove that such gap is not present in our study. Second, loyalty incentives in our study are limited to price bonus and tarpaulins as financial and non-financial incentives, respectively, and experimented with one single crop, soybean. These results may vary with other types of incentives that use cash or other types of incentives and assessed with other staple crops such as maize or rice.

Third, the results of this study are based on an experiment with samples drawn from an existing ICT platform within an already established relationship with farmers. These results may be valid for this specific context and may vary in other settings where previous ICT use among farmers is absent. Moreover, while this setting is not unique, it has the unusual feature of long term interaction between the farmers and the ICT platform. Future research could explore and compare different ICT contexts to allow for generalization of the research outcomes, in a comparative study. Fourth, we conducted this study within one crop season. Future research should consider developing long term loyalty interventions and measuring loyalty over time and determine the long term effects.

5.7 Conclusion

This research set out to empirically test the effect of financial and non-financial loyalty incentives on farmers loyalty intentions while testing for the mediating role of commitment (affective and calculative) and moderating roles of trust in the ICT platform and pressure from other buyers. The results of the study reveal that both loyalty incentives work in a rural context with effects strong enough on their own, and even stronger combined and that it doesn't even matter so much whether they are financial or non-financial, but they do influence farmers' marketing decisions. The results show that loyalty incentives can stand pressure from other buyers and trust in the ICT platform. While this study contextualized loyalty in existing literature, developing these types of loyalty incentives in smallholder agricultural value chains in emerging economies is new, and shows potential to be developed into loyalty schemes for reciprocal, long term value chain gains.

Appendix 5.1: Timeline of our field experiment

Experimental steps	when	Who
Intervention design	July 2021	Principal researcher in consultation with experts
Sample recruitment and random assignment of participants into treatments	July 2021	Principal researcher
Implementation of the loyalty incentives to manipulate our constructs,	August 2021-December 2022	Principal researcher and ICT platform
Sampling for post-treatment outcome measures	January 2022	Principal researcher
Post-treatment measurement of outcomes.	Jan-February 2022	Principal researcher and enumerators
Send announcement to with draw from the market	February	Principal researcher, ICT platform, and the focal buyer
Debrief meetings	March 2022	Principal researcher, ICT platform, and the focal buyer

Appendix 5.2: Loyalty intervention information sent to individual farmers across the treatment and Control groups

	Financial	Non-Financial	Financial + Non-financial	Control
1st set	Dear (farmer name), as you plan to plant for the new season, m-Omulimisa has brought on-board a new company called "focal buyer" to ensure that, you have a market for your soybean at the end of season. "focal buyer" will offer you a guaranteed competitive price for your soybean. Peter from m-Omulimisa.			
	To ensure you benefit from this competitive price offered by "focal buyer", we recommend that you use improved production inputs such as improved seed, fertilisers and inoculants. To purchase, contact Denis 0778200390 for seed, Ogwang Isaac on 0781796669 for fertilisers.			
	For an additional improvement in your yield, we highly recommend to use good farming practices such as timely planting and appropriate spacing, row planting, timely weeding, among others in addition to improved inputs. Send queries to 0800219999 for more information.			
	Because soybean is an important crop as a cheap protein source for humans and animals, we are delighted to partner with you by ensuring you have a good market for your soybean so that those who are not able to grow it, can equally benefit from its protein source _"focal buyer"			
	To show our commitment to this partnership, we are keen to sign contracts with you as farmer groups as a guarantee to buy your produce at end of season. "focal buyer" staff will be in touch during the season to make sure you get the best quality harvest. We (m-Omilimisa) are in this together _Paul "focal buyer"			
	We as "focal buyer", guarantee a price bonus of 100 shs per kilo if you deliver 20 tonnes of soybean or more as a group at the end of season _"focal buyer".	We as "focal buyer", guarantee to reward a tarpaulin for each member of the group that will supply 20 tonnes of soybean or more _"focal buyer".	We as "focal buyer", will offer a price bonus of 100 shs per kilo and tarpaulins for each member of the group that delivers 20 tonnes of soybean or more _"focal buyer".	
2nd set	Hello xxxx (farmer name) To maximise your yields and be able to earn the price bonuses of 100 shs per kilo offered by "focal buyer", you are reminded to use good farming practices such as timely planting and appropriate spacing, row planting, timely weeding, etc. _m-Omulimisa.	To maximise your yields and be able to earn the gift rewards of tarpaulins offered by "focal buyer", you are reminded to use good farming practices such as timely planting and appropriate spacing, row planting, timely weeding, etc. _m-Omulimisa	To maximise your yields and be able to earn the price bonuses of 100 shs per kilo and gift rewards of tarpaulins offered by "focal buyer", you are reminded to use good farming practices such as timely planting and appropriate spacing, row planting, timely weeding, etc. _m-Omulimisa	To maximise your yields, you are reminded to use good farming practices such as timely planting and appropriate spacing, row planting, timely weeding, etc. _m-Omulimisa
3rd set	As the time for harvesting nears, we remind you to exercise good practices such as harvesting only ripe plants and drying your produce on a tarpaulin to improve the quality and marketability of your produce and be able to earn the	As the time for harvesting nears, we remind you to exercise good practices such as harvesting only ripe plants and drying your produce on a tarpaulin to improve the quality and marketability of your produce	As the time for harvesting nears, we remind you to exercise good practices such as harvesting only ripe plants and drying your produce on a tarpaulin to improve the quality and marketability of your produce and be able to earn the price bonuses of	As the time for harvesting nears, we remind you to exercise good practices such as harvesting only ripe plants and drying your produce on a tarpaulin to improve

	price bonuses of 100shs per kilo offered by "focal buyer". _m-Omulimisa.	and be able to earn gift rewards of tarpaulins offered by "focal buyer". _m-Omulimisa.	100shs per kilo and gift rewards of tarpaulins offered by "focal buyer". _m-Omulimisa.	the quality and marketability of your produce. _m-Omulimisa.
4th set	The buying season is here, as "focal buyer", we are ready to buy your soybean produce. Our bulking centres are located at ....., ... Contact us on			
	As you bring your produce to the bulking centre, make sure our buying agents record your name, produce supply and your group name, in order for your group to be awarded bonus points that will earn you the offered price bonuses of 100 shs per kilo if your group brings 20 tonnes and above of soybean produce. _"focal buyer"	As you bring your produce to the bulking centre, make sure our buying agents record your name, produce supply and your group name, in order for your group to be awarded bonus points that will earn you the offered gift rewards of tarpaulins if your group brings 20 tonnes and above of soybean produce. _"focal buyer"	As you bring your produce to the bulking centre, make sure our buying agents record your name, produce supply and your group name, in order for your group to be awarded bonus points that will earn you the offered price bonuses of 100 shs per kilo and gift rewards of tarpaulins if your group brings 20 tonnes and above of soybean produce. _"focal buyer"	
	To earn your price bonuses, make sure you receive a supply card indicating your ID number, quantity of produce supplied and the name of your group. _"focal buyer"	To earn your gift rewards of tarpaulins, make sure you receive a supply card indicating your ID number, quantity of produce supplied and the name of your group. _"focal buyer"	To earn your price bonus and gift rewards of tarpaulins, make sure you receive a supply card indicating your ID number, quantity of produce supplied and the name of your group. _"focal buyer"	
5th set	As you can see, we will not be able to proceed with the buying arrangements for soybean due to low produce volumes and high prices. We regret the inconveniences and are open to having meetings with you to improve on our relationships. Our main buying centre in Lira town remains open to buy other produce __ "focal buyer"			

6

Chapter 6

General Discussion and Conclusions

6.1 Introduction

The rapid growth of ICT platforms in agriculture continues to increase due to donor funding and commercial investments, which are predicted to continue (CTA, 2019). ICT platforms have been widely implemented in sub-Saharan African agriculture to solve and enhance smallholders' farm productivity by facilitating access to production information, inputs, output markets and other related services such as microfinance and index insurance. It is argued that such platforms can solve most of the challenges faced by smallholders as they have the potential to reach many scattered farmers with information and market linkages so that farmers can reach higher-value markets and increase their incomes. While ICT platforms are sometimes called digital-enabled technologies or digital tools, they all mean web and mobile-based digital tools that are used to share information and services to smallholder farmers. This thesis focused on Uganda as a study case, a country with over 38 ICT platforms. These platforms include extension advisory-based tools, market information apps, and web-based information-sharing platforms, among others.

Most ICT platforms started from an information-sharing focus, with extension advisory services taking the biggest share to push agricultural technologies by building awareness about using inputs such as seeds, fertilizers agro-chemicals and other farm equipment. Over time, it has been realised that information provision alone cannot push adoption as farmers also require linkages to agro-input dealers that supply these inputs, but also to output markets and other services (Chavas and Nauges, 2020; Ezeomah and Duncombe, 2019). To solve these additional barriers, many platforms have evolved, while new ones are being set up, to provide linkages to inputs, output markets and other services simultaneously. This thesis reconciles these arguments in literature to understand the roles ICT platforms can play to enhance the uptake of smallholders to boost farm productivity and contribute to food security.

To achieve the overall aim, we started out by focusing on ICT platforms as the object of investigation in Chapter 2. We explored the motivations and actions of ICT platforms in a qualitative case study of four ICT platforms, to understand the strategies used by the four ICT platforms in improving the uptake of agricultural inputs among smallholders and their future strategic directions. Comprehensive empirical insights from this chapter showed how ICT platforms have started converging towards becoming coordinators of value-chain ecosystems in order to solve many value-chain challenges faced by smallholder farmers. However, we also realised that most of the ICT platforms focused on smallholder farmers alone. Using the new service development literature that argue for value propositions for all actors in service design, we then zoomed into one of the ICT platforms in Chapter 3, to try to understand what core value chain actors need from ICT platforms.

The findings in Chapter 3 proposed loyalty interventions as one of the synergetic service needs among key actors of the value chain, for ICT platforms to build relationship and loyalty among the key actors, specifically between farmers and input providers and output buyers. The results from Chapter 3 resulted in loyalty interventions in Chapters 4 and 5, to assess the effects of such loyalty interventions on farmers' use of inputs, yield increments and loyalty to a specific output buyer. Hence, the thesis evolved to address the following research questions: (1) What strategies do different types of ICT platforms use to improve the uptake of agricultural input technologies among smallholder farmers? (2) What do actors need from ICT platforms in smallholder-based value chains? (3) What is the effect of an ICT-coordinated loyalty intervention with an assured produce market on farmers' use of agricultural inputs and crop yields? (4) What is the effect of loyalty incentives on farmers' loyalty behaviour?

The next section provides an overview of the main findings, reflections upon these findings from a theoretical point of view in the domain of ICT4D in smallholder-based agricultural value chains and discusses implications for research and practice.

6.2 Overview of the main findings

Building on rich literature from economics, business ecosystem, marketing and qualitative data from four case studies of ICT platforms in Uganda, Chapter 2 explored the strategies used by ICT platforms to increase smallholders' uptake of productive inputs and their future strategic directions. The study revealed that ICT platforms adapt their strategies with regard to market system positioning, services offered, and value co-created with other value chain actors to influence farmers' use of inputs. Unlike the ICT platforms that did not adapt their strategies, the ones that adapted their strategies influenced farmers' use of inputs more. As a result, the ICT platforms had started converging towards becoming coordinators of value-chain ecosystems in order to solve the many value-chain challenges faced by smallholder farmers. The dynamic positioning of ICT platforms within the market system, their services, the value they co-create and their strategic direction towards becoming value-chain coordinators indicate their recognition of the need to address challenges faced by smallholders simultaneously. With such evolvement, this chapter proposes that the capacity of the people behind these ICT platforms is therefore built to develop sustainable business models that can enhance the value from ICT platforms without depending on external donor funds.

The focus of a single case ICT platform in Chapter 3 showed that various key value chain actors require similar ICT services. Synergistic needs among these actors were value chain coordination by the platform, loyalty building, digital literacy for farmers and multifaced ICT interfaces. On the other hand, the identification of preferences for interface design features among the key actors led to diverging preferences with respect to simple or advanced interface features. Specifically, farmers preferred a simple feature phone whereas the remainder of the value chain actors preferred a smartphone. The actor preferences for ICT interface design features resulted in trade-offs in interface preferences which included "reach versus efficiency" (either reach many farmers and create more impact by using simple-feature phones, or prioritise

efficiency within the value chain and reach a more limited number of farmers, with the use of smartphones to abide by the needs of other value chain actors). The other trade-off is "inclusion versus exclusion" (use of English and impede farmers' access to ICT services and exclude their participation in ICT-based value chains). The findings of this chapter emphasise the need for ICT platforms to first to prioritise needs that cut across all value chain actors and make trade-offs about whose needs they consider most important, an idea that was developed further in Chapter 4.

Based on insights provided in Chapter 3 and particularly the synergistic need for loyalty building to correct output market uncertainties and improve farmers' access to output markets -- identified as a factor that hinders the use of agricultural inputs -- Chapter 4 assessed the effects of an ICT-based loyalty programme on farmers' use of inputs and yields. Using a cluster randomised controlled trial, this chapter provided evidence that the financial and non-financial benefits of an ICT-based loyalty programme with output market linkages positively influences farmers' use of agricultural inputs and soybean yields. This chapter also provided evidence that loyalty incentives, already common with larger firms, are also effective in smallholder-based value chains, thereby advancing the knowledge on loyalty interventions for sustainable intensification of agricultural production and technology adoption through ICTs.

In Chapter 5, we further extended the evidence on the effects of loyalty incentives on smallholders' loyalty intention to the specific output buyer. The findings in this chapter show that loyalty incentives offered through an ICT-platform have a positive effect on farmers' loyalty towards the output buyer, thereby contributing to the development of stable value chains through relationship building. We also showed that the effect is generalisable across financial and non-financial incentives, and that both types of loyalty incentives stimulate different types of commitment (calculative and affective), respectively. The findings of this chapter help to explain why loyalty instruments eventually influence loyalty, suggesting that relationships in

agricultural value chains are strengthened more effectively when the new ICT platforms are also trustworthy.

In the next section, I explore the research findings of this thesis in the broader context, highlighting the key themes coming up across the chapters, and I draw conclusions and implications from the main findings

6.3 Boosting farmers' use of inputs through ICT platforms

Smallholder-based agricultural value chains are composed of smallholder farmers and other independent actors, including input suppliers for seeds and fertilisers, small-scale aggregators (buyers), wholesalers/traders, extension agents and service providers, such as microloan banks and, in some cases, insurance companies (Agyekumhene et al., 2020). However, smallholder-based value chains face many challenges which include drastic variations in weather conditions (Nhemachena et al., 2020; Vaughan et al., 2019) and the inadequacy of both public and private extension systems to cover the often widely dispersed farmers (Munthali et al., 2018). Reaching farmers by the often few input suppliers and output buyers (e.g., Ingenbleek et al., 2013) is difficult due to the high operating costs resulting from poor road infrastructure (Mishra and Dey, 2018). Such challenges limit farmers' access to information and markets for inputs, outputs, credit and other production-related services and resources, thereby reducing investments in input technologies and use by farmers.

As argued by several authors, ICT platforms can address some of these challenges in an efficient way (Foster and Graham, 2017; Krone and Dannenberg, 2018). Findings from my thesis indicate that ICT platforms offer great potential to enhance input and output market linkages and other services within agricultural value chains and improve farmers' use of agricultural inputs. Comparing four cases of ICT platforms in Chapter 2, we explored and found that such platforms adapt their strategies to design services that provide solutions to the challenges faced

by smallholders in using agricultural inputs. Although there were different points of departure for the different ICT platforms in our study, the endpoints will likely be the same.

As indicated by previous research on value chains, our findings agree and argue that farmers' use of inputs requires more than just providing agricultural information. Improving use of inputs necessitates linking to both input and output markets simultaneously in order to resolve the barriers to uptake (Lambrecht and Ragasa, 2018; Mishra and Dey, 2018), a role that ICT platforms can fulfil as seen in this thesis. A case in example from this thesis is how one of the ICT platforms has continued to disseminate soybean technologies even after a project disseminating legume technologies in Uganda ended, with linkages to improved seed through micro loans now available to rural farmers through the platform. If input and output markets are coordinated simultaneously, increased use of inputs for food production is to be expected.

An important insight from Chapter 4 is that while development resources have gone into developing low-cost agricultural innovations such as inoculants to boost smallholders' productivity for soybean, their availability among farmers' communities and knowledge of their benefits is needed to increase their use and yields even more. Thus ICT platforms could further their roles by predicting or forecasting input demands and coordinate with the suppliers to arrange logistics in time for farmers.

6.4 ICT platforms as one stop centres for value chain services and linkages

Previous research argued that ICT platforms can transform value chain processes by facilitating connections and coordinating the entire value chain between the demand and supply of agricultural markets (inputs, outputs, microcredit, and associated services) across value chain actors (Chuang, Wang, & Liou, 2020). However, the uptake of ICT services amongst smallholders remains limited. According to existing evidence, although many farmers sign up for ICT services, no more than 30% actively use them (Goedde et al., 2021; Krell et al., 2021;

Tsan et al., 2019). In this study, we show that, despite availability of ICT platforms trying to reach the smallholders, none of the platforms under study provided all the required services the farmers needed. As such, farmers abandon the ICT platforms if the design and services do not meet their expectations (Kieti et al., 2022).

In Chapter 2, we showed that the developers behind ICT platforms go through a learning process—as emphasised by the literature on organisational learning leading to changes in strategies and practices (Santa and Nurcan, 2016) and evolving into new roles, as discussed in the literature on human evolution (Seabright, 2010; Wilson, 2020). To improve ICT-based value chain coordination and enhance use of agricultural technologies among smallholders, ICT platforms need to orient themselves towards the needs of not only the smallholders, but also the different actors that provide services to smallholders to create value for all (cf. Kohli and Jaworski, 1990; Narver and Slater, 1990). By coordinating and aligning value chain services to all actors' needs, as revealed in Chapter 3, ICT platforms can stimulate the use of ICT services among their users and create mutual benefits for all value chain actors, hence increasing farmers' access to value chain services that stimulate use of inputs. Thus, a one-stop centre ICT platform can reduce transactions costs across the value chain and ensure that farmers access all the required services to produce and market their produce without the need to register and navigate different platforms that cause digital fatigue.

6.5 Enhancing actor relationships through ICT platforms

Considering that there is a mismatch of needs and services provided by ICT platforms, in Chapter 3 we revealed the importance of involving users in the design process to create ICT services that meet their needs, preferences and capabilities (Kitsios and Kamariotou, 2020; Magesa and Jonathan, 2022). Using a smallholder-centred design as a specific case of the user-oriented design approach helped identify synergies and trade-offs in service needs and interface preferences among key value chain actors. The insights from Chapter 3 helped design a loyalty

intervention based on the needs and challenges of smallholders and the actors they interact with (Graham, 2019; Steinke et al., 2021). The positive effects of ICT-based financial and non-financial loyalty incentives on farmers' use of inputs and yields indicated that enhancing relationships through interactions to share information and commit to actions (Mukhtar and Azhar, 2020) is important to enhance gains from ICT platforms. Notably, Chapters 4 and 5, contribute to the adoption and marketing literature, by highlighting the role of ICT platform in fostering relationships, trust and loyalty between value chain actors, critical for correcting market uncertainties that hinder farmers' uptake of agricultural inputs (Lajoie-O'Malley et al., 2020).

In the past, it was sheer impossible to reach farmers with information on production and marketing without excessive transaction costs, but the rapid dissemination of mobile phones creates new opportunities through ICT platforms that can efficiently reach farmers through SMS messages, audios and videos (Fabregas et al., 2019; Gupta et al., 2020). Chapters 4 and 5 show that the rapid development of ICT platforms in rural areas, referred to as frugal innovations (Leliveld and Knorringa, 2018), are game changers and centres of innovations that can strengthen actor relationships and transform rural agricultural markets.

To understand how ICT platforms can strengthen actor relationships, the context of our study in Northern Uganda, is particularly a suitable context with a competitive market environment of both local and regional output processers and traders because of its soybean production potential (CSA, 2015). The region has seen soybean production replace cotton growing, which declined due to the collapse of institutions and social strife in the late 1970s and 1980s (De Haas, 2021; Walusimbi, 2002). With the potential to increase farmers' incomes and food and nutrition for humans and livestock, as a way to rebuild the region, large investments have been made by government and donors in agricultural innovations to enhance soybean production. Such innovations have also come with interventions in value chain development to enable

farmers to access inputs and output markets for soybean. However, with the increasing food demand and influx of traders, stable relationships are increasingly becoming important. The results of Chapter 5 add to the few studies in marketing that look at hindrances to market integration in rural markets of emerging economies (Ingenbleek et al., 2013; Kwaramba et al., 2022).

Historically, agricultural cooperatives were seen as vehicles that can enhance farmers' access to market linkages through bulk marketing and price negotiations (Mangnus and Schoonhoven-Speijer, 2020). With lack of institutional support, mismanagement of major cotton and coffee cooperatives led to their collapse. Although, the national development plan vision 2030, focuses on rebuilding cooperatives (NPA, 2013), past experiences by farmers remain a threat to their re-development. The advent of ICT platforms in smallholder agriculture, however, provides an opportunity to strengthen marketing relationships between the farmers and output buyers to benefit from their interactions in a way that farmers access produce markets at fitting prices, and buyers can obtain the needed produce volumes.

6.6 Multifaceted interfaces for one stop centre-based ICT platforms

To design a one-stop ICT interface and enable access to the required value chain services, Chapter 3 demonstrated how ICT platforms can integrate different needs and challenges by paying particular attention to the social cultural disparities, capabilities and business goals of various value chain actors (i.e., language, literacy, and efficiency requirements). ICT-based services have largely on making agricultural information and knowledge accessible to farmers through the use of simple mobile phones that use USSD code (Abdulai et al., 2023). With the increasing availability of mobile phones, the internet, and emerging technologies such as big data analytics (Wolfert et al., 2017), Chapter 3 emphasizes that investments for ICT services should be centred around designing multifaceted interfaces that integrate both simple feature phone and smartphone tools. Such tools need to be tailored to different languages, and type of

access (on-demand, online and offline), to help bring on board all value chain actors for functional ICT-based value chains.

As indicated in Chapters 3, 4 and 5, integrating tools and mechanisms that enhance information exchange and interactions can improve trust and build strong buyer-seller relationships among business actors (Lajoie-O'Malley et al., 2020; Liverpool-Tasie et al., 2020). These suggestions echo studies on ICT4D that emphasize deeper and broader participation in designing technology platforms to suit the changing and functional requirements of the multiple users of such technology (Liu et al., 2017). The use of multifaceted interfaces will create a balance between user preferences, technological feasibility, and economic feasibility (LaFond and Davis, 2016), to reduce "design-reality gaps" and result in more inclusive and better fitting service innovations (Ortiz-Crespo et al., 2020; Steinke et al., 2021; Van der Burg et al., 2019).

6.7 Digital literacy for farmers

To optimise interactions, linkages, service delivery, and improve the use of ICT services among smallholder-based value chain actors, Chapter 3 demonstrates the need for digital literacy among farmers. The results of Chapters 3, 4 and 5 demonstrate synergistic benefits to all actors if farmers are able to use ICT services. The lack of digital literacy among farmers hinders their access to ICT-based services (McCampbell et al., 2021a). To tackle this challenge, we agree with recommendations from other studies that training and re-training farmers in using mobile phones is crucial for functional ICT-based value chains (Abdullahi et al., 2021; McCampbell et al., 2021b). Furthermore, awareness campaigns led by ICT platforms and other stakeholders such as government and telecommunications companies can improve digital literacy among farmers (Girma and Kelil, 2021). Digital literacy among farmers will enhance the role of ICTs in creating efficiency in business processes, and to supporting local decision making i.e., production information, marketing processes (bulking, produce bulking/pickups), input delivery, extension delivery, etc.

6.8 Limitations and opportunities for future research

While my thesis contributes to the smallholder literature on use of ICT platforms to enhance uptake of agricultural inputs and yields, it inevitably leaves unexplored avenues for future research. First, we addressed the relationship between ICT platforms and smallholders' uptake of production technologies based on one case for each archetype of ICT platforms, in a qualitative manner. Future research assessing different pathways could further test these effects quantitatively. This thesis showed that learning on the part of ICT platforms regarding orientation towards users (farmers and other key actors) is essential to stimulating uptake of input technologies. As such, there may be many micro-level barriers (e.g. interface design and service marketing) that impede ICT platforms from stimulating uptake, that may be overlooked by managers who consider only strategic aspects, as discussed in this thesis. Further research could explore these micro-level barriers to understand how they could be solved.

Second, this thesis provides important insights into the relevance of eliciting all value chain actors' needs and preferences in a (re)-design process of ICT services for the development of smallholder-based value chains. Namely, developing multifaceted interfaces that integrate different actors' design interface preferences. I recognise that developing such an interface could enhance coordination of the entire value chain while enhancing mutual value for all actors. Therefore future research is needed to collect empirical evidence on the impacts of such recommendation.

Third, this thesis tested the effect of financial and non-financial loyalty benefits of an ICT-coordinated loyalty intervention on smallholders' use of inputs in the context of soybean inputs (improved seed varieties, fertilisers and inoculants) and smallholders in Northern Uganda. We were not able to assess effects on the use of inoculants because of the absolute numbers of farmers using such an input being very small. We recognise that institutional gaps and logistic arrangements of such a loyalty intervention maybe different for other parts of the country and

countries. Accordingly, the effectiveness of ICT-coordinated loyalty interventions may vary depending on the context and experience with the ICT platform. Further research could explore the role of farmers' experiences with the ICT platform and the inputs in farmers' uptake of inputs.

Finally, while this thesis took steps to identify roles ICT platforms could play in reducing market uncertainties through relationship and loyalty building between farmers and buyers, the factors that disrupt value chain development such as influx of many buyers locally and regionally in the market resulted in way higher prices that could not be matched by the output buyer. Thus, we could not extend our research to investigate effectiveness of ICT- coordinated loyalty intervention on farmers' actual selling behaviour. In a nutshell, while ICT platforms are assumed to be silver bullets in facilitating and fostering agricultural value chain linkages cost-effectively, our study results show it is not so much in how fancy the digital platforms are, but how they address the user's needs as well as how well they coordinate the 'physical' process. Such ICT-based coordination mechanisms remain a lengthy process, requiring consideration and alignment of different actors, their needs and preferences as well as developing sustainable development models.

6.9 Implications for practitioners and policy makers

Each chapter of this thesis provides a different perspective on the use of ICT platform in the adoption of agricultural inputs. The implications from this thesis are summarised in the Table 6.1 below.

Table 6.1 Summary of implications

Practitioners	Implications
Policy	• There is need for policy interventions to create a conducive business environment such as improved physical road infrastructure, better network connectivity and access to cheap internet for rural areas to support ICT-coordinated value chains.
ICT developers	• ICT services should prioritise solutions that cut across the needs of the different actors, for mutual benefits • ICT platforms should learn from each other and acquire new skills and knowledge, and reduce costs by engaging in cost-sharing collaborative arrangements with other actors within the market system. ICT platforms could join forces through mergers and acquisitions and/or form an industry organisation that facilitates learning and harmonisation. • ICT platforms should develop multi-faceted interfaces that integrate tools for both simple-feature phones and smartphones, customised to different languages, different types of media - e.g. audio, video, SMS etc., to cater to the preferences of different value chain actors. • ICT platforms alone are not enough, the functioning of these platforms still relies on the physical presence of actors; such as village agents. Hence, managers of ICT platforms need to develop their own capacity and the capacity of those they work with to ensure quality and reliable information exchange. • must develop their capacity in terms of human resources, as well as the capacity of those on whom they rely to provide this range of services (village agents) if they are to play multiple roles, including demand articulation, network building, knowledge brokering.
Other value chain actors	• Input suppliers and companies need to develop viable business models for the delivery of inputs such as fertilizer and rhizobial inoculants to ensure greater access by farmers in rural areas. Addressing the low use of inputs and low yields among smallholder farmers necessitates improving farmers' physical linkages to inputs through input loans, quality inputs within their localities and knowledge about the benefits and use of the inputs. • In collaboration with ICT platforms, other value chain actors need to build trust with each other through loyalty interventions and ensure delivery of timely and quality services such as inputs, output pickups, microcredit access etc. Such arrangements will enhance buyer relationships, increase price transparency and exchange of credible marketing information to pull investments in input use by farmers.

6.10 Concluding remarks

For the last ten years of working in agricultural value chains in Uganda and specifically in central, eastern, south western, and Lango sub regions, I have had a chance to interact with different market-based interventions for various crops including pineapple, apple bananas,

oyster mushrooms, and grain legumes as well as apiculture. My main concern has always been why there seem to be large investments in agricultural value chains, but with limited impacts on farm productivity and incomes for smallholder farmers. Working with a research into development project (N2Africa) before the start of my PhD research, helped shape my understanding of agricultural input technologies and the challenges farmers meet in the uptake of such input technologies. Through this thesis, I have been able to explore how the increasing deployment of ICT platforms in smallholder-based agricultural can be used to boost farmers' use of agricultural inputs, farm productivity and incomes.

My study revealed a large diversity of ICT platforms in agriculture that use different strategies to influence smallholders' use of agricultural inputs. Although with different points of departure, ICT platforms are adapting their strategies towards coordination of the entire value chain ecosystem to solve the many challenges faced by farmers and realise improved use of inputs among farmers for productivity increments. One of the key findings of this research is that indeed ICT platforms can play a role in building actor relationships to remove market uncertainties and stabilise agricultural markets. To do this, addressing key value chain challenges and needs of the different actors is particularly important for co-creating value and to achieve the use of ICT services, which are currently very restricted. However, through this research, I have appreciated the value of a multi-disciplinary perspective. Scholars from economics, agronomy and marketing should read and learn from each other's work, if agricultural productivity is to be realised. An overly narrow disciplinary perspective of research can hamper societal impacts of the research and development by overlooking important lessons and market developments.

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Summary

The demand for food is growing globally due to population growth, growing incomes and rapid urbanisation. In Africa alone, food demand is projected to double by 2050. Yet, food production depends on rain-fed subsistence agriculture, characterised by low levels of input use and low productivity due to decreasing soil fertility and shrinking farms. Various agricultural innovations have been deployed to enhance productivity and incomes for smallholders. However, smallholders' use of such technologies has remained generally low, worsened by rising production risks and uncertainties driven by climate change. Agricultural technology adoption constraints are well documented; these are largely information (weather, input, output and financial markets) and knowledge-related, besides infrastructure and human capital.

The recent proliferation of mobile-based Information Communication and Technologies (ICT) in sub-Saharan Africa presents a great opportunity to reach many farmers with information on new varieties, weather forecasts, prices and market information in a timely manner. Various studies have explored how the application of ICT platforms could improve the uptake of agricultural input technologies in smallholder agriculture in sub-Saharan Africa. However, the evidence of the impacts of ICT platforms on smallholders' uptake of agricultural technologies is mixed. There are concerns about whether ICT platforms should prioritise: input markets, output markets, or perhaps both, to create transparency on the incentives for farmers to "pull" and "push" investments in inputs. This thesis explores and analyses the roles of ICT platforms on farmers' uptake of agricultural input technologies and find entry points for improved functioning of ICT platforms in smallholder-based value chains to boost farm productivity and contribute to food security, focusing on Uganda, as a case.

In Chapter 2, I explored the motivations and actions of ICT platforms in a qualitative case study of four ICT platforms, to understand the strategies used by the four ICT platforms in improving the uptake of agricultural inputs among smallholders and their future strategic directions. The

results revealed that ICT platforms adapt their strategies with regard to market system positioning, services offered, and value co-created with other value chain actors to influence farmers' use of inputs. Unlike the ICT platforms that did not adapt their strategies, the ones that adapted their strategies influenced farmers' use of inputs more. Insights from this chapter showed how ICT platforms started converging towards becoming coordinators of value-chain ecosystems to solve many value-chain challenges faced by smallholder farmers.

Insights from Chapter 2 showed that most of the ICT platforms focused on smallholder farmers alone. Using the new service development literature that argues for value propositions for all actors in service design, I then zoomed into one of the ICT platforms in Chapter 3 to try to understand what core value chain actors need from ICT platforms. The findings showed that value chain actors indeed require similar ICT services such as value chain coordination, loyalty building, digital literacy for farmers and multifaced ICT interfaces. Results also showed a preference for simple and advanced interface features, specifically, a simple feature phone for farmers and a smartphone for the remainder of the value chain actors. The findings of this chapter emphasise the need for ICT platforms to first prioritise needs that cut across all value chain actors and make trade-offs about whose needs they consider most important. This idea was developed further in Chapter 4.

Based on insights provided in Chapter 3 and particularly the synergistic need for loyalty building to correct output market uncertainties, Chapter 4 examined the effects loyalty incentives shared by an Information and Communication Technology (ICT) platform on farmers' use of agricultural inputs and soybean yields using survey data from 234 farmers in Northern Uganda. The results indicated a significant (P<0.001) influence of financial and non-financial loyalty incentives on farmers' use of improved seed and fertiliser compared with no incentives. Average soybean yields significantly increased above the control (619 kg ha^{-1}) by 525, 747 and 854 kg ha^{-1} for non-financial, financial, and a combination of financial and non-

financial incentives, respectively. The findings showed that the financial and non-financial benefits of an ICT-based loyalty programme with output market linkages positively influence farmers' use of agricultural inputs and soybean yields. This chapter also provided evidence that loyalty incentives (common with larger firms) are also effective in smallholder-based value chains, thereby advancing the knowledge on loyalty interventions for sustainable intensification of agricultural production and technology adoption through ICTs.

In Chapter 5, the evidence in Chapter 4 was extended to assess the effects of loyalty incentives on smallholders' loyalty behaviour to the specific output buyer. The findings showed that loyalty incentives offered through an ICT platform have a positive effect on farmers' loyalty, thereby contributing to the development of stable value chains through relationship building. The results also show that the effect is generalisable across the financial and non-financial incentives, and both types of loyalty incentives stimulate different types of commitment (calculative and affective), respectively. The findings of this chapter help to explain why loyalty instruments eventually influence loyalty, suggesting that relationships in agricultural value chains are strengthened more effectively when the new ICT institutions are also trustworthy.

To increase access and use of ICT services among smallholder-based value chain actors, this study emphasizes that investments in ICT services should be centred around designing multifaceted interfaces that integrate both simple feature phone and smartphone tools. Such tools need to be tailored to different languages and types of access (on-demand, online and offline) to help bring on board all value chain actors for functional ICT-based value chains. Furthermore, to optimise interactions, linkages, and service delivery and improve the use of ICT services among smallholder-based value chain actors, this study strongly recommends digital literacy training for farmers and awareness campaigns led by ICT platforms and other stakeholders such as government and telecommunications companies. Digital literacy among farmers will enhance the role of ICTs in creating efficiency in business processes and supporting

local decision-making, i.e., production information, marketing processes (bulking, produce bulking/pickups), inputs delivery, extension delivery, etc., making ICT-based value chains functional.

The positive effects of ICT-based financial and non-financial loyalty incentives on farmers' use of inputs and yields indicated that enhancing relationships through interactions to share information and commit to actions is important to enhance gains from ICT platforms. Notably, this study highlights the role of the ICT platforms in fostering relationships, trust and loyalty between value chain actors, which is critical for correcting market uncertainties that hinder farmers' uptake of agricultural inputs. This chapter strongly recommends integrating tools and mechanisms that enhance information exchange and interactions to improve trust and build strong buyer-seller relationships among key value chain actors.

Overall, this current study recommends a one-stop centre ICT platform to reduce transaction costs across the value chain and ensure that farmers access all the required services to produce and market their produce without the need to register and navigate different platforms that cause digital fatigue. A one-stop centre will ensure a well-functional and coordinated value chain between the demand and supply of agricultural markets (inputs, outputs, microcredit, and associated services) across value chain actors. To do this, ICT platforms need to orient themselves towards the needs of not only the smallholders but also the needs of the different actors that provide services to smallholders for mutual benefits.

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Connetie

About the Author

Connetie Ayesiga born in Hoima, Uganda, obtained her Bachelor's degree in Development studies from Makerere University. She joined Swisscontact the Swiss Development cooperation where she served as a Junior officer and later project officer managing the Development Programme of the cooperation. During her tenure at Swisscontact she worked with different value chains including Coffee, pineapples, mushrooms, apple bananas and bee keeping. At Swisscontact she contributed to the development of agricultural export markets in the value chains working with exporters and producers. She also contributed to the development of a local mushroom and training centre which saw increased production of mushroom seed and mushroom production among women in south western Uganda. She developed training manuals for farmer organisation development. While at Swisscontact, she enrolled for a self-funding Master's programme at Makerere University and obtained a Master's degree in Rural Development majoring in Agribusiness Development. She joined Technoserve as a Business Development Advisor before joining the International Institute of Tropical Agriculture as a Business Development Officer for the N2Africa project overseeing the partnerships and Business Development of the project. At IITA, she contributed to the dissemination and uptake agricultural technologies, and development of agricultural input and output markets, and presented on national and international conferences. In 2018, she started her PhD at Wageningen University, Marketing and Consumer Behaviour group. Her PhD research focuses on the use of digital platforms in the uptake of agricultural inputs among smallholder farmers in an effort to improve farm productivity and contribute to food security for the growing population in Africa and globally.

Completed training and supervision plan

Connetie Ayesiga
Wageningen School of Social Sciences (WASS)
Completed Training and Supervision Plan

Name of the learning activity	Department/Institute	Year	ECTS*
A) Project related competences			
A1 Managing a research project			
WASS Introduction Course	WASS	2018	1
Writing research proposal	WUR	2018	6
MCB Lunch meetings/seminars/ PhD day	MCB	2018, 2022, 2023	2
Searching and organising literature	WUR Library	2018	0.6
Scientific writing	Wageningen In'to languages	2023	1.8
How to write great papers in less time	Prof. Dr Christina Sichtmann	2021	2
Reviewing a Scientific Paper	WGS	2018	0.1
'The role of ICT platforms in smallholder agriculture'	IITA Research seminar	2018	0.8
A2 Integrating research in the corresponding discipline			
Creating frameworks for marketing and consumer behaviour, MCB 31306	WUR	2018	6
Advances in legume science and practice 2	Association of Applied Biologists	2021	0.8
BREAD-IGC Virtual PhD Course on Firms and Development 2023	The Bureau for Research and Economic Analysis of Development (BREAD), in collaboration with the International Growth Centre (IGC)	2023	4
B) General research related competences			
B1 Placing research in a broader scientific context			
Quantitative data analysis: Multivariate TECHNIQUES	MAT, WUR	2019	2
Introduction to R and R studio	PE&RC & WIMEK	2020	0.9
Farming systems and rural livelihoods: Pathways to sustainable development	PE&RC	2018	3
B2 Placing research in a societal context.			
Transformative partnerships, collaboration and engagement to address the pressing food system challenges of today and tomorrow	NL-CGIAR	2022	0.3
C) Career-related competences/personal development			
C1 Employing transferable skills in different domains/careers			
Brain-friendly Working & Writing	WGS	2020	0.3
PhD workshop carousel	WGS	2018	0.3
Total			**31.9**

*One credit according to ECTS is on average equivalent to 28 hours of study load

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