

The role of ICTs in improving smallholder maize farming livelihoods: The mediation of trust in value chain financing

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Abstract: *Maize production is of critical relevance to smallholder farmers in Ghana. Various factors however continue to limit the productivity of smallholder maize farming systems undergirded by the lack of capital for critical investments both at farm and national policy levels. Using a value chain approach in a diagnostic study, we explain the enduring absence of credit support through an analysis of a complex configuration of actor interaction in the agrarian context. We find a cycle of credit rationing resulting from value chain challenges and credit uncertainties generated by both institutional and environmental factors. This condition is sustained by an interplay between mistrust, insufficient information across the value chain and inadequate control strategies in the maize credit system. We argue that Digital Information Systems (DIS) show potential under some conditions, to generate new networks and forms of cooperation which offer a means of overcoming some uncertainties impeding traditional value chain credit arrangements. This is promising in terms of aiding coordinated responsiveness to farm conditions and records generation. As a tool for mediating trust in value chain credit partnerships, strategic use of DIS could help initiate an entry point for recalibration of trust perceptions. However significant considerations and improvements are needed to harness this successfully in the maize farming context, not least being farmer access and use of digital technologies and effective intermediation arrangements. This approach to trust building should therefore not be viewed as a quick fix but a process of trial and error, and learning by doing.*

Keywords: *Trust, Smallholder livelihoods, Value Chain, Ghana, Maize, Credit, Digital*

Introduction

Maize output in Ghana is dominated by smallholder farmers, generating an estimated 70% of total produce (Angelucci, 2012). The Ghana Living Standards Survey (2008) showed that, of the number of households who harvested staple and/or cash crops in 2008, the majority (41%) harvested maize. At GHS 412.3 million (approx. USD\$93M), the annual sales value of maize was 42% of total crop sales by households surveyed, followed by cocoa (37%) in the nationwide survey. This indicates the critical relevance of the crop to the livelihood of smallholder farmers in Ghana as well as the importance of smallholders to maize production (Chamberlin, 2007).

Nonetheless, smallholder maize farmers continue to face various problems that limit the growth potential of maize farming (Dixon et al., 2001). Key factors include: (increasingly) variable annual rainfall, pests and diseases and decreasing soil quality (ISSER, 2017). These problems interrelate and reinforce each other, sustaining a precarious livelihood system (Van Ginkel et al., 2013; Scoones, 1998). The persistence of these farmer livelihood challenges have been attributed, in addition, to the lack of capital for critical investments at farm levels (Salami and Awaromo, 2013). This makes access to credit by smallholder farmers one of the most crucial factors in improving farmer livelihood. Credit access presents a means of breaking the cycle of low investments in smallholder agriculture in stemming the precariousness of smallholder maize farmers' livelihoods (Salami et al., 2010). However, even with the rise of the microfinance sector improving smallholder access to credit has proved challenging. This is, in part, due to the multifaceted and multi-disciplinary challenges

in farmer livelihood systems, which microfinance has struggled to address (Llanto, 2007). This advances the argument for developing integrated system-level approaches that facilitate credit alongside and in addition to addressing complementary challenges, such as improving farmer productivity and market access (Van Ginkel et al., 2013). In other words, looking at it from a value chain perspective. In the last decade there has been renewed interest in value chain cooperation as providing critical analytical and practical resources to deliver multifaceted solutions. This approach is relevant to the challenge of facilitating farmer access to credit since agricultural credit is attractive and profitable to financial institutions when producers are well integrated into a coordinated and viable value chain (Shwedel, 2007).

However, achieving cooperation in the value chain is a complex process. This is because value chains represent interactive processes between diverse actors, of different perspectives, interests, and positions which lead to intended and unintended outcomes (Van Woerkum et al., 2011). As such, successful value chain cooperation has been argued to require evidence of clear beneficial outcomes to multiple actors (Perez et al., 2010) and a bond of trust between actors (Miller and Jones, 2010). This is however challenging in smallholder farming contexts where outcomes are generally volatile (Chamberlin, 2007). This limited sense of control creates risks, increases the cost of cooperation and puts pressure on trust relations (Lyon, 2000; Trienekens, 2011). In other words, cooperation which facilitates credit access is highly influenced by trust between actors and a degree of certainty regarding beneficial outcomes, which are usually lacking. It is therefore critical to find effective ways by which these barriers to cooperation might be overcome.

In light of this, advancements in mobile based digital information systems (DIS) have been seen as a promising way forward. DIS offer new and relatively faster means of monitoring and communicating the agro-ecological as well as social environment in the agricultural domain (Buytaert et al., 2012; Karpouzoglou et al., 2016). These systems could contribute to potentially cost effective opportunities to decentralize the collection of data on farmers, and monitoring of farmer practices and farm conditions (Cieslik et al., this volume). By so doing, DIS could improve trust relations through enhanced information flow and transparency between actors (Larson, 1992) as well as improve perceived certainty of cooperation benefits. Essentially, DIS may contribute to building effective strategic value chain alliances which support credit supply in smallholder value chains. Underlying these attributions is the idea that, just as information technologies have enabled radical new forms of networking across multiple spheres (Castells, 2009; van Zomeren et al., 2008), DIS offers the potential to enhance trust relations between cooperating actors by improving information access and positive expectations of mutually beneficial outcomes.

Despite the positive attributions ascribed to DIS, empirical studies that explore the role of DIS in smallholder credit access are lacking, particularly that which take into account the role of trust in complex actor interactions in the value chain. Consequently, it remains unclear whether, and how DIS influence trust and actor cooperation for improved smallholder credit access in maize production in Ghana. Responding to this gap, the aim of this paper is to analyse the role of trust in credit related value chain cooperation, its relation with information and the extent to which DIS could mediate it.

To operationalise our research objective, we adopt a value chain approach in doing an explorative case study. After presenting our methods and theoretical framework, we focus on the maize production system, livelihoods and value chain credit supply in the Techiman area;

situating the study in the context of Ghana and Western Africa. This deep contextualisation is undertaken in line with the dimensions of the responsible innovation perspective. We then describe factors affecting credit cooperation and their relationship with information and communication. Building on this, we examine, via case study, the potential and constraints of DIS in facilitating farmer credit in value chain partnerships. From this, we discuss and conclude on the vital role of trust and the dynamics of DIS mediation of trust in credit cooperation.

Research methods

Study Site

The research was carried out in the Techiman municipality in the Brong-Ahafo region of Ghana (Fig. 1). The Techiman municipality is situated in the central part of the Brong-Ahafo Region and lies between longitudes 10 49` east and 20 30` west and latitude 80 00` north and 70 35` south. The municipal capital, Techiman, is a nodal town, where roads converge making it a bustling commercial centre and one of the biggest market centres for maize trade both within and across Ghana's borders (GSS, 2014). The municipality thus constitutes an area populated with multiple actors and strategic interactions within the maize farming value chain, making it an appropriate study area for this research.

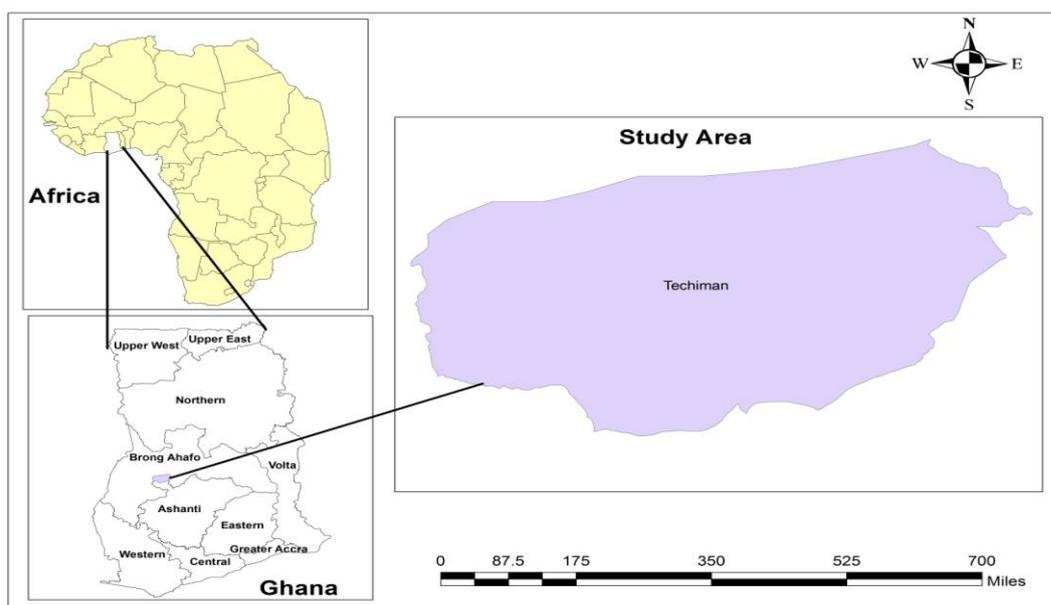


Figure 1: Location of Study Area

Tools and Methods for Data Collection

The research was carried out in three stages. The first stage comprised of informal discussions with various agricultural input suppliers, traders and farmers in and around the town to determine what arrangements are usually made regarding input supply for farmers in the area. These discussions were used as a means of focusing the research on the key actors in the value chain regarding smallholder credit: Smallholder farmers, Traders and Financial Institutions. Following this, we identified ICT mediated initiatives involving farmer-trader credit interaction in villages near the Techiman town, sourced from institutions active in the locality. Based on this information, Mesedan and Dwenewoho were sampled for farmer data collection. Another village, Amponsem was selected from the surrounding villages as a site without an ICT initiative. All three villages are representative of farming communities in

the municipality and each has a history of maize production. For data gathering in the villages, farmers were selected by means of the lead researcher taking a walk in the village, with a farmer, community leader or extension agent serving as a guide. For trader engagement, we selected traders based on whether they had prior experience of ICT mediated farmer arrangements, to gain insights of practices with and without using ICT. Financial institutions were selected based on preliminary discussions with farmers on the types of creditors they usually engage with.

In the second stage, semi-structured interviews were conducted with the purpose of generating data. Between 15 and 20 maize farmers were interviewed in each village. Farmer interviews were conducted in Twi, a local language. Five traders were interviewed from a sample of 15, each selected on the basis of having met the ICT experience criteria. Three categories of financial institutions were engaged with in data collection, with three interviews per category: rural bank, microfinance, and cooperatives/credit unions. In addition, interviews were conducted with representatives of the Ministry of Food and Agriculture, ARB Apex Bank, Alliance for Green Revolution Africa (AGRA), Bank of Ghana, Esoko, and Grameen Foundation. Topics discussed in the interviews were based on information raised in preliminary discussions as well as from agricultural credit and value chain literature. Based on the interview results, 3 focus group discussions (FGD) were undertaken in the third stage (one per village). FGD groups consisted of between 7 to 9 discussants who were selected based on the predominance of maize in their cropping system. Female farmer views were included through one female-only FGD conducted in Dwenewoho. The FGDs took between 60 to 150 minutes and were audio-taped.

Table 1: Data Collection Methods

Stages	Method	Actors	Sample Size
Stage 1	Informal interviews	Input Suppliers, Traders, Farmers, Extension Agents	
Stage 2	Semi-structured interviews	Farmers	50
		Traders	5
		Financial Institutions	9
		Key informants: Ministry of Food and Agriculture, ARB Apex Bank, Alliance for Green Revolution Africa (AGRA), Bank of Ghana, Esoko, Grameen Foundation	
Stage 3	Focus groups	Maize Farmers	7 to 9 discussants (32 farmers)

Data analysis

After the interviews and discussions, the audiotapes were translated where necessary, transcribed and anonymised. Translation of Twi was conducted with the approach of maintaining content and semantic equivalence in English as possible (Temple et al., 2006). Thematic content analysis was used for analysing the data. The themes were determined based on categorization of data relating to actor challenges in value chain roles and interaction, actor concerns and needs for effective cooperation, and actor experiences from digitally supported cooperation. The themes derived from the content analysis were: (1)

farmer livelihood problems and dynamics reinforcing a low credit supply (2) credit cooperation impediments (information related or otherwise) (3) current use of digital information structures, and (4) limitations and opportunities for DIS based value chain credit cooperation.

Theoretical Framework

Uncertainty, trust, information and control

In societal interactions where diverse outcomes are possible, trust is instrumental in reducing uncertainty and complexity for action (Lane and Bachmann, 1996). Luhmann (2000) argues that in uncertain conditions, the lack of trust simply leads to the withdrawal of activities by actors and therefore limits the options for rational action. In other words, trust is generally seen as a key element in bridging uncertainty and generating action in perceived risky situations involving others. This is because trust is an assurance of “the reliability of a person or system regarding a given set of outcomes or events” (Giddens, 2013: 34). For Das and Teng (1998), trust relates to expectations regarding the motives of the subject of trust. Trust, then, is argued to be a relevant factor only in uncertain conditions where negative outcomes are likely (Kee and Knox, 1970). The willingness to be vulnerable to the actions of others, in expectation of favourable action when negative outcomes are possible, is essentially trust (Hosmer, 1995).

Although trust has been described as drawing on past experiences (Simmel, 1978), both personal and of others, trust is not static but dynamic and continually being influenced by new information received and interpreted by actors (Luhmann, 2000; De Vries et al., 2014a). The flow of new information to actors, which may be of varied importance, and viewed from differentiated perspectives continuously influence actor perceptions and reshaping of relationships (Lewicki et al., 1998). Thus, information availability may directly or indirectly affect trust between actors. Larson (1992) therefore argues that more open and frequent communication between actors leads to information symmetry and can contribute to more trusting partnerships.

In matters of uncertainty, Das and Teng (1998) argue that when trust is insufficient, the ability to exert some control over outcomes become more pertinent. Control is defined as “a regulatory process by which the elements of a system are made more predictable through the establishment of standards in the pursuit of some desired objective or state” (Leifer and Mills, 1996: 117). Control therefore reduces uncertainty by laying structures which increase the likelihood of anticipated outcomes. Thus, control could serve as a bridge for acting in uncertain situations when trust is inadequate.

Partner Cooperation

In networks of working relationships such as trading arrangements, reliable working relations are formed through a complex pattern of current, past or expected future exchanges (Lyon, 2000). Because such arrangements create some form of dependence on another, there is vulnerability due to a lack of certainty of the other’s actions. Depending on the reliability of others to act in one’s favour in working relationships can be described as trust. Partnerships require a minimum level of trust to accept vulnerability since one cannot monitor all actions in exchanges (Das and Teng, 1998; Kumar, 1996). Trust is therefore a key element in the development of partnerships and cooperative relationships between actors (Das and Teng, 1998). Trust alone however is not necessarily sufficient in facilitating cooperation between

actors. Actors use control mechanisms to make the attainment of goals more predictable, which ensures more certain outcomes and thereby generates willingness to cooperate (Das and Teng, 1998). Potential partners therefore rely on trust and control in a complementary manner (Beamish, 1988) in developing a self-assurance for cooperation.

Building on these theoretical notions, we explore value chain credit partnerships and the mediatory capacity of DIS for cooperation and trust building in Ghana by taking into account maize value chain challenges and credit uncertainties, and the dynamics between trust, control and information access in these uncertainties.

Results

In this section, we first contextualize credit relations by showing (1) existing livelihood problems and dynamics supporting low credit supply; (2) the requirements for credit cooperation and relation with information gaps. We then present (3) experiences from an existing digital platform mediating credit cooperation within this context.

(1) Livelihood Problems and Uncertainties influencing Low Credit Supply

Agro-ecological Uncertainties

Rainfall in the major farming season has been described as increasingly erratic in recent years. Farmers find it difficult to determine the appropriate time to plant or apply fertilizer. This situation has made some farmers more averse to credit, fearing the additional risks: *“The moment you use a loan to pay and apply inputs to your land and it fails to rain properly, the money is stuck in the ground and you are in trouble”* (Smallholder farmer). Farmers however lack funds for more drought resistant maize varieties: *“The Pioneer hybrid seeds for instance can fare well even when the rain is not enough but they are also expensive”* (Smallholder farmer). Furthermore, the traditional dry season is observed to have waned, discouraging traders from making credit arrangements with farmers during the major rainy season due to likely losses from fungi growth and poor maize quality: *“I usually do not provide credit in the major season”* (Trader). In effect, trader incentive to offer credit appears to diminish as climate variability increases. In addition, farmers are challenged by diseases and pest outbreaks, with the Fall Armyworm posing significant threat to production in recent years.

Limited Access to Agricultural Training

The ability of farmers to produce reliable quantities of maize is fundamental to the credit process. *“When I inspect the farms of farmer’s applying for the loan, I look to see if the farmer follows good agricultural practices in determining whether he should be provided a loan”* (FI representative). Extension services are however significantly low, with local extension departments understaffed and underequipped to offer needed support. As a consequence, farmers possess limited knowledge of GAP for ensuring good production yields, thereby producing low quantities and quality of maize. As one of the smallholder farmer explains: *“We used to have one trader come here requesting to buy our maize but he stopped because he said we were not producing enough”*.

Farmer Monitoring and Accountability

FIs are apt to restrict credit to smallholder farmers due to the perceived likelihood of strategic debt defaults. *“If you want to trust farmers, you will go mad. I will take only about 20% to be trustworthy. The rest 80% are not trustworthy”* (FI Representative). Some traders share a

similar perspective as to the trustworthiness of farmers, claiming that while hoarding produce in order to side-sell to other traders, many farmers report poor harvests and default on loans: *“Right now its harvesting season, I have to run to the field to monitor the harvest otherwise I will end up losing so much from what the farmers hoard away”* (Trader). Nonetheless, creditor capacity to directly monitor and ensure farmer accountability is limited due to resource constraints. This leads creditors to depend on direct contact with trusted individuals, but this is not a panacea: *“Sometimes relying on farmers to check themselves works and sometimes it doesn’t. Mostly in the places where it’s not very effective, the communities are not as bonded or the leaders are not strong enough to ensure compliance”* (Trader).

Trader Power in Maize Purchase

Farmers are generally dissatisfied with maize purchase standards which they deem unfair. *“The traders cheat maize farmers a lot. They sometimes come with tampered sacks which are able to expand to buy our maize. Since they don’t use scales or standard 100kg bags like in cocoa trading, we end up with low returns from sales”* (Smallholder Farmer). This perception is coupled with weak and relatively powerless farmer organizations, who have limited bargaining power towards traders. This status quo is unfavourable to farmers as well as FIs who seek to maximise returns per bag to offset outstanding debts. Thus, when FIs are involved, measuring scales and standard purchasing bags tend to be used. *“When farmers work with traders arranged by the Bank, they have a better agreement than what they get with those traders who are in the market. Our traders may weigh it with scales. So they prefer our buyers”* (FI Representative). In such cases, trader power is mitigated. But as FI collaboration with traders is not widespread, existent trader-farmer power relations tend to prevail.

Maize Market Oversupply

Drying equipment and warehousing facilities are critically undersupplied in maize production in the Techiman area. This storage gap leaves the maize trade volatile and highly susceptible to short-term market forces. After the major season’s harvest the market enters a state of acute oversupply and depressed prices. Creditors require loan repayment soon after harvest when prices are quite low. With many farmers repaying debts from their maize sales, more bags are required to offset loans at those low prices. This situation therefore contributes to difficulties in debt repayment: *“As for the farmers, their main challenge is with the price of the maize. Sometimes they need GHS 100 per bag to cover their costs but before they realize they are only being offered around GHS 70 in the market”* (Trader). Market conditions are further exacerbated by trader import of cheaper maize from neighbouring countries such as Burkina Faso. The Techiman maize farming context and the pathways that entrench a vicious cycle of low credit supply to farmers are presented in Figure 2.

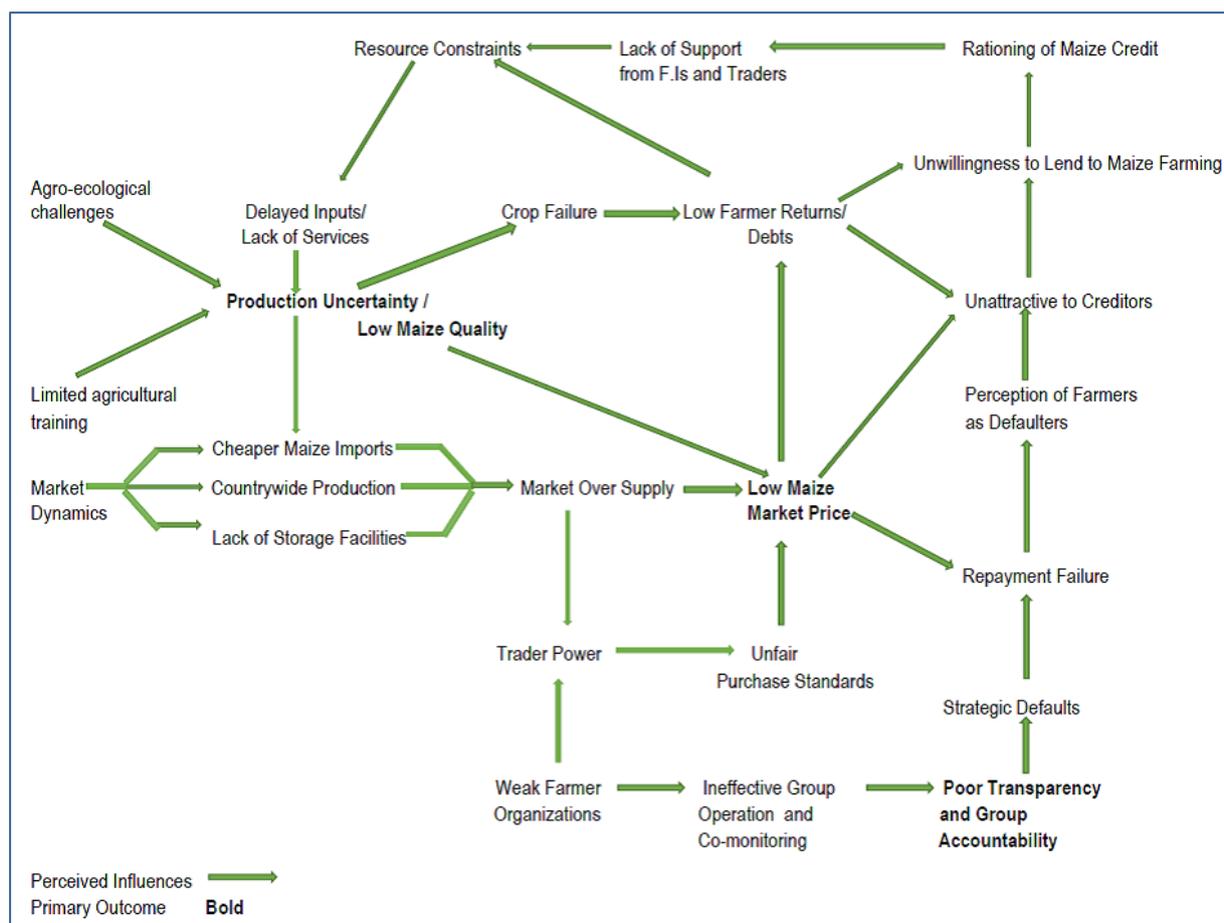


Figure 2: Maize Value Chain Cycle of Low Credit Supply

(2) Information, Trust and Control Dynamics Impeding Credit Cooperation

In this section we highlight some factors that are required for credit cooperation in the uncertain maize farming context, and the challenges which impede them. We describe these factors in terms of trust and control, and indicate their relationship with information/communication gaps or otherwise.

Farmer Production Capability and Performance

The ability of creditors to assess and differentiate smallholder farmers is often challenged due to inadequate records: “We mainly rely on other community members to know how capable and reliable a farmer has been in production when considering partnering and advancing credit” (Trader). Furthermore, lack of records limits demonstration of farmer experience in managing shocks such as pest and diseases outbreaks. As such, with scarce background information, creditors have to trust farmers’ ability to deal with agro-ecological challenges in highly volatile contexts. When farmers fail to produce as expected, mistrust is bred and consequently unwillingness to cooperate. In addition, inadequate weather information systems and high agriculture insurance premiums limit actors’ control over farmer production outcomes.

On the other hand, farmer willingness to cooperate with creditors is hampered by communication challenges between cooperating actors at key production points and failed promises: “Last time they brought the credited inputs weeks after the time we should have applied it, so the heads of the maize did not grow as big as it should have by harvest. But we

still had to pay the loan as agreed” (Smallholder Farmer). This point of view sustains mutual distrust between actors as farmers feel that they have to bear the risks of production and debt alone.

Marketability of Maize Produce for Ease of Debt Repayment

The quality of maize produce affects its marketing potential and the odds of securing sale to repay debts. Lack of information on actual on-farm decisions and actions to ensure quality maize harvest therefore impede cooperation. For instance, creditors need affirmation of the willingness and ability of farmers to apply the inputs that are provided on credit: *“In order to benefit, some farmers under apply the input on maize seedlings and apply the rest to other crops for which inputs were not advanced on credit”* (Trader). As such, creditors are often concerned over marketability of produce at harvest: *“We provided fertilizer on credit to some maize farmers who apparently were not knowledgeable in how to use it effectively; they kept applying too much per plant.”* (Bank Representative). Such situations lead to poor produce quality, disappointments and diminishing trust. Limited information on farmer integrity and consistency in taking appropriate decisions in this regard is thus un conducive for cooperation.

Furthermore, since control over the maize market lies generally outside the domain of farmers, their bargaining position with traders is relatively weak. This limits trust in the ability of maize farmers to secure optimum prices and repay loans in a timely manner: *“The low price for maize means that farmers take time to sell enough bags to be able to clear their debts compared to crops like cashew”* (FI representative). Some FIs attempt to generate some control over this uncertainty by providing credit only to farmers with secured purchasers prior to harvest. The effectiveness of this control mechanism is limited due to difficulties in finding reliable purchasers. *“We had some problems in the past, the buyer came and took the maize from the farmers but he couldn’t pay off the farmers’ debt at a go but in installments. It was not favorable, so the farmers who took the loan defaulted”* (FI Representative). This has meant that FIs who engage in this collaboration require information on the credibility of traders, including credit history checks. Since such information is generally limited, trust and cooperation tends to be low.

Security of Maize Farming Credit from Strategic Defaults

In the absence of assets for collateral, credit to smallholder farmers is generally difficult to secure. As such, difficulties in monitoring farmer activities, lack of information during harvest, and room for farmer opportunistic behaviour garners mistrust. *“Many farmers tend to hide behind other farmer complaints about weather, poor harvests and crop failure even when they have managed to produce something adequate which could repay their debts”* (FI representative). Current creditor dependence on alternative security measures such as credit guarantors faces challenges in enforcement. For instance, some creditors indicate that it is a costly process to track down dispersed defaulters for payments on relatively small loan amounts. However, *“When we are forced to restructure debts for defaulting farmers, other farmers are emboldened to miss payments as well since others seem to have got away with it.... More defaults therefore even occur in follow up loans to farmers”* (FI Representative).

FIs therefore focus on default prevention and significantly rely on farmer group bonds as a means of reducing strategic defaults. Creditor lending to farmer groups is essentially dependent on creditor trust in the capacity of the farmer group. That is, trust in a group’s ability to prevent defaults is key to creditor interest in maize credit arrangements: *“We prefer*

to give to women's groups since they usually default less" (FI representative). Creditors therefore need more information on the capability of groups to perform this role. This is particularly pertinent in the face of more competitive lending ventures: "The main challenge for financing agriculture is that there are many other ventures competing for rural finance which appear to be more secure" (Rural Bank representative).

To summarize, we find that an interplay between mistrust, insufficient information across the value chain and inadequate mutual control strategies in the maize credit system contribute to impeding maize credit cooperation. These dynamics relate to institutional as well as more environmental sources of uncertainty in the maize value chain. Thus, effective credit collaboration may require the introduction of critical interventions which mitigate institutional and environmental uncertainties in partner relations. As identified, such interventions would require informational and non-informational changes that restructure perceptions of trust amongst different actors in the value chain in a manner which adequately addresses credit cooperation needs. Table 2 provides a summary of these dynamics. We explore in the next sections the role digital information could play in the process of facilitating such changes.

Table 2: Information, Trust and Control Dynamics for Creditor Cooperation

Creditor Cooperation Requirements	Control Measures	Trust Measures	Information/communication gaps in Trust development	Information/communication gaps for Control	Non-information factors
Farmer Production Capability and Performance	Weather/crop insurance	Farmer integrity regarding harvest reporting	Farmer past production records	Weather information availability	Cost of insurance
	Irrigation	Farmer benevolence to avoid side selling	Third Party Accounts of performance	Real time estimates of harvest quantities	Cost/Feasibility of irrigation facilities
	Availability and timely access to inputs			GAPs information provision	Lack of guaranteed loans
Marketability of Maize Produce for Repayment Security	Ability to engage in GAP for quality produce	Farmer willingness to practice GAP	Communication on inputs delivery	Information on Farmer on-farm practices	Access to drying facilities Cost of Extension agent
	Availability and timely access to inputs from creditors			GAPs information provision	Costs of monitoring farm activities
	Trader power reduction	Negotiating ability of farmer	Purchase records of potential buyers	Pre-determined contract prices	Cost of warehouse construction
	Market supply regulation Access to storage facilities		Credit history of potential buyers		Non-use of scales Enforcing buyer completion of purchase
Security from Strategic Defaults	Collateral based contract	Social contract	Records on group effectiveness	Improved information on farmer activity	Competing ventures
	Effective social	Reliability of			Contract

pressure (joint liability)	farmer to repay	Farmer traceability	(monitoring)	enforcement costs
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(3) Case Study: DIS Supported Credit Cooperation in Maize Farming

In current day-to-day agricultural practices of maize farming in the Techiman municipality, DIS serve various purposes and are used in different ways. These range from SMS and radio for weather forecasts for farmers to WhatsApp and Telegram for sharing pictures of disease infected plants for extension officers (See Munthali et al., this volume). DIS are used as part of everyday working practices. In addition, DIS have been introduced as part of value chain development initiatives to facilitate cooperation. In this section, we explore an example of a development project in Techiman that has sought to improve communication through digital information as means of enhancing collaboration for credit access; The AgroTech Digital platform.

Experience from The AgroTech Digital Platform

AgroTech SmartEx is a mobile application designed and implemented by Grameen Foundation and partners with the aim of improving farm business productivity and profitability. It offers a tool that aims to help manage investments by traders and smallholder farmers by supporting both actors to optimize their decision-making processes. A mobile application enables a field agent to collect data on the farm situation and management, as well as to provide essential information to the farmer. Data collected include farmer biographies, farm information including geo-data, farmer activities, and input needs. A dashboard enables a user to receive and visualize real-time data in a form that allows the tracking and monitoring of key farm performance indicators as well as for planning purposes. The aim of the software application is to reduce the risks, overhead costs and other constraints faced by smallholder farmers as well as actors who transact with them. It is hoped that by this model, farmers would be better able to produce maize effectively and transparently. This possibility is then leveraged to attract traders who aggregate maize produce to partner and provide inputs on credit to farmers in exchange for maize at harvest. The traders therefore bear the responsibility of employing and remunerating field agents to implement the AgroTech application. By improving trader-farmer transaction relations, AgroTech aims to improve farmer access to trader credit and also attract FI credit services.

AgroTech seeks to facilitate access to credit through three key pillars; extension services, farming data management, and farmer monitoring. First, it looks to improve farmer access to extension information¹ in order to build farmer capacity to produce maize effectively, and with it creditor assurance and willingness to lend. Secondly, AgroTech seeks to create an effective database on farmer activities by offering a digital structure for record keeping. In particular, the platform aims to track over time the performance of farmers with regards to production quantities, skills set, credit history amongst others. By so doing, it looks to provide a structured means for evaluating farmers for credit facilities. Finally, tablets and mobile devices by agents enables the mapping and identification of farmlands through the use of the GPS function. The use of media such as pictures and videos from the device's camera create a means of monitoring and documenting occurrences on farms periodically through visits from agents.

In support of this system, the AgroTech platform ensures farmer use of hybrid seeds with high yield potential and significant resistance to drought are supplied on credit. This aims to

¹ For more details on the AgroTech Platform functionality for extension services, see Munthali et al, this volume.

reduce the likelihood of production failure and secure investments so as to maintain actor interest in cooperation. In addition, the project encourages the formation of farmer groups and uses this as a further means of ensuring accountability through joint liability and monitoring. Finally, cooperating traders and farmers are assisted in accessing credit support from FIs or large produce buying companies. In this, the AgroTech platform seeks to act as a boundary object² creating a bridge between actors in value chain partnerships to enable them work together and support the building of trusting relations for collaboration.

Contributions and Challenges of the AgroTech Platform in Maize Credit Lending

Farmer and trader interaction on the AgroTech Smartex platform appears to have generated some degree of coordinated action for managing agro-ecological uncertainty. Traders have taken up new roles, assisting farmers with information relating to extension and marketing where possible. *“As soon as the farmers identify a problem they call you to see if you can help. We also contact some extension officers for technical information when we don’t have answers”* (Trader). In relation to communication, the platform seems to facilitate participatory response in a rapid manner. *“During the Fall Army Worm outbreak, the farmers contacted me that they had seen the worm on the farm. So we quickly mobilized to verify and provided them chemicals to spray the crops. We also informed the other farmers that they all had to apply the chemicals since the pest was in the community and would likely infect the other farms”* (Trader). Thus, it could be argued that the platform is contributing somewhat to joint participation of farmers and traders in responding to some emerging farm conditions.

However, the platform generally remains vulnerable to agro-ecological challenges. Farmers indicate experiencing occasions of crop failure resulting from pest invasion or weather conditions. This has severe repercussions on the functioning of the AgroTech model since traders rely on returns from sales of farmer produce as the means of remunerating their field agents. Thus, remuneration challenges significantly affected agents’ activities such as transferring knowledge to farmers. This means that key challenges remain in the adoption of this digital model in delivering extension services (Munthali et al, this volume).

This notwithstanding, the AgroTech approach, citing secured produce purchasers, better records keeping and monitoring, has managed to attract credit from various categories of lenders: *“We’ve had support from a bank. Last time we made arrangement with a credit union and this time we have Agricare supplying us inputs on credit”* (Farmer Group Leader). This demonstrates some potential to facilitate credit availability to smallholder farmers. On the other hand, maintaining FI relationships has been constrained by difficulties regarding production: *“We had support from a bank last two years. In the first year, it was good when rainfall was good. However in the second the rainfall was poor and so our relationship has strained due to the delayed repayment”* (Farmer Group Leader). This shows that without effective control measures against agro-ecological challenges, relationship building with FIs remains difficult.

As a farmer monitoring tool, the AgroTech platform, according to some traders, appears to garner some farmer accountability. *“Farmers used to report that their crops had failed when it was not the case. Now with agents among them, they can visit the farm, take pictures to*

² A boundary object is defined as “an entity shared by several different communities but viewed or used differently by each of them, being both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites” (Star and Griesemer, 1989, p. 393)

show that everything is perfect' (Trader). However, with AgroTech agents restricted in their ability to visit farmers frequently, the efficacy of AgroTech monitoring seems limited.

Overall, despite some positive experiences, there appears to be significant challenges affecting the utility of the AgroTech platform for generating credit support for smallholder farmers. As we have shown, in relation to existing dynamics on the ground, maize farming credit requires concerted multifaceted efforts to overcome the barriers reinforcing creditor unwillingness to cooperate with maize farmers. AgroTech is still in the process of learning to adapt to these needs. However, the AgroTech model provides insights into the potential of DIS to overcome some key challenges in credit cooperation as well as relevant considerations for implementation.

Analysis

Based on our findings on factors impeding credit access and cooperation, and the AgroTech case assessment, we present in this section an analysis of the potential and challenges of DIS to mitigate key uncertainties in credit cooperation in the Techiman maize value chain.

Improving information and cooperation in maize production

Lack of up-to-date information is a key factor shaping farmer inability to respond appropriately to farming shocks (Deressa et al., 2009). Thus, digital information may have a key role in filling the gaps created by diffuse and under-resourced extension services. However, the use of DIS as a means of delivering GAPs information is generally impeded by the limited literacy amongst farmers and smart phone access amongst farmers. Under current conditions of low farmer literacy and limited smart device access, farmers cannot access GAPs information available on the DIS. This creates a need for an intermediary between farmers and DIS to ensure farmer ability to benefit from the system. Challenges facing agents remuneration limit DIS significantly reducing uncertainties caused by lack of extension services.

More positively, we see in the AgroTech platform that improved interaction between farmers and traders enables farmers to take advantage of the knowledge, networks and technological savviness of traders in accessing information to address farm conditions. This offers some support beyond farmer traditional knowledge in the dearth of extension services. These interactions may be done through existing social media platforms such as WhatsApp or Telegram that value chain actors are familiar with. Collaboratively addressing farm conditions, facilitated by a DIS, also creates the opportunity for relationship building and the deepening of trusting relations particularly between traders and farmers. This, however, depends on the capacity of traders to respond effectively as expected by farmers. Hence, DIS appear to create an avenue for further interaction between value chain actors and improvement of relations.

Additionally, records of these farmer-trader relationship outcomes such as produce harvest and purchase quantities may generate key data on farmer performance and output over time. Detailed farmer performance records and databases on a DIS could help begin the transition of trader/farmer relations to a more formalized structure. DIS can simplify book keeping, records and data management processes for farmer groups, and support the provision of critical business skills through relationships with traders. Such digital records are relevant

also to farmer-trader–FI relations as they would improve the ability of farmers to meet FI requirements as well as the evaluation of trader capacity to fulfil middleman roles in collaborative funding arrangements. In sum, for uncertainties and cooperation requirements related to maize production, DIS presently appears more suited for facilitating coordinated responsiveness in addressing farm challenges and serving as a records database.

Improving transparency and accountability

Creditors argue that the efficacy of farmer groups as organisations that can provide accountability depends significantly on good leadership. “*We use the farmer group leaders to assess which farmers should be part of the trading arrangements....also the leaders provide the checks and balances for farmers to comply to terms*” (FI Representative). In essence, the ability of farmers’ leaders to monitor and keep members of farm groups in compliance is a key ingredient for success. This places a significant responsibility on farmer group leaders to ensure social cohesion and compliance within the group. By improving communication, DIS have potential to close the gap between group members and lenders in support of leadership. As seen in the AgroTech model, the inability of farmer leaders to utilize the mobile app means that costs of remunerating intermediary agents generally constrain monitoring contributions by the DIS. Essentially, uncertainties regarding farmer accountability in production and harvest are not significantly improved.

In response to this drawback, DIS and smart mobile devices offer new opportunities for farmer group leaders to be trained in the use of smart devices on documenting and sharing of data on farming activities by farmer group members. For instance, through the use of device cameras and geo-tagging, farm progress can be reported and records kept for group purposes by group leaders. The credibility of such documentation would be verified based on pre-determined geolocations on farms as well as corresponding dates. This could facilitate transparency and provide a further check on farmers who enter into clandestine arrangements with traders. Thus DIS could complement leaders’ management skills with technical skills (Kangazi et al., 2009) making them a more effective boundary between other farmers and the technology (Oreszczyn et al., 2010).

Of course, in a context of weak farmer groups, DIS monitoring could also lead to new forms of control, surveillance and technology capture which conversely offers the potential of diminishing trust relations within the group. There is a delicate balance between monitoring, control and trust (Das and Teng, 1998). DIS use in this manner therefore opens room for further power imbalances. If monitoring turns into one-sided control from lenders over farmers, it can strain trust relations even further (De Vries et al., 2014b).

Nevertheless, improved communication between farmer groups and creditors offer potential to reduce the effects of information asymmetry; a key generator of conflicts and mistrust (Larson 1992). In a context where there is a high perception of farmers as credit defaulters, such mechanisms could be significant in enhancing transparency and accountability, and consequently improving credit relations. DIS could therefore not only contribute to farmer group ability to monitor compliance but also provide records on debt repayment history as demonstration of group’s effectiveness in ensuring loan security, in order to attract credit

from FIs. Questions still remain however with regards to the credibility of such records generated from traders and farmer groups.

It is important to point out that transparency and accountability are also necessary regarding creditor/trader actions. Farmers distrust traders due to past experiences of trader failure to purchase produce as agreed in the beginning of the season. Even in the AgroTech project, inadequate transparency regarding input delivery created situations where farmers felt let down by undisclosed delays in delivery. In effect, a more open form of communication through the entire credit process would be good for credit cooperation. Thus, a DIS should not only focus on carrying one way information to creditors but two way access for both farmers and creditors, if mutual trust is to be built. In addition, there is a need to consider how to ensure trader compliance and accountability in DIS based arrangements. This is however unclear from the AgroTech model.

Improving access to markets

The main factors contributing to the low market price of maize include the oversupply of maize compared to the limited storage capacity, competition from low priced maize imports from neighbouring countries, and poor maize quality. In some contexts, farmer access to market information can empower farmers to secure better prices at sale through negotiations or market timing (Markelova et al., 2009). In smallholder maize farming contexts in the Techiman area, digital information appears to have less potential to address market related challenges as these emanate from more infrastructural and policy gaps (Kydd and Dorward, 2004). Better access to market information may offer little help to overcome these challenges. Thus, as seen in the AgroTech model, rather than seeking better prices in the open market, DIS could focus on linking traders/large buyers and farmers for collaborative and fairer trade arrangements which can attract credit support. Caution must however be taken not to generate one sided dependency relations in this process.

Overall, based on our analyses we find that a DIS presents key contributions to credit cooperation by supporting coordinated responsiveness to production challenges, records keeping and information sharing. DIS could also potentially attract collaborative buyers for market security. Through these influences, DIS could aid actors overcome some uncertainties in cooperation. DIS however face difficulty in supporting monitoring and accountability due to agent remuneration costs. Our analyses also shows that the design, implementation and use of DIS also hold several constraints and risks including generating increased power imbalance and control, surveillance and one sided dependency.

Discussion

DIS as Mediatory Tools for Trust in Maize Value Chain Credit Partnerships

Based on our study, we offer a discussion on key dynamics regarding trust building via DIS in maize credit collaborative arrangements. We address the question: To what extent can DIS contributions facilitate the needed trust within partnerships?

In deliberating this matter, we look again at how trust works. Trust is influenced by historical experiences (personal or institutional) that serve as a background upon which actors assess present circumstances to determine appropriate responses (Simmel, 1978; De Vries et al., 2014b). This can be observed in maize farming credit where creditors have become highly averse to farmer lending due to negative experiences in the past. This supports Luhmann's

(1979) argument that the past acts as a backdrop for present patterns of trust (and distrust) between actors, and as a means of simplifying complex situations. In the context of widespread mistrust, coupled with persistent known uncertainties in the production process, creditors become resistant to providing credit to farmers. In this setting, emergent DIS may offer a modest set of opportunities to reconfigure creditor perceptions and kick-start interactions between actors.

However, since trust is dynamic and develops through an actor's experience (either face-to-face or mediated) with others in complex and situation-specific contexts (Luhmann, 2000), it is possible that elements of trust and distrust can be manifest and co-exist (Lewicki et al., 1998). In other words, actions can be carried out in relations where an actor has both trust and distrust in the same actor. Thus, depending on the particular issue being dealt with in which trust is performed, an actor could act in a trusting manner towards an actor distrusted in other domains. This implies that trust is very specific, and even though creditors may not be predisposed towards smallholder lending, improving and leveraging DIS contributions to coordinated responsiveness and records generation, could foster some creditor trust in this domain. Essentially, strategic use of DIS, through a process of learning by doing (Jakku and Thorburn, 2010; Thorburn et al., 2011), could help initiate an entry point for recalibration of trust perceptions from mistrust towards 'good enough' trust.

This suggests a crucial role for an intermediary organization in this process of learning for trust building. This is because the challenges of maize credit cooperation not only arise from interpersonal mistrust but also a lack of trust that the farming and livelihood system would be able to ensure that expected outcomes for maize lending are met. This is seen for instance in creditor concerns over agro-ecological uncertainties as well as farmers' over markets. This means that maize credit cooperation faces not just the challenge of interpersonal trust but also of system trust (Giddens, 2013). However, system trust is "automatically built up through continual, affirmative" experiences (Luhmann, 1979:50). As seen in the AgroTech platform, DIS face quite a few challenges in providing consistent affirmative outcomes for actor concerns. Intermediary organizations could therefore help mediate conflicts arising from unexpected system outcomes to keep relations through the learning process. This crucial role is highlighted in the AgroTech project where due to NGO mediation in arrangements, FIs were willing to lend to farmers, despite system mistrust. This shows that intermediation by a neutral actor could critically complement this process of learning in DIS based trust building.

Intermediation conversely raises key concerns for the sustainability of relations. In the AgroTech case, significant power is wielded over the digital platform by the trader and agent without clear checks on the ground. Exit by the intermediary organization could lead to strategic use of DIS against weaker actors like farmers (Klerkx et al., 2012), through increased trader power and technology capture, and consequently deepen mistrust. On the other hand, medium to long term approaches in digital network building raises cost implications of such mediation. As seen in the AgroTech example, mediating organizations facilitated clustered services such as drought resistant varieties and/or weather information as support mechanisms in DIS operationalization. The costs and risks of the intermediation structure/duration therefore necessitate critical consideration for contextual appropriateness in implementation (Klerkx et al., 2009).

Finally, the ability of cooperating actors to use the digital technology appears relevant for trust building. The efficacy of digital communication tools as boundary objects lies in the

ability to reach various actors cost-effectively (Lupia and Sin, 2003). This impact is limited where the mediating technology remains unusable among key actors. This raises issues of DIS adaptability to context and the need for more farmer friendly tools in digital system design (Eastwood et al., 2017). By limiting two way information flow, this challenge could hinder the development of mutual trust and DIS credibility to farmers (Cash et al., 2001).

Thus, DIS face key challenges in trust building, particularly requiring critical considerations in intermediary arrangements at both the farmer-level and the macro-level (intermediating organization). Linking the above arguments, it can be intimated that although opportunities have been created for digital platforms to facilitate new forms of connectivity in support of credit cooperation, several requirements need to be assessed and addressed for DIS to harness these effectively for trust building in the maize farming context.

Conclusion

Overlooking our results and analyses of the potential of DIS, we have shown that a complex configuration of actor interaction has evolved in the maize agrarian context in response to institutional gaps and environmental dynamics, reinforcing a cycle of low credit access in the value chain. Assessing existing DIS, we argued that although significantly challenged in the maize farming context, DIS show potential under some conditions, to generate new networks and forms of cooperation which offer a means of overcoming some uncertainties impeding traditional value chain credit arrangements. As a tool for mediating trust in value chain credit partnerships, strategic use of DIS could help initiate an entry point for recalibration of trust perceptions. However significant considerations and improvements in DIS need addressing to harness this, not least being farmer access and use of digital technologies and effective intermediation arrangements. This approach to trust building should therefore not be viewed as a quick fix but a process of trial and error, and learning by doing.

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