THE LONG WALK TO ECONOMIC FREEDOM

Smallholder farmers' access to technology and capital

Propositions

1. Information transparency holds significant promise in overcoming market and trade inefficiencies in smallholder farming. (this thesis)
2. Smallholders' poverty negatively influences farm investment choices and commitment to long term savings. (this thesis)
3. For as long as the North has capital and subsidies, and the South has empty pockets and corruption, "free" trade policies are nothing short of neo-colonialism.
4. Ensuring food security in face of climate change in Africa will need an enormous influx of capital and R&D from the Northern hemisphere.
5. When you make difficult but right choices in life – choices made out of love – the whole universe conspires to help you, sooner or later.
6. There's no such thing as failure: we succeed or learn – and both are hard.

Propositions belonging to the thesis entitled:

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Diana Kos,

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The long walk to economic freedom: Smallholder farmers' access to technology and capital

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1. General Introduction

1.1. Background

Having worked in the private sector and NGOs for some years prior to starting my PhD, I was greatly surprised to what extent the joint efforts of multilateral organisations, international governments, NGOs and private sector efforts are not enough to help Africa's smallholder farmers produce the right crops in optimal quantities, and more importantly, to make enough income through farming to sustain themselves beyond the minimum income of $US1.25 per day. A great majority of African farmers are still smallholders, despite the evident lack of scale economies. Exploitation of the continent's resources by the rest of the world persists, given our inability to cultivate oil palm, coffee or cocoa in the Northern hemisphere; yet the added value of production of raw materials for farmers remains fundamentally unrewarding. Much of today's farmers in Sub-Saharan Africa are oppressed by unregulated capitalism and failing institutions which are not able to form the kind of welfare states that we enjoy in the Northern hemisphere.

The aim of this thesis is to assess to what extent farmers can bypass dysfunctional institutions and enhance welfare by getting access to technology and capital. As we will see, access to these assets is necessary to help farmers optimize farm productivity and give them a choice – independence and freedom – of what they produce, what they sell and to whom, who they borrow from etc. The title of this thesis was inspired by Mandela's book "The Long Walk to Freedom", an autobiography which stands as a symbol of fight against apartheid and colonialism, a life-long battle to liberate the oppressed from the oppressor. The main question my thesis aims to address is this: can access to technology and capital bypass failing states and help alleviate farmers out of poverty? Before explaining how access to technology and capital can help farmers on the road to freedom, I will briefly elaborate on why inefficient institutions keep African farmers in a vicious circle of poverty.

1.2. Problem statement: Implications of poor institutions in Africa

A common justification of poverty across farmlands in Africa are poor institutions (North, 1989, Acemoglu et al, 2005), which are arguably a result of poor management of resources, red tape, persistent corruption, conflict, etc. Part of the problem in post-colonial Africa are traditional pluralistic societies and political objectives which combine religions and kinship on the one hand and economic demands of modern democracies on the other hand (Skalnik 2013). Locally segmented governments struggle with a barrier between modern and traditional Africa, where the latter is largely dominated ritual, religious, economic and kinship limitations (see a broad review of relevant literature provided in Skalnik, 2013, p. 111). Levcenko (2007) argues that strong institutions enhance contract enforcement, property rights and shareholder protection. On the other hand, countries with weak institutions suffer from incomplete contracts and higher transaction costs of doing business. Poor institutions translate to poor property

rights management and contracting, which serve the purpose of protecting citizens and businesses. As such, these institutions contribute directly to economic growth, investment and financial development (Acemoglu & Johnson, 2005, North, 1989).

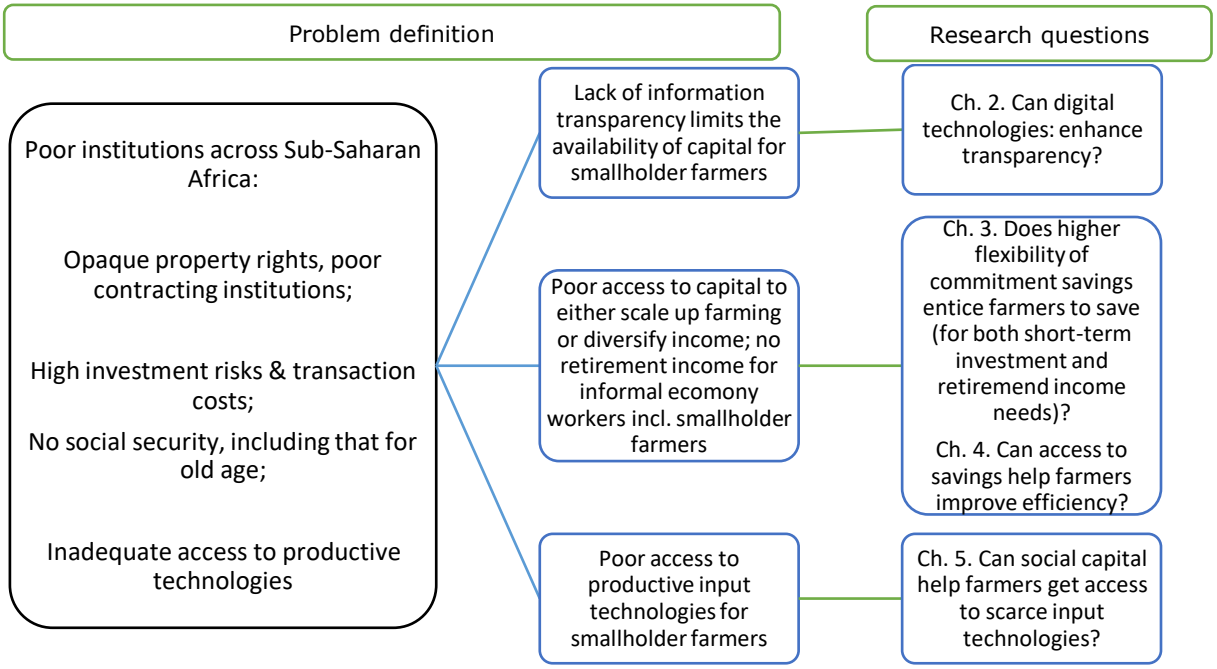
Financial inclusion is an important variable in economic growth for smallholder farmers. Examples of institutions which could support financial inclusion of its smallholders immensely are integrated collateral registries and credit bureaus (Chinaka, 2016). The former are institutions which allow for verification of property and other assets, whereas latter check borrowers' credit history. Both of these are sources of verified information transparency and have a twofold role: providing information verification by an independent third party, thereby protecting economic agents from risk, and enhancing efficiency of collaboration between any two parties. Information transparency (as opposed to information asymmetry or opaqueness) occurs when two parties involved in any form of commercial relationship do not have the same information at their disposal. Even though "perfect information" is rarely achieved (Vishwanath & Kaufmann, 2001), consequences of imperfect information can create market inefficiencies and divergences between supply and demand. Extensive body of existing literature shows the benefits of information transparency for banks, both commercial and MFIs. These range from decreased portfolio risk (Jappelli & Pagano, 1993), establishment of long-term borrowers' history and reputation with lenders (Jappelli & Pagano, 2002; Padilla & Pagano, 2000; Vercammen, 1995), limited multiple contracting by borrowers (McIntosh et al., 2005), higher repayment rate and increased growth of future loans (De Janvry et all, 2010). Undoubtably, imbedding such transparency on an institutional level contributes towards a decreased country investment and operational risks, making investing in the region more attractive. The direct outcome of that are stronger capital markets, with increased inflow of capital and foreign direct investment (FDI), and consequently, stronger disbursement of the capital where it is needed – including farms.

Another institutional problem closely linked to capital markets are government social security programs, including those of public pensions schemes. Kpessa (2010) divides social protection plans supporting old age in Sub-Saharan Africa into 4 categories: state and market as formal retirement plans, and family and community as informal plans. In Ghana for example, the social security falls short in meeting any formal retirement plans (Darkwa, 1997) because the majority of the population works in the informal economy, including smallholder farmers. When the state and markets fails to support its farmers' social security needs, farmers can only resort to family and the community for protection against adversities such as illness, unemployment and hardship (Boon, 2007) including old age (Hyden, 2008). With increased migration of younger generations to towns and changing social culture from collective to individualistic (Kpessa, 2010), relying on remittances from younger family members in old age is a suboptimal solution.

Finally, another consequence of failing institutions is related specifically to transparency on governments' provision of public services, such as education, public health and infrastructure (Vishwanath & Kaufmann, 2001). Looking at smallholder farmers specifically, if a government establishes a subsidy program on productive input technologies, but fails to distribute the subsidies equally so that those who need it the most can get access to it, then the country risks increasing its income disparity. Differences in technology adoption across countries are amongst the main explanatory factors for differences in income per capita worldwide (Caselli and Coleman, 2003; Comin and Hobijn, 2004). Poverty reduction and sustainable development require an increase in productivity in the agricultural sector, given that three out of four of the World's poor live in rural areas (Brune et al 2016; World Bank 2008). Adoption of modern technologies in agriculture, such as fertilizers and improved seeds, can significantly increase productivity (Just & Zilberman 1983; Besley & Case 1993; Simtowe 2006), especially in Sub-Saharan Africa (Nakano et al. 2018).

1.3. Objectives: a hope for the future

My thesis attempts to test how some practical tools can overcome these institutional failures in Sub-Saharan Africa. More concretely, what can farmers do, within their realm of power, to improve their welfare despite failing institutions. The diagram below highlights some problems associated with poor institutions which inspired my research questions.



The most recent World Bank report on agribusiness (2013) concludes that Africa's farmers and agribusinesses could create a trillion-dollar food market by 2030 if they can expand their *access to more*

capital, electricity, better technology and irrigated land to grow high-value nutritious foods, since the continent is home to half of the world's agriculturally suitable yet unused land (this is excluding rainforests!), and significant untapped water resources. The pressure to produce sustainable amounts of food for an ever-growing world population, to make a more efficient and effective use of scarce natural resources, while simultaneously managing the threat of climate change, calls for vast innovation in the agricultural sector. Sustainable agriculture is dependent on the availability of credit to purchase input supplies, efficient seed varieties, and/or services that are a prerequisite to sustainable production of crops (Poulton, Doward, Kydd, 2010).

The question remains of course, how can farmers make the most of their circumstances in countries where institutions fail to support them in getting access to capital and technologies? When we scratch the surface of institutional failures behind poor access to capital, we see that the common denominator to administering contracts and property rights, reducing transaction costs of doing business etc. is the lack of information transparency of market activities and players involved. Information transparency can be defined as "the increased flow of timely and reliable economic, social, and political information about investors' use of loans; the creditworthiness of borrowers; governments' provision of public services, such as education, public health and infrastructure; monetary and fiscal policy; and the activities of international institutions" (Vishwanath & Kaufmann, 2001, p. 42). There is significant hope for digital technologies in enhancing such information transparency, however there is relatively little empirical evidence on the subject so far . The next chapter provides an overview of their potential in overcoming market and institution failures. One example where technology helps to go the extra mile to assess credit-worthiness of smallholder farmers and other micro-entrepreneurs is mobile banking. Based on historical mobile credit purchase and transaction data, mobile providers, linked to a financial institution, extend micro-loans to those who would probably otherwise not have access to formal credit (Jack & Suri 2014, Aker et al. 2016). Mobile phone access increases borrowing, saving and remittances (Munyegera et al. 2018). Further to access to capital, mobile applications can link buyers and sellers via intermediated exchanges, cutting out middlemen (Chakravarty et al. 2018). Apps can also act as a group selling tool, allowing farmers to bring produce to central drop-off points and get e-payments (Duncombe 2018). Furthermore, both near-field sensing, such as sensors and RFID chips on farms, and remote sensing by satellites and drones, enable recording of socio-economic and environmental information (e.g. Gale et al 2017). Credit products can then also be made based on farm yield history which is then used to inform credit worthiness or acquire a land title (Blumenstock, 2016). Finally, technology can facilitate trade logistics and cross-border information processing incl. small volume trade (Jouanjean, 2019).

As much as technology can be an important piece of the puzzle in bridging market failures and helping smallholders get access to credit and markets, farmers themselves can contribute to those market failures

through their own irrational decision-making. Namely, if part of information that signals credit worthiness and represents "reputation collateral" is farmers' saving behaviour (Miller, 2003; Padilla & Pagano, 2000; Vercammen, 1995), then lack of discipline to save becomes a problem. Mobile technologies can potentially reduce transaction costs, knowledge gaps and trust, but farmers' actual savings behaviour will depend on their individual efforts. There are a number of factors that influence people's uptake of savings accounts in general, including transaction costs, travel costs to the bank branch, information and knowledge gaps and trust in the financial institution (Karlan et al. 2014). There are also intrahousehold power dynamics (Ashraf 2009) which define the uptake of savings accounts in general. The third chapter addresses exactly this saving behaviour. More specifically, I look at a commitment device as an incentive to take up a savings account. Commitment devices are designed to help people reach a goal in future that is otherwise difficult due to intrapersonal conflict stemming from lack of self-control or instant gratification (Bryan et al, 2010). In this case, we test farmers' uptake of long-term savings by locking a portion of their savings until retirement age. That is, if they withdraw more than the agreed proportion of their savings prior to that, they will not get any interest rate. The reason why we choose pensions savings is three-fold. First, lack of social security at old age is another evident institutional failure even for urban dwellers in Africa, let alone the rural sector. Second, there is very little literature on retirement savings in Africa, and to the best of my knowledge, non on smallholder farmers in Africa. Finally, accumulating savings is a a form of collateral which could make farmers eligible for credit. Our study looks at how to encourage farmers to take up a pensions savings product, such that a portion of savings is saved for retirement age, and a portion of savings is flexible and can be used earlier for other purposes (for example, as collateral for access to capital).

So, besides retirement savings, why is access to capital so important to smallholder farmers? Given a small plot of land, a farmer has a choice to either increase productivity on his existing farm to increase income, or invest in farm expansion, or invest in an alternative source of income on- or off-farm. All of these choices require investments. This brings me to my third paper. If farmers have access to savings, do they adopt different, more productive technologies, and are they more efficient? In this chapter we analyse the relationship between access to savings and technology adoption. We are not the first to study technology adoption of farmers. Technical efficiency and technological gaps have been addressed by many agricultural researchers to estimate farm performance (Anyanwu, 2011; Feder, 1985; Hernández et al.,2005, Just & Zilberman, 1983, Kevane, 1996, Mariko et al. 2019). Some examples include the effect of farm size and technology adoption on productivity (Just & Zilberman, 1983); or technical efficiency of SMEs based on firm access to credit (Hernández et al, 2005). However, there are no studies available that compare the technical efficiency of farmers with and without access to a formal savings account

(Hernández et al. 2005, Hulme, 2009, Karlan et al., 2014). This is especially relevant in circumstances where their own savings might be the only access to capital farmers have.

A rich body of literature shows that access to productive technologies increase efficiency, and access to capital enhances adoption of input supplies. But what happens if we take capital out of the equation, and look at adoption of government-provided free productive technologies to farmers? Chapter 5 of this thesis addresses the issue of access to subsidized input supplies. When governments directly intervene in inputs markets through subsidies, there is a risk that the inputs do not arrive in time, in good quality, or in sufficient quantities (Dorward, 2009). A number of studies address the role of social capital on adoption of input technologies (e.g. Barr 2000, Boahene et al. 1999, Coleman et al., 1966, Deaton, 1997, Grootaert and Bastelaer, 2002, Ryan et al. 1943). Whereas most of these studies focus on farmer learning from one another, we define social capital as investment in social connections with an expected return (Lin, 1999). When we look at social capital in that light, measured by community status and frequency of interaction with other farmers, can social capital help farmers get access to a scarce subsidized good? This can potentially be seen as another way of bypassing some institutional failures in getting access to free goods which are supposed to be available for everyone equally in theory, but in practice – they are not.

1.4. Outline of the thesis

This thesis consists of 6 chapters. Chapter 2 summarizes the potential of digital technologies in enhancing market information transparency, and consequently closing some of the market and institutional gaps that prevent smallholder farmers from getting access to capital, productive input technologies and markets. This chapter is a published literature review with concluding policy recommendations.

Chapter 3 addresses access to savings accounts and savings accumulation as a source of capital for smallholder farmers. We conducted a Randomized Controlled Trial (RCT) to test the take-up of flexible savings accounts for cocoa farmers in Ghana. We test the uptake of 2 flexible pension savings products, where a portion of their savings is designed to meet their near-future capital needs, and a portion of their savings is locked until retirement age. In the study, we vary the proportion of savings which is locked until retirement age. The idea behind opening savings accounts and locking a portion of savings is to overcome some of the impulse spending behaviour and assist farmers in mental accounting towards better management of their limited assets. We believe that this product would create opportunities for farmers to balance near-future capital requirements with old-age income needs. They can utilize the near-future savings to help them get access to credit and offset any income shocks; and the long-term locked savings would allow them to continue having some income past the retirement age. This study relies on data from a field survey of cocoa farmers in Eastern Ghana. We randomized farmers in 3 groups: two groups were

introduced 2 flexible pension savings with a different percentage of those savings fixed until retirement; and the third group is a control group, where we did not introduce any pension savings products.

Chapter 4 builds on theory of savings as a source of capital for farmers. In this study we look at the efficiency of smallholder farmers. More specifically, we use meta-frontier analysis (MFA) to compare the technical efficiency of two groups of farmers – those with access to savings, and those without. The study uses the same survey data of 1503 cocoa farmers in Ghana, as the previous study. We use access to savings as a proxy for access to a different pool of input technologies. The underlying assumption is that savings, as a proxy for access to capital, would give farmers access to more productive input technologies, like seed and fertilizer, and additional labour. Meta Frontier Analysis approach allows us to pool data from farmers with access to savings and those without access to savings (i.e. with different production frontiers), and create a common underlying production function while increasing the degree of reliability of the estimated production function. Finally, the newly established meta frontier allows us to check how far each individual is from the overarching meta-frontier technology.

Chapter 5 takes access to capital out of the equation, and returns to the idea of institutions and access to productive technologies. Namely, this chapter addresses what happens when governments provide subsidized input technologies, in this case seeds and fertilizer. Our starting assumption is that demand for a free good which increases productivity should be high. Under such circumstances, social capital is an important factor to consider in getting access to a free good. We measure to what extent social capital helps farmers get access to subsidized input supplies. We use factor analysis and Principle Component Analysis (PCA) for robustness, to create a single variable measuring social capital out of a few indicators measuring frequency of interaction and community status. We then use OLS analysis to test the correlation between social capital and access to subsidized input supplies.

Finally, the last chapter provides discussion and conclusions, policy recommendations as well as limitations and future recommendations.

The table below assesses the methodology used in each chapter.

Table 1.1 Overview of the research approaches adopted in this thesis.

Chapter	Data	Methodology
2. Potential of digital technologies	N/A	Literature review
3. Adoption of long-term savings accounts	Survey of 1503 cocoa farmers in Ghana	Randomized Controlled Trial (RCT), Linear Ordinary Least Squares (OLS) regression

4. Efficiency analysis of farmers with and without access to savings	Survey of 1503 cocoa farmers in Ghana	Stochastic Frontier Analysis (SFA) Meta Frontier Analysis (MFA)
5. The role of social capital in access to subsidized input technologies	Survey of 1503 cocoa farmers in Ghana	Factor analysis and Principle Component Analysis for social capital variable definition; Combination of Linear Ordinary Least Squares (OLS) regression and Logit regressions.

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2. Digital technologies, hyper-transparency and smallholder farmer inclusion in global value chains[1]

2.1. Abstract

Globalization of food value chains has increased the demand for greater transparency over where food is produced, how, by whom and with what effect on society and the environment. A range of new digital technologies are available to facilitate transparency, with the promise of leading the global food system to an era of 'hyper-transparency'. Its impact on smallholder farmer inclusion, however, remains questionable. The potential benefits of hyper-transparency for smallholders are improved access to services and markets. Thus far, important challenges remain. These are limited access to these technologies for smallholders and new power relations that emerge around access, use and control of data.

2.2. Introduction

Digital technologies such as sensors, drones, satellites and blockchain are seen as a promising developments for value chain transparency. These technologies are often envisioned to enable more detailed, objective, and complete information collection, and to create secure, transparent and democratic ways of information sharing. The development of such digitally-enabled modes of information collection and analysis leads to what we term the rise of 'hyper-transparency'. Hyper-transparency is a digitally-enabled, real-time, and often automated mode of data collection and analysis for management and governance of global value chains (GVCs). In the field of agriculture and sustainable development a number of organisations and companies are proclaiming the benefits of hyper-transparency for smallholder farmers. However, it is still unclear how the use of these technologies influences transparency, and what effects it may have on the sustainability and inclusiveness of global value chains.

The aim of this chapter is to describe how hyper-transparency can enhance smallholder market inclusion. There are a number of ways to define "inclusive business" (Gale et al., 2017). They generally refer to businesses that integrate smallholders into markets such that activities benefit the business community while enabling the poor to move out of poverty. In this chapter we extend the definition beyond smallholders' access to markets, such that inclusiveness enables farmers to become competitive in local or international markets. Enhancing smallholders' competitiveness and production capacity involves access to services which reduce farming cost, enhance efficiency of farms, facilitate product marketing

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and improve farmer negotiation power in GVCs. Enhancing competitiveness of farmers therefore enables them to get out of poverty. We build up the chapter as follows: First, we define characteristics of hyper-transparency; Second, we review current opinions around the promises and pitfalls of digital technologies designed to enable hyper-transparency for smallholder producers; Finally, we provide recommendations for policy makers and international organisations on how to enhance the benefits of digital technology use for smallholder farmers.

2.3. The rise of hyper-transparency in global value chains

The proliferation of new digital technologies is transforming existing modes of data collection and analysis in value chains. Both near-field sensing on farms and remote sensing by drones and satellites enable the recording of socio-economic and environmental information (Gale et al., 2017). Technologies such as mobile phones and drones, allow for the tracking and monitoring of activities of smallholders and their farms, while RFID (Radio Frequency Identification) tags enable the tracking of food products in supply chains. Together these monitoring technologies create new modes of data collection that generate 'direct, continuous, and real-time information' (Gale et al., 2017).

Developments in monitoring technologies also go along with innovations in data analysis such as artificial intelligence (AI) and machine learning, in which algorithms are applied to make sense of the data (Wolfert et al., 2017). Once collected new technologies such as blockchain are being used to ensure the validity of shared information, including the data on transactions.

We label the combination of these new modes of data collection with forms of automated, algorithmic analysis as *hyper-transparency* in global value chains. We argue that hyper-transparency has the following six characteristics:

1) A shift from information collection by human actors to direct data collection by fixed and mobile devices and sensors at different levels, including embedded sensors, terrestrial, aerial and remote sensors. Such sensors and monitoring devices enable the collection of more and increasingly-accurate data (Gale et al., 2017. Wolfert et al., 2017);

2) A change in the temporalities of information collection away from periodical information collection to continuous, (near) real-time data collection. This includes real-time environmental monitoring (Gale et al., 2017), but also real-time traceability of food products and transactions in supply chains (Saberi et al., 2019);

3) A shift in the interpretation of information and decision-making by human actors to algorithms. Behind the development of algorithmic decision-making is often a demand for greater efficiency and objectivity in handling the vast amounts of data (Wolfert et al., 2017);

4) A change in the materiality of information from paper-based to electronic, with information being processed and analysed in digital (often remote, cloud based) databases. Related to the electronic character of information, there is also a change from linear (producer to consumer) information flows to multi-directional information flows in value chains;

5) Changes in roles and responsibilities of actors in GVCs as well as shifting relations between them. In particular, the use of digital platforms can mean disintermediation, or the removal of intermediaries in GVCs (Ezeomah & Duncombe, 2019, Gale et al., 2017) and facilitate more direct interactions between producers and consumers (Walter et. al., 2017);

6) Extended boundaries of value chains (what is inside and outside the value chain) and their governance due to the incorporation of new types and sources of information into value chain transparency. This includes, for example, data about the actions and activities of smallholders, such as their historical transactions or their spatial whereabouts. In terms of governance of global value chains, the increased availability and accessibility of information may enable some actors (e.g. consumers) to hold others (e.g. supermarkets) accountable.

Hyper-transparency thus refers to digitally-enabled, real-time, and often automated ways in which information is gathered, processed, made available, and used in global value chains. The next section elaborates on how this hyper-transparency may affect smallholder inclusion in value chains.

2.4. Promises and concerns around digital technologies and information transparency for smallholder inclusion in GVCs

There is a growing literature that identifies the promises and concerns of applying various technologies of hyper-transparency and their effect on smallholder inclusion in GVCs. To reduce the scope of our review, we limit our focus to the use of digital devices for gathering data about, or for farmers and their activities (i.e. mobile phones, satellites, drones and sensors), and on digital technologies for data processing and storage that are envisioned to have an emancipatory potential for smallholders (i.e. blockchain and mobile applications). As summarised in Table 1, there are a range of potential benefits and concerns surrounding the application of digital technologies in value chains and its effects on smallholders.

Table 1: Promises and concerns around digital innovations and the position of smallholders in global value chains

Promises of digital innovation	**Beneficiaries: market, state and civil society**	**Digital technology involved**	**How?**	**References**	**Concerns**
Access to services: - Credit and input supplies (e.g. fertilizer & seeds)	Market: Smallholders	Blockchain	- Blockchain applications use smallholders' financial and/or production data in order to give them access to credit and input supplies. - Blockchain could produce cheaper, faster and safer transactions, facilitating trade finance.	Aker et al., 2016a, UNCTAD 2017, Jouanjean, 2019	- Loans and input supplies provided on credit by traders tie farmers to respective value chain partners, giving the latter more power.
		Mobile phones	- Mobile providers use historical mobile transaction data to extend short-term loans to farmers - Mobile phone access increases borrowing, saving and remmittances	Aker et al., 2016b, Jack & Suri, 2014 Munyegera & Matsumoto, 2018	- Strict risk regulation (Basel II and III) remain a challenge for trade finance - Farmers in remote rural areas or marginal farmers remain difficult to reach given high cost of information delivery or poor mobile networks.
		Satellite data and drones	- Credit products are made based on farm yield history and farm mapping tools which are then used to acquire land titles	Blumenstock et al., 2016, Bourgoin et al., 2016	
			- Providing agronomical information via SMS/voice messages expands scope and scale of extension services, with more timely & tailored information	Aker et al., 2016b,	- There is a gap in expected benefits of mobile-phone services and the empirical evidence (Burrell & Oreglia, 2015, Duncombe, 2016)
- Information: training, advice, market prices		Satellite data	- Remote sensing used to measure area–averaged risk and yield performance.	Chakravarty et al., 2018;	
		Drones	- Mapping tools link satellite data to centralized information systems, and identify and monitor land processes. Access to land titles will further influence access to insurance for farmers.	Burke & Lobell, 2017, Carter et al., 2016, Wolfert et al., 2017, De Leeuw et al., 2014	- Low take-up and mixed evidence of impact of index insurance in developing countries (Giné & Yang, 2009, Karlan, 2014)
- Index insurance					

Farm optimization and better risk management	Smallholders	Drones Satellite data & farm management systems	- Drones (terrestrial laser scanning - TLS) can estimate field biomass and count tree height and volume of a given area, both of which can be used to estimate productivity - Satellite datasets with minimal field data collection have the potential to estimate farm yields, and can accelerate learning about the effectiveness of farming interventions	Disney et al., 2019 (Wolfert et al., 2017, Burke & Lobell, 2017)	- The technology is expensive. - Geolocation accuracies are problematic for smaller fields. - Measuring productivity more difficult on farms with multiple crops, and with overlapping tree canopies.
Access to markets: Lower trade transaction costs: 1. fewer middlemen, 2. quicker contract implementation, 3. lower cost of escrow services and tariffs Traceability, sustainability certification, and food safety	Smallholders, downstream value chain players	Mobile applications for data collection, processing; Internet of Things (IoT) and blockchain.	- Link buyers and sellers via intermediated exchanges, cutting out middlemen; apps can also act as a group selling tool, allowing farmers to bring produce to central drop-off points and get e-payments. - Blockchain can be used to digitise and share trade-related information, including small volume trade monitor financial transactions in real-time, and automate settlements of payments. E.g. through the use of smart contracts, blockchain can ensure that smallholders receive timely and complete payments - With IoT, physical objects' embedded sensors (e.g.soil, food products) send information to a blockchain/IoT-based digital platform that processes this information. IoT thereby links material flows in value chains with information flows. -Blockchain allows for real-time tracing of products and product information (e.g. environmental, social and governance data) in supply chains, and enables farmers to capture, communicate and access origin data.	Duncombe, 2018 UNCTAD, 2017, Jouanjean, 2019, Cong & He, 2019 Elijah et al., 2018, Gardner et al., 2018, Wolfert et al., 2017) Gale et al. 2017, Saberi et al., 2019, Nikolakis et al. 2018	-Data access requires basic literacy and access to smart phones. Mobile data upload is often inaccurate and incomplete. -Blockchain should reduce the power and role of middlemen in supply chains, but it often is the very middleman (traders) who use blockchain to facilitate transparency in trade. -Sensors and blockchain are still inaccessible to smallholders. -Restricted impact on smallholders because of cost, trust and lack of expertise. -Unequal data access and verification rights between

and quality assurance					smallholders and other value chain players.
Reduction of commodity market speculation and improve transfer pricing towards farmers	Smallholders, commodity processors, consumers	High resolution satellite data	- Satellite images are used by trading companies to estimate crop yields. Commodity traders speculate and hedge on futures markets based on private information about crop supply. - Making this information public reduces speculators' margins, by reducing informational noise from supply shocks and futures market trading on commodity demand and spot prices.	Burke & Lobell, 2017, Kamilaris et al., 2017, Sockin & Xiong, 2015, Wolfert et al., 2017	The use of satellite data in financial markets is common practice, however no research to our knowledge studies that.
Environmental monitoring	State and civil society	Open data portals Satellite/ drone images	Use of time series satellite image data to monitor environmental degradation, Life Cycle Assessment (LCA), carbon measurement requirements and illegal/unreported farming and fishing activities	Bakker & Ritts, 2018, Toonen & Bush, 2018, Wolfert et al., 2017	Digital surveillance and control of smallholders and their activities

2.5. Potential benefits of hyper-transparency for smallholders

2.5.1. Improved access to services for finance, information and input supplies

The first potential benefit is that the collection and use of farm-level data can improve farmers' access to services. This includes data about land size and digital land title (Carter et al., 2016), (expected) output and historical weather data (Burke & Lobell, 2017). This information can open smallholders to a range of services, such as access to fertilizer (UNCTAD, 2017, Jouanjean, 2019), credit (Bourgoin et al., 2016, Burke & Lobell, 2017), crop insurance (Burke & Lobell, 2017, Carter et al., 2016) and farming advice (Chakravarty et al., 2018). Data about land size and location for example, is used to provide customized SMS advice to farmers on optimal use of input supplies necessary to increase productivity while avoiding over- or underutilization of fertilizer and chemicals (Chakravarty et al., 2018). Furthermore, weather data enhances farmers' access to index insurance which insures their crops against major losses (Burke & Lobell, 2017) and helps farmers manage income fluctuations. There are a number of case studies showing how the use of satellite data, drones and mobile phones can enhance farmers' access to services[2], but few are peer-reviewed studies. Today data-driven services for smallholders bring in new intermediaries in the form of mobile phone providers (Duncombe, 2018) or software application builders and owners (Ezeomah & Duncombe, 2019). For example, the role of mobile phone providers nowadays has shifted towards becoming an information and loan provider (e.g. see studies on M-Pesa in Kenya). Alternatively, digital technologies can facilitate middlemen to take a more active role in servicing smallholder farmers to better be able to meet market needs. We see for example how trading companies step in the role of input and credit suppliers and certification facilitators, and use of blockchain to verify produce information and payment transfer to farmers (Rueda et al., 2017).

2.5.2. Improved access to markets and international supply chains

Hyper-transparency is envisioned to improve farmers' access to markets. Farmers can benefit from being able to access more buyers via intermediated platforms (Jouanjean, 2019) where farmers can get direct access to buyers, such as for example the Ethiopia Commodity Exchange. Increasing information transparency allows for increased farmer access to multiple buyers and consequently increase their negotiation power (Gashaw & Kibret, 2018, Duncombe, 2018). Duncombe (2018) describes an example where mobile applications are used to cut out middlemen by grouping smallholders and linking farmers' produce directly to buyers. In addition, linking farmers to market data (e.g. market prices and buyers) and linking farmer produce information to buyers (e.g. origin, certification- or other quality related information) can facilitate international trade (Gardner et al., 2018). Hyper-transparency here allows multiple buyers to

[2] See publications of Global Open Data for Agriculture: https://www.godan.info/resources/research

review produce information, from growing practices and certification, to farm location and other farm data. In addition, automation of certification data collection through soil sensors and data sharing via mobile apps and platforms can reduce the cost of certification (Abbasi et al., 2014). Reduced costs of certification enhances farmers' inclusion by opening opportunities in international markets where their produce can be sold at higher prices than in local markets. The implementation of technologies of hyper-transparency further down the value chain can also bring along benefits for smallholders. Technologies that disintermediate transactions, such as blockchain, could lower transaction costs. Blockchain can reduce the role of downstream GVC actors, such as clearing houses and other organisations ensuring compliance to trade rules (Jouanjean, 2019). This decentralization adds value to smallholders by facilitating market access and increasing negotiation power as a result of increased market visibility: Verified information transparency about produce and production practices can therefore help GVC actors manage trade risks (Rueda et al., 2017), increase buyer trust across borders and facilitate GVC integration (Mitra et al., 2018), reduce transaction costs by cutting out middlemen and facilitate contract implementation (Jouanjean, 2019, UNCTAD, 2017).

2.6. Risks and limitations of hyper-transparency for smallholders

Although the current literature is mainly focused on the promises of hyper-transparency, there are a number of concerns, particularly around access to and use of digital technologies and the data these produce.

2.6.1. Access to and use of technologies

Increased technology availability to meet transparency demand does not automatically translate to farmer technology adoption. First, there are functional limitations to technology uptake, such as low literacy rates, and poor mobile and logistics networks in rural areas linking farmers to markets (e.g. Aker et al., 2016a). Second, farmers' willingness to adopt- or get access to- technology is greatly dependent on their social network and social norms (Nakano et. al, 2018). Finally, there are behavioural aspects of innovation adoption such as time preferences, which partially explain why farmers have difficulties choosing habits and actions they know are good for them (Bonan et al., 2019). Beyond farm level, governments in countries with high number of smallholders lack the capacity to generate and transform data gathered by digital technologies into useful information that can be used to increase productivity and profits (UNCTAD, 2018).

2.6.2. Access, control and use of data

With the provisioning of services, private sector intermediaries gain control over farm level information relating to both sourcing and production Wahl & Bull, 2014. The concern is that they have little incentive to

open information to the public eye beyond the selected data for branding and strategic CSR (Rueda et al., 2017, Egels-Zanden et al., 2015), resulting in discrepancies between information available to industry actors and that available to governments, NGOs or smallholders or their respective communities (Gardner et al., 2018). This is especially disadvantageous for some governments which have little capacity to generate data or regulate data being collected by the industry UNCTAD, 2018.

Consequently, concerns about the role of increased information transparency on the power relations between smallholders and other GVC actors remain: who can access and use the data that is generated with the help of digital technologies, and for what purposes (Bronson & Knezevic, 2016)? In several application areas, such as the use of drones, satellites, and mobile phones, data about smallholders' activities, their farms and products is collected, which is subsequently processed, and often monetised, by other parties (Fraser, 2018). The data may, for example, be used to generate new services that can be sold to smallholders, but it may also be used by third parties for other purposes Wiseman & Sanderson, 2019); e.g. to verify whether smallholders comply with standards and regulations (Walter et. al., 2017), or to assess the creditworthiness of smallholders (Björkegren & Grissen, 2018).

2.7. Conclusions

In this chapter we characterised hyper-transparency as a digitally-enabled, real-time, and often automated mode of data collection and gathering for the functioning and governance of GVCs. This kind of hyper-transparency shifts the roles of stakeholders and broadens the boundaries of GVCs. One of the promises around hyper-transparency is that it could improve the lives of smallholders by creating new opportunities for them to access services and markets, and to generally become more 'visible' in GVCs. Yet, there is little empirical data that shows whether the claims about potential benefits can be substantiated in practice. At the same time, several factors limit the possibilities for smallholders to benefit from hyper-transparency, while it also places new burdens on smallholders to collect data, or can become a new way for other parties to increase their control over smallholders.

Consequently, strategies and policies are needed to 1) ensure that farmers' data rights are protected and that there is a fair sharing of the benefits of the collection and analysis of data; 2) guide learning and knowledge development of how to use and interpret information available in a way that it becomes a tool for empowerment of smallholder farmers rather than a surveillance quest. Hyper-transparency means that smallholders and other value chain players should not only be seen as economic actors in value chains, but also as data subjects and users. Digital technologies can generate and analyse vast amounts of data about farmers, their activities, and their environment, but the important question is who can access, control, and use this data (Wolfert et al., 2017). Here lies an important task for governments and international

organisations: they should focus on improving data regulation, and informational and digital literacy at all levels of society, especially the smallholder farmer, to enhance market inclusion and increase productivity through technological advancements. Only then the "invisible hand"[3] can work in the advantage of smallholders.

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3. Do smallholder farmers prefer commitment or flexibility in pensions savings accounts? A randomized experiment of cocoa farmers in Ghana[4]

3.1. Abstract

The aim of this chapter is to examine the intertemporal choice preference for long term savings of cocoa farmers in Ghana. We test the uptake of two pension products: with one, famers are free to withdraw 50% of their savings with no penalties prior to retirement age; with the other, only 30%. Neo-classical economists argue that rational individuals want to even out consumption over their lifespan, thus having preference for flexible saving, especially in the face of high income fluctuation. Behavioural economists argue that individuals have hyperbolic preferences and would prefer to lock their savings to avoid their own spending or spending by family members. Using a randomized controlled trial (RCT), we test the difference in uptake of two pensions products where we vary the flexibility of cash withdrawals from the pension account.

We find an overall higher uptake of the more flexible pensions account, especially for *women*, who cannot inherit land titles in Ghana and thus cannot use it as retirement income; and farmers who are able to diversify their income through *non-farming activities.* We find a significantly lower uptake of the less flexible account for farmers who have experienced a severe financial shock in the last year, and those who receive no remittances from their family members. We conclude that the more flexible savings allow farmers a better balance between current and future consumption needs, as well as locking savings away from other household members. We explain the low uptake of rigid accounts in line with neo-classical assumptions – farmers who are financially constrained in the present cannot be expected to lock a higher proportion of their income for retirement than what they consume today.

3.2. Introduction

An extensive body of development economics literature stresses the importance of personal savings. An increase in savings can help improve the welfare of the poor (Karlan et al., 2014). Furthermore, not only are savings considered less risky than credit, but they can also provide insurance against unexpected expenditure shocks, such as those caused by disasters, health problems, and seasonal shortfalls. Therefore, several studies have examined possibilities to increase the uptake of savings. In the informal finance sector, for example, multiple randomised controlled trials have addressed the uptake of savings accounts by rural and urban dwellers (for a literature review, see Karlan et al., 2014).

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Another stream of literature shows that committing or locking a part of savings is an effective way to increase savings rates (Ashraf et al., 2006; Bryan et al., 2010). However, only a few studies have examined the uptake of long-term or pension savings. This is surprising given increased social change with stronger reliance on the nuclear family than the wider family or community.

The aim of this chapter is to compare the uptake of two pension savings products that differ in the degree of flexibility for cocoa farmers in Ghana. To the best of our knowledge, our study is the first to consider the uptake of any commitment long-term savings product for a homogeneous group of smallholder cocoa farmers. Focusing on the 'pension behaviour' of cocoa farmers is particularly useful because these farmers are faced with extremely high income fluctuation. Moreover, cocoa is a biannual crop, yielding income only twice a year. Farmers are faced with the challenge of aligning consumption needs in the present with future consumption needs when they are no longer able to work on farms.

Our study compares the uptake of two pension products that differ in the degree of flexibility savings withdrawals: one pension product locks half the savings until retirement age, such that agents are not allowed to access it until a future date, and allows withdrawals of the other half with no financial consequences. The other product locks 70% of savings until retirement age, thereby allowing flexible withdrawals for only 30% of savings. By varying the degree of flexibility of savings withdrawals, our study addresses the question whether committing or locking a part of savings may be an effective approach to increase savings. The literature is still ambiguous about the relevance of commitments in increasing long-term savings rates.

The literature provides two reasons commitment savings may be relevant. First, a commitment device that restricts possibilities to save and dissave may be welfare improving for somebody who is a hyperbolic discounter (Ashraf et al., 2006). Compared with agents with an exponential discount function, agents with a hyperbolic discount function have a high discount rate at present and a low discount rate over longer horizons (Laibson, 1997). According to the multiple selves model, a taste for immediate gratification may result in self-control problems if all selves have present-biased preferences. However, in the case of a sophisticated hyperbolic discounter (Laibson, 1997; Gul and Pesendorfer, 2001; Bauer et al., 2012), commitment devices may be attractive because they restrict behaviour of the future self. Savings rates for sophisticated agents with hyperbolic preferences are therefore likely to increase if they are given the choice to opt in to commitments (Ashraf et al., 2006; Bauer et al., 2012). Basu and Bisht (2015) find that this type of committed savings motivated rural entrepreneurs in India to take up long-term (pension) savings accounts.

In addition to self-control issues, research emphasises that individuals may prefer commitment devices because of spousal, familial, and neighbour bargaining (e.g., Platteau, 2000; Anderson and Baland 2002; Ashraf, 2009); this is especially the case in a developing country context. Anderson and Baland (2002) find that using group rotating savings commitment accounts is a strategy that married women in Kenya employ to protect savings against claims by husbands for immediate consumption. This was especially the case for women who had some but not much or too little autonomy. Consequently, we can assume that women with a high degree of autonomy, such as female household heads, would prefer lower restrictions or commitments due to spousal relations. A few factors are positively associated with the uptake of commitment savings, including higher education level, being female, and having limited spousal control (Karlan et al., 2014).

Locking savings might not be a preferred strategy for many reasons, however. While the neoclassical model does not explicitly consider the relevance of commitments, locking savings would clearly prevent individuals from maintaining a constant level of consumption throughout their lifetime and thus be negatively valued. Moreover, commitments, in the form of withdrawal fees or minimum balance requirements, imply an increase in transaction costs. Commitments also reduce liquidity for borrowers, which may not be compensated by higher returns, which would especially be problematic for poor credit-constrained households faced with uncertain future income flows. Therefore, it seems obvious that rational agents, who, in line with the neoclassical theory, discount the future exponentially, would always prefer the most flexible savings possibilities available: a savings product with whatever form of commitment attached, which is not compensated by higher returns, would always be inferior to a similar savings product without commitments attached.

There is a dearth of literature on commitment pension savings in any context, especially that of farming of a biannual crop with high income fluctuations, such as cocoa farming. Grameen Bank introduced a hard commitment mid-term savings scheme in Bangladesh in the early 2000s in which no interest was paid on accounts with withdrawals within five years of opening an account. The program was a huge success, attracting millions of users (Rutherford, 2006). Ashraf et al. (2006) and Basu and Bisht (2015) found that commitment savings products with penalties for early withdrawals had a significantly higher uptake than savings accounts with no penalties, a finding that likewise applies to an urban context with high financial literacy (Thaler and Benartzi, 2004). Beshears et al. (2020) found similar results in their more recent study. They conducted an experiment to compare account deposits on a liquid account without any withdrawal restrictions with commitment accounts with different early withdrawal penalties, using participants from the RAND American Life Panel. In general, higher early-withdrawal penalties attracted more deposits.

We compare preference for commitments of cocoa farmers in Ghana, who have uneven income distribution throughout the year, as cocoa is a biannual crop. On the one hand, their savings must cover expenses incurred between two income seasons; on the other hand, they need to fend off the present bias and ensure their long-term well-being. Managing these two opposing demands is a balancing act between exerting self-control and having high income fluctuation and uncertainty of expenditures. Designing a pension savings product suitable for seasonality of income of cocoa farmers thus needs to combine farmers' current and future financial needs.

Finding the right balance between managing current cash flow needs and the future cash needs is challenging for agents themselves, but even more so for institutions that are trying to encourage agents to save. For this reason, we aim to compare uptake of two types of pension savings products that differ only in the percentage of savings that can be withdrawn freely without penalties. More specifically, we offer a randomly selected group of cocoa farmers in Ghana the possibility to open a long-term savings account from which they can withdraw 50% of the savings at any moment in time without penalties and offer another randomly selected group the possibility to withdraw only 30% without penalties. In addition, we conduct heterogeneous treatment analyses to test which group of farmers values flexibility over commitments.

In section 2, we elaborate on current elderly care mechanisms in Ghana. Section 3 describes the methodology of the intervention itself and the relevant findings from our baseline survey. Section 4 summarises the results. Finally, section 5 presents the limitations and suggestions for future research.

3.3. Literature Review: Current social security systems for the elderly in Ghana

Kpessa (2010) examines how the state, the market, and pre-existing social norms interact to ensure old-age income support in Sub-Saharan countries. The social protection plans supporting old age can broadly be divided into four categories: state, market, family, and community. During the last century, Ghana went through various stages of these four support structures. The traditional social support system is structured around the family and the community. Dating back to pre-colonial times, the family was the epicentre of social support, where the nature of social interactions was collective and reciprocal, and extensive family members and the community were the only source of risk and resource pooling in times of need or in old age (Hyden, 2008). Throughout history, as well as today in the informal and rural sector, people typically rely on rotating schemes for wealth accumulation against old-age income insecurity or protection against adversities such as illness, unemployment, and hardship (Boon, 2007).

On the opposite end of family- and community-based social security systems are state- and market-social schemes. These formal schemes were initially designed to reward 'loyal' civil servants and

employees during colonial times (Darkwa, 1997). However, anyone within the informal economy, which includes the agricultural and mining sectors, was excluded from the colonial pension scheme. In the 1990s, Ghana moved to pay-as-you-go social security schemes, under which benefits are directly linked to contributions. In the 2000s, Ghanaian social security has officially progressed towards a three-tier pension system comprising a mixture of pay-as-you-go and state-defined benefit arrangements (Dorkenoo, 2006). Some blue-collar workers and the urban middle class enjoy access to these protectionist arrangements, while rural inhabitants continue to rely on informal social mechanisms (MacLean, 2002). However, Ghana's social security falls short of meeting any formal retirement plans (Darkwa, 1997), as an estimated 80% of the population works in the informal economy (Baah-Boateng and Turkson, 2005). The elderly often find themselves in a vulnerable position as their children no longer feel obliged to support them (Collard, 2000). This is a direct result of migration, the breakdown of extended family structures, and a cultural shift to self-reliance in Sub-Saharan Africa.

In the context of cocoa farmers in Ghana, multiple studies have reported a drastic problem of aging farmers, with children of cocoa farmers moving to towns in search of higher-paid work opportunities (Bymolt et al., 2018). By contrast, few studies address retirement income of cocoa farmers in Ghana. Older farmers in Ghana usually have land, but above the age of 60, they are not very active on farms, nor do they make any farm investments. Some elderly cocoa farmers view cocoa as a cash crop and use it as retirement income, without making farm investments. These farmers are referred to as 'harvesters' because they are inactive on their farms (Bymolt et al., 2018). Typically, their children have migrated to towns, so in the absence of the younger generations, they often engage in sharecropping contracts, leasing land to younger farmers who can manage and harvest the cocoa plantation (Bymolt et al., 2018). Proceeds from these sharecropping arrangements are then shared between the landowner and the sharecropper, with the harvest serving as a source of retirement income for landowners.

Offering farmers an option between flexible and less flexible pension savings accounts helps us evaluate the extent of trade-off between current consumption needs of farmers and their family/network and their long-term consumption needs.

3.4. Theory

There are a number of factors that influence people's uptake of savings accounts in general, including transaction costs, travel costs to the bank branch, information and knowledge gaps and trust in the financial institution (Karlan et al. 2014). Furthermore, Ashraf (2009) finds that intrahousehold power

dynamics likewise define the uptake of savings accounts in general. However, the focus of this study is on uptake of *commitment* savings.

A commitment device is an arrangement entered into by an agent which helps him or her fulfil a goal in future that is otherwise difficult due to intrapersonal conflict stemming from lack of self-control or instant gratification (Bryan et al, 2010). Bryan et al. (2010) distinguish between soft and hard commitments, though they are not always mutually exclusive. Soft commitments refer to psychological consequences of breaking commitments, such as shame or loss of self-esteem. Hard commitments on the other hand, refer to economic consequences with financial repercussions such as paying a fine, getting no interest on savings etc.

There is little literature so far on commitment pension savings in any context, especially not in the context of farming of a biannual crop with high income fluctuations, such as the cocoa farming. Grameen introduced a hard commitment mid-term savings scheme in Bangladesh in the early 2000's where no interest was paid on accounts with withdrawals within five years of opening an account. The program was a huge success, generating millions of users (Rutherford, 2006). Ashraf et al (2006), and Basu & Bisht (2015) among others, have found that commitment savings products with penalties for early withdrawals had a significantly higher uptake than savings accounts with no penalties, a finding that likewise applies to urban context with high financial literacy (Thaler & Benartzi, 2004). Similar results are found in a recent study by Beshears et al. (2020). They conducted an experiment to compare account deposits on a liquid account without any withdrawal restrictions and commitment accounts with different early withdrawal penalties, using participants from the RAND American Life Panel. In general, higher early-withdrawal penalties attracted more deposits.

So, why is it that we test the effect of two different commitment savings products? Because from a theoretical perspective, commitment savings are suboptimal and irrational choice according to neoclassical economics, and possibly a very justified and optimal choice of behavioral economics. Classical and behavioural economists differ significantly in the way they view choices agents make in relation to consumption today versus future consumption. We now compare how they differ.

3.4.1. Neo-classical economics perspective on consumption and saving

Neo-classical theory assumes that people discount a future reward exponentially – by a fixed percentage for each unit of time they must wait. Exponential discounting reduces a future reward by a factor of $\frac{1}{(1+\delta)^t}$ where δ is the constant discount rate per time unit over a given time frame *t*. According to a standard neo-classical model, households devise a consumption plan that maximizes utility over its lifetime, subject to an intertemporal budget constraint. The first-order condition, in the case where there are no (liquidity or savings) constraints and there is perfect foresight would ensure that the marginal benefits of an increase in current consumption equals the marginal costs of an increase in consumption now (reflected by lower consumption in the next period). Formally this would lead to the following condition:

$$u'(c_t) = \frac{1+r}{1+\rho}\mathrm{u}'(c_{t+1}) \quad \text{with } u'(c_t) > 0 \text{and } u''(c_t) < 0 \qquad (1)$$

Where $u'(c_t)$, and $\mathrm{u}'(c_{t+1})$ reflect the marginal utility of consumption in period *t* and the marginal utility of consumption in a later period, *t+1*; r the interest rate (which is assumed to be the same for borrowing and/or saving) and the constant rate of time preference, ρ.

The condition implies that the higher the interest rate relative to the rate of time preference, the more it pays off to reduce the current level of consumption (save) in order to enjoy higher consumption later. Formally, an increase in r vis-à-vis ρ is reflected in an increase in $u'(c_t)$, which is brought about by a decrease in c, assuming that $u''(c_t) < 0$. The neo-classical consumption/ savings function implies that consumption and savings patterns fully depend on prices (interest and discount rates) and preferences.

Ando & Modigliani (1963) show that an individual is expected to maintain a more-or-less constant level of consumption throughout life. Typically, one has an income stream which is relatively low at the beginning and the end of his life, and high during the middle of his life. The model suggests that in the early years of a person's life, an agent is a net borrower; in the middle years, she saves to repay debt and provide for retirement. In the late years, she dissaves. Thus, the standard neo-classical model of consumption/saving implies perfect consumption smoothing every period.

The analysis above assumes perfect foresight. However, what would happen, according to the neo-classical model, if future income would be uncertain? In that case, $\mathrm{u}'(c_{t+1})$ in the condition above would be replaced by $E\mathrm{u}'(c_{t+1})$, the expected marginal value of consumption in a later period. A well-known result applies that, in the case where the marginal utility of income function is convex, greater

uncertainty in income would increase current savings (Leland, 1968). Intuitively, pre-cautionary savings counteract possible future fluctuations in income.

The neo-classical model, however, is based on several stringent assumptions, which often do not hold in practice. An important assumption is that transaction costs are zero. However, (formal) savings accounts often involve substantial costs, such as opening fees, minimum balance requirements and withdrawal fees. An increase in these costs, e.g. due to commitments, would discourage savings.

The standard neo-classical model also assumes that there are no liquidity constraints. It is easy to show that adding a liquidity constraint to the neo-classical framework would boosts the incentive to save. Intuitively, if there is a liquidity constraint, households will be prevented from borrowing in any future period if income would turn out to be too low. The only possibility to encounter this constraint is too save more now.

However, in practice it often appears difficult for poor people to save their way out of credit constraints. There are different reasons for this (Armendariz and Aghion, 2010, Chapter 6). It may be the case, that risk and persistent negative shocks are so high that asset accumulation becomes almost impossible as assets are wiped out continuously, which somehow contradicts the neo-classical insight that more uncertainty may actually boost savings. Moreover, there may be social impediments to save, if there is a need to support family and friend when they need assistance. Another important reason for under-saving is the lack of reliable saving possibilities, or the existence of saving constraints. The unavailability of convenient savings possibilities may be reflected in a low effective interest rate on savings, which would in terms of our simple condition above imply that $r < \rho$. More importantly, in terms of the savings function, an important implication of liquidity constraints as well as saving constraints may be that the neo-classical first order condition as given above would break down and change into (see Armendariz and Morduch, 2010, p. 181): $u'(c_t) = \frac{1+r}{1+\rho}\mathrm{u}'(c_{t+1}) + \lambda$ where λ reflects the extent of borrowing and savings constraints. The implication will be that perfect consumption smoothing is not possible anymore, and that consumption (and savings) patters would be dependent on current income. However, agents with an exponential discount rate may still try to smooth consumption as much as possible.

3.4.2. Behavioural economics perspective on consumption

An obvious reason for suboptimal saving may be that agents are simply too impatient to save enough. In the neo-classical framework, this may be reflected by $\rho > r$. Behavioral economists also refer to impatience as a possible reason for undersaving, but via another channel. Behavioral economists point

at problems related to self-discipline as a potential reason for undersaving. They assume that agents have hyperbolic preferences, meaning that they want rewards sooner rather than later. Hyperbolic discounting implies, in its most simple form, a discount function represented by: $D(t) = \frac{1}{1+\alpha t}$, which results in a discount rate that is, contrary to exponential discounting, declining over time: $-\frac{D'(t)}{D(t)} = \frac{\alpha}{1+\alpha t}$. The hyperbolic discounting function implies that the longer the time horizon before a reward is received, the lower is the per-period discount rate (the more patient is the person). One of the main implications of hyperbolic discounting is that, in contrast to the model with exponential discounting, perfect consumption smoothing doesn't take place: there will be more immediate consumption (and hence lower savings), and lower future consumption. Moreover, the pre-cautionary savings effect, that is the impact of income uncertainty on savings, is much smaller for hyperbolic discounters than for exponential discounters. This is intuitive as the present bias of hyperbolic discounters will prevent agents to conduct the necessary precautionary savings.

3.4.3. Implications for commitments

The analysis above does not say anything regarding preferences for commitments. While the neo-classical model doesn't explicitly consider the relevance of commitments, it seems clear that, if anything, locking savings would prevent an individual from maintaining a constant level of consumption throughout lifetime, and hence be valued negatively. Moreover, commitments, in the form of withdrawal fees or minimum balance requirements, imply an increase in transaction costs. Commitments also reduce liquidity for the borrowers, which may not be compensated by higher returns, which would especially be problematic for poor credit constrained households, faced with uncertain future income flows. Therefore, it seems obvious that rational agents, who, in line with the neo-classical theory, discount the future exponentially, would always prefer the most flexible savings possibilities available: a savings product with whatever form of commitment attached, which is not compensated by higher returns, would always be inferior to a similar savings product without commitments attached.

However, there are two potential reasons as to why somebody might prefer commitment devices. First, a commitment device that restricts possibilities to save and dissave may be welfare improving for somebody who is a hyperbolic discounter. The easiest way to explain this counterintuitive outcome is to assume that a decision maker consists of multiple selves, one for each period. If all selves have present-biased preferences, a taste for immediate gratification may result in self-control problems. A feature of the multiple selves' models is that future selves cannot be fully controlled by current selves. This may cause problems for the current self if, for instance, the future self undersaves, leading to a

too small pension for the current self, something which cannot happen in the neo-classical world where everybody has time consistent preferences. However, the current self may take actions that restrict behaviour of the future self, for instance by using commitments. Fudenberg & Levine (2006) argue that decision problems should be viewed as a game between the short-run impulsive self and the long-run patient self. Actions of dual-selves even stem from different parts of the brain according to some MRI studies (e.g. McClure et al., 2004). Important in this respect is the degree of awareness the current self has about the amount of self-control problems of the future self. It is common to differentiate between *Sophisticates*, who are aware of the fact that they (the current selves) as well as the future selves have equal degrees of present-bias and *Naifs* who are aware of their own present-bias but, incorrectly, assume that the future selves are time consistent (Bauer et al. 2012, Gul & Pesendorfer, 2001, Laibson, 1997). Especially in the case where the current self believes that the future self has self-control problems, which will be the case for a *sophisticated* hyperbolic discounter, commitment devices may be attractive as they may restrict behaviour of the future self. Locking savings would help people make wiser choices by directly specifying the actions of future selves, which are then binding with financial consequences. Savings rates for sophisticated agents with hyperbolic preferences are expected to increase given the choice to opt into commitments and limit withdrawals (Ashraf et al. 2006, Bauer et al. 2012). Basu & Bisht (2015) find that this type of committed savings motivated rural entrepreneurs in India to take up long term (pensions) savings accounts.

Besides self-control issues, literature emphasizes that individuals may prefer commitment devices because of spousal, familial, and neighbour bargaining (e.g., see, Plateau 2001). This is especially the case in a developing country context. In relationships where husbands have relatively more decision power than wives, women may prefer commitments (such as savings via rotating savings accounts - ROSCAS). Anderson & Baland (2002) find that using group rotating savings commitment accounts (ROSCAs), even without any interest over those savings, is a strategy wives in Kenya employ to protect savings against claims by husbands for immediate consumption. This was especially the case for women who have some but not too much or too little autonomy. Consequently, we can assume that women with a lot of autonomy would prefer lower restrictions or commitments due to spousal relations – such as for instance female household heads. There are a few factors that are positively associated to the take-up of commitment savings. Some of these include higher education level, being female and having limited spousal control (Karlan et al. 2014).

The discussion above suggests that it is not clear beforehand whether somebody prefers more or less flexible savings possibilities. The savings experiment we will explain below provides new evidence on this important question.

3.5. Methodology

3.5.1. Pension product design

To test the relevance of commitments versus flexibility in the context of a long-term savings product, we set up an intervention with Pension Trust Ghana, which introduced a retirement savings program for micro-entrepreneurs in Ghana. The product is a combination of a pension and a savings account, which allows consumers to withdraw a part of their savings at any point in time to give some flexibility for financing emergencies, with the other part locked until their retirement (60 years of age). Pension Trust Ghana introduced two pension products. Pension 1 allows farmers to withdraw 50% of their savings at any point in time, with the other 50% saved until their official retirement age. Pension 2 allows them to withdraw only 30% of their savings, with the other 70% saved until their retirement age. Thus, the only difference between the Pension 1 and Pension 2 account is that the latter offers reduced liquidity, which is not compensated by higher returns. One might expect Pension 1 to always be preferred to Pension 2; however, as we explained previously, this may not be the case. Note that the pension accounts yield returns that are higher than alternative options available in Ghana. The interest rate on the pension accounts is twice the treasury bills rate, 24% per annum, and there is no opening fee for farmers in our experiment, whereas the interest rate on a 'momo' (mobile money) account is only 7% per annum and on a Yello Save is approximately 12% per annum.

In our study, a commissioned agent kept record of every farmer's pension contribution in a ledger received from Pension Trust. The information recorded includes farmer names, the amount of savings received from each farmer, and the date the savings were collected. The agent would then go to the nearest bank and deposit the money in a collective account of the pension company.

3.5.2 Experiment design and model specification

We conducted a baseline survey of 1500 farmers dispersed over 22 communities in 2016. Later that year, one community was expelled from the cooperative, leaving us with 21 communities with 1169 farmers. To assess the uptake and use of the two committed pension products, we employed an experimental approach. More specifically, we randomly determined three groups: (i) all farmers in group 1 (Group1) were introduced to and allowed to open a Pension 1 account, (ii) all farmers in group 2 (Group2) were introduced to and allowed to open a Pension 2 account, and (iii) all farmers in group 3 (Group3) were also allowed to open a Pension 1 account; however, they were not exposed to any direct promotion or encouraged to open accounts. We randomised the three groups at the community level. Note that we instructed sales agents to open only the account type that we assigned to the

group. Thus, farmers in Group2 (Group1 and Group3) were not allowed to open Pension 1 (Pension 2) accounts.

We randomly selected three groups of seven communities each. For Group1, a representative from Pension Trust visited seven selected communities and introduced Pension 1 (50% locked, 50% flexible savings) to all farmers. For Group2, the same Pension Trust representative visited seven other communities to introduce Pension 2 (70% locked, 30% flexible savings). For Group3, the pension product was not introduced directly to farmers; rather, the experiment (including details of Pension 1) was explained at a cooperative assembly meeting, which was attended by community leaders from all 21 communities.

Our design enables us to test the impact of product design (flexible vs. less flexible) by comparing uptake of pension accounts by farmers from Group1 and Group2. It also enables us to test the impact of differences in promoting the pension product by comparing uptake of pension accounts by farmers in Group1 with the uptake of pensions by farmers in Group3. While the latter analysis is not the main aim of the paper, it provides information about the possibility to promote the product at the cooperative level, which has the potential to reduce transaction costs for Pension Trust. A comparison of uptake by farmers in Group3 and Group2 would test a combination of differences in design and promotion strategy; however, we are not interested in this comparison and do not refer to it further.

We examine uptake by running simple linear probability regressions, of the following form:

$$Y = \sum \beta_i P_i + \gamma X + \varepsilon, \quad (1)$$

where Y is a binary uptake dummy equal to 1 if an account has been opened and 0 otherwise; P refers to the three treatments (Group1, Group2, and Group3); the subscript i refers to Group1, Group2, or Group3; X is a vector of controls; and ε is an error term. We cluster all standard errors at the community level to control for within-community-level correlation of error terms.

We are primarily interested in the comparison of uptake of the three groups. In principle, due to the randomisation, simply comparing means of the three groups would suffice. However, to improve precision of the estimates, we add controls, which also enables us to test the extent to which uptake is affected by different controls.

To avoid ethical issues and spill-over effects, we randomised at the community level rather than the individual level. To improve balance and power, we first ranked the 21 communities on the basis of

weighted averages of relevant independent variables, including number of farmers per community, average years of schooling, age, gender, whether farmers have a bank account already, cocoa income, income in good versus bad months, total savings (formal and informal), whether farmers have income from other farming activities or from non-farming activities, and any outstanding debts. After ranking communities by the normalised score of these variables, we assigned 21 communities to seven strata, which we then randomly assigned to one of the three treatments per stratum. We verified whether the randomisation resulted in equal groups by performing balancing tests (see Table A1a and Table A1b in the Appendix), which showed that the groups are indeed balanced. The only two variables that were not balanced are years of schooling and total savings. Although perfectly balanced groups are not a prerequisite for making valid statistical references (Mutz et al., 2019), we include these variables as control variables in our regression analysis, to avoid potential issues with endogeneity.

3.5.3. Study context: descriptive statistics and balance tests

Table 1 lists descriptive statistics for the cocoa farmers in our sample, presenting averages (and standard deviations) for the whole sample, but also by group. The demographics obtained from our baseline survey show that 71% of the respondents were male, that the average age was 55 years, and that, on average, farmers had 11 years of schooling. Approximately 25% of the respondents were above the official retirement age of 60 years. Considering that Ghana's median age is 21 years, we can indeed confirm that cocoa farming is an aging business. The survey also revealed that approximately 17% of the families of our respondents have a loan or some type of debt, while 56% have a self-owned savings bank account, 89% (44% of total) of whom have savings in it. Almost 40% of the respondents receive remittances. When asked about their interest in taking up pensions, a great majority (92%) indicated they were interested in saving for retirement. However, we also found that old farmers are less likely to be interested in pensions, especially those with low income.

Cocoa is a biannual crop; the main cropping season in Ghana is from August to January, and the light-crop season is from April to June. Improperly maintained farms have harvest only during the main season. Savings and diversification into other farm or non-farm activities enable farmers to better cope with income fluctuations resulting from unpredictable production of this biannual crop.

Our survey shows that 83% of our respondents have other farming activities, whereas 45% are involved in non-farming activities. According to our baseline, income diversification into both other farming or non-farming activities is more common among young farmers than old farmers. In addition, 71% of our respondents are landowners. Approximately 22% are Abunu farmers, or sharecroppers who take over a farm, make all the investments to replant trees, apply input supplies, and so on, and they give

one-third of proceeds to the landowner. Another sharecropping arrangement is Abusa farmers, who are simply farm caretakers, and they give two-thirds of their proceeds to the landowners. Less than 7% of Abusa farmers make up our sample.

Table 1: Descriptive statistics

Variables	**Overall**		**Group1**		**Group2**		**Group3**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Nr inhabit in community	3174	3600	2723	1888	3929	6300	3068	1826
Female	0.29	0.45	0.35	0.48	0.25	0.43	0.27	0.44
Age	55	13	55	14	55	13	56	13
Years of schooling	11	4	11	4	11	4	11	4
Interest in pension	0.92	0.28	0.91	0.28	0.92	0.27	0.92	0.28
Shock 1	0.41	0.49	0.35	0.48	0.50	0.50	0.41	0.49
Shock 2	0.47	0.50	0.46	0.50	0.43	0.50	0.50	0.50
Income from other farming	0.83	0.38	0.82	0.38	0.867	0.340	0.814	0.389
Income good month	2663	3737	2494	3775	2322	3746	2278	3704
Income bad month	803	1382	786	1332	840	1450	794	1382
Existing loans	0.173	0.378	0.185	0.39	0.150	0.357	0.177	0.382
Bank savings	0.562	0.496	0.528	0.500	0.571	0.500	0.585	0.493
Total savings	2966	5133	2891	5074	3404	5529	2749	4908
Receive remittances	0.395	0.489	0.393	0.489	0.412	0.493	0.387	0.488

Note: Nr inhabit in community = number of inhabitants in a community; Female = female (a binary gender dummy equal to 1 for female); Age = age; Years of schooling = number of years of schooling; Interest in pension = dummy variable with 1 if respondent indicated being interested in a pension product; Shock 1 = Shocks related to drought, floods, bushfire, or landslides; dummy equal to 1 if respondent experienced these shocks in last 12 months; Shock 2 = Shocks related to unusually high levels of pests and diseases on farm (dummy equal to 1 if respondent experienced these shocks in last 12 months); Income from other farming = binary dummy equal to 1 if a farmer farms any crop other than cocoa; Income good month = income of a farmer in a good month; Income bad month = income of a farmer in a bad month; Existing loans: a binary dummy equal to 1 if the respondent or any household members have any debts or loans at the moment; Bank savings = binary dummy equal to 1 if respondent or anyone in household has a self-owned savings bank account; Total savings = Total amount respondent has in savings at the moment of interview; Receive remittances = a binary dummy equal to 1 if respondent receives remittances.

Table 1 suggests that for almost all variables presented, averages per group do not differ substantially: for most variables, the group averages are similar and similar to the overall average. As is common practice, we formally tested whether the averages per group significantly differ from each other. In other words, we conducted balance tests for the three groups of farmers in the study. Balance tests provide evidence for whether the randomisation 'worked' (i.e., resulted in similar treatment groups). Tables A1a and A1b in the Appendix present the results. The balance checks indicate that the

randomisation was carried out correctly: for all observational characteristics, there is balance between Group1 and Group2. In the comparison of Group1 (Group2) and Group3, the variables years of schooling and total savings are not balanced. However, this is not a problem because at a 5% significance level, lack of balance will occur by chance for 1 out of 20 variables. Yet we add these variables to our regressions as explanatory variables to control for any possible remaining imbalances.

Table 2 summarises the annual income of the farmers we surveyed and how it compares with that of alternative jobs in towns. Considering income is important given that the ability to commit to savings depends on current income earned. We created income categories comparable to a local minimum wage in Ghana, a low-wage equivalent in town based on the 2016 exchange rate (US$100/month), and a taxi driver wage equivalent in town (US$200/month). It appears that roughly 24% of farmers live below the minimum wage equivalent (US$1.9 per day). Whether anyone from this group of farmers would be able to commit to any savings account is questionable. Table 2 also presents percentages of respondents in each income category, per treatment group. The percentages are comparable for each treatment group. Yet Group2 has relatively more respondents in the poorest income group and fewer respondents in the highest income group.

Table 2. Total annual income 2016 (in Ghana Cedis, GhC)

	Income equivalence	Total	Group1	Group2	Group3
<2851	Below minimum wage ($1.8/day)	24	21	29	24
2851–5,244	Min. wage–$100/month	27	25	30	28
5,245–10,944	$100/month–$200/month	34	36	30	36
>10,944	>$200/month	14	17	11	13
# of respondents		1017	345	264	408

Note: The columns Total, Group1, Group2, and Group3 show which percentage of respondents belongs to the different income categories for the different treatment groups, as well as the total sample. The last row presents the total number of respondents per group.

3.6. Results

Table 3 provides a summary of our regression analysis. Dummies for strata, as explained previously, are taken into account in all regressions. Regressions 1, 2, and 3 use the whole sample, whereas regressions 4 and 5 use a restricted sample (sample of farmers in Group1 and Group2 only).

As column 1 of Table 3 shows, the uptake in Group1 (i.e., Pension 1) is higher than that in Group2 (i.e., Pension 2) and Group3 (the latter is reflected by the constant; i.e., Pension 1, without personal visits). Almost 25% of farmers in Group1 have taken up a pension (reflected by the sum of the constant and the coefficient for the group), whereas only 14% in Group2 have done so (constant plus coefficient Group2).

Table 3: Regression analysis summary

Variables	(1) Without controls	(2) With 2 controls	(3) All controls	(4) Restricted sample	(5) Restricted sample with 2 controls
Group1	0.140	0.141	0.141		
	(0.124)	(0.124)	(0.117)		
Group2	0.0169	0.0179	-0.0128	-0.147	-0.146
	(0.0697)	(0.0696)	(0.0632)	(0.110)	(0.110)
Strata1	-0.0420	-0.0434	0.0407	-0.0375	-0.0411
	(0.0751)	(0.0760)	(0.0998)	(0.0523)	(0.0530)
Strata2	-0.168**	-0.167**	-0.0843	-0.234***	-0.235***
	(0.0748)	(0.0742)	(0.0967)	(0.0749)	(0.0743)
Strata3	-0.174**	-0.174**	-0.116	-0.237***	-0.236***
	(0.0749)	(0.0742)	(0.0991)	(0.0737)	(0.0719)
Strata4	0.213	0.214	0.232	-0.0570	-0.0585
	(0.226)	(0.227)	(0.213)	(0.257)	(0.257)
Strata5	-0.0482	-0.0484	-0.0325	-0.0114	-0.0109
	(0.114)	(0.114)	(0.110)	(0.166)	(0.165)
Strata6	-0.0394	-0.0387	0.0332	-0.0441	-0.0410
	(0.100)	(0.0999)	(0.106)	(0.117)	(0.117)
Nr inhabit in com.			2.00e-05*		
			(9.94e-06)		
Gender			0.0199		
			(0.0273)		
Age			0.000625		
			(0.000646)		
Bank savings			0.00619		
			(0.0202)		
Total savings		-9.98e-07	-1.06e-06		-2.92e-06
		(1.64e-06)	(1.80e-06)		(2.06e-06)
Income good month			5.58e-06		
			(1.12e-05)		
Income bad month			-8.22e-06		

			(2.73e-05)		
Income from other farming			-0.0226		
			(0.0372)		
Existing loans			-0.0135		
			(0.0141)		
Interest in pension			-0.0669		
			(0.0578)		
Years of schooling		-0.000991	-0.00227		0.000603
		(0.00216)	(0.00185)		(0.00259)
Shock 1			0.0116		
			(0.0235)		
Shock 2			-0.0199		
			(0.0141)		
Receive remittances			-0.0149		
			(0.0216)		
Constant	0.108	0.121	0.0893	0.302***	0.304***
	(0.0947)	(0.109)	(0.175)	(0.0454)	(0.0642)
Observations	1,169	1,169	1,137	701	701
Adjusted R^2	0.139	0.138	0.172	0.101	0.100

Note: Cluster robust standard errors are in parentheses; ordinary least squares (OLS) regressions; dependent variable: a binary dummy uptake of pension product equal to 1 if a pension account has been opened. Linear probability regressions are conducted for ease of interpretation. Restricted sample: *Group1* and *Group2* only, without *Group3*. *** $p<0.01$, ** $p<0.05$, * $p<0.10$.

Although this difference is large, it is not statistically significant, probably due to the cluster randomisation and the implied correlation within clusters, which increased the cluster robust standard errors. We may be faced with power problems and incorrectly dismiss significance because we have too few communities from which to draw any significant statistical inferences. Adding controls in columns 2 and 3 does not change the results much. Yet, for the model with a full set of controls, the difference between the coefficients for Group1 and Group2 is non-significant at the 10% level. Thus, we find some modest evidence of a preference for the more flexible pension product.

In columns 4 and 5 of Table 3, we ignore farmers from Group3 who were offered Pension 1 through community leaders and not directly through Pension Trust. Here, the pension uptake in Group1 is

30%, reflected by the constant, and is significantly higher than the uptake of Group2, which is less than 16%. We confirm this finding when adding the control variables.

3.6.1. Heterogeneity effects

In addition to these simple linear regressions, we test for heterogeneous treatment effects by interacting the treatment dummies with different variables. That is, we test whether the uptake for different subgroups of the more restricted long-term savings product differs significantly from the uptake of the group with the more flexible pension. As the main aim of our analysis is to test whether the uptake differs for two pension products that vary in the degree of flexibility of withdrawals of savings, we only consider the restricted sample (i.e., Group1 and Group2, without Group3). By focusing on this restricted sample, the interpretation of the results becomes more straightforward. However, we also carry out all regressions with the whole sample. These results are qualitatively similar to the results presented in the main text.

The regressions are specified as follows:

$$Y = \alpha + \beta_1(1 - I) * P_2 + \beta_2 * I * P_2 + \beta_3 * I * P_1 + \mu X + \varepsilon \quad (2)$$

where α represents the constant, P2 refers to treatment Group2, P1 refers to treatment Group1, X is a vector of controls (including the strata dummies), and I is a vector of interaction terms (always binary, defining 'groups'). Note that the constant reflects the uptake of Pension 1 by the group defined by 1 – I. For example, if I denotes the binary variable gender, equal to 1 for female and 0 otherwise, the constant reflects uptake by men in Group1 and, thus, Pension 1. Next, β_1,β_2 measure the increase/decrease in uptake of Group2 (and, thus, Pension 2) for groups denoted by I or 1 – I compared with the uptake of Group1 (and, thus, Pension 1) for the group denoted by 1 – I, and β_3 measures the additional increase/decrease in uptake of treatment Group1 (and, thus, Pension 1) for group I compared with the uptake of treatment for Group1 (and, thus, Pension 1) by group 1 – I.

The individual characteristics include the existence of income diversification strategies or financial shock management strategies (see balance tests in section 4.4 for a summary of all variables considered). Examples of these strategies include income from non-farming activities, other savings, health insurance, and remittances.

Tables 4a and 4b summarise our findings of the heterogeneous effects regressions. In column 1 of Table 4a, we test the difference between men and women. Recall that one reason for a preference for commitment devices is bargaining power. Women may prefer commitments to be able to counteract

their spouse's claims for immediate consumption. However, our results do not provide support for this view, as they show that women have a significantly higher uptake of the more flexible pension (column 1) than men, as is indicated by a significant coefficient for the interaction term Female*Group1. Moreover, women have a higher uptake of Pension 1 than of Pension 2, as is indicated by a significant difference between Female*Group2 and Female*Group1 (see Wald 2), and women do not choose to save in Pension 2 accounts significantly more often than men, as is indicated by the finding that Female*Group2 and (1-female)*Group2 do not differ significantly from each other (see Wald 1). These results suggest that women prefer a higher level of flexibility or liquidity than men. Regarding level of schooling, we find no significant evidence that the uptake of Group1 as compared with that of Group2 is higher for either the highly educated group or the less educated group. Several income fluctuation management strategies also influence farmers' preference for commitment versus flexibility. First, we test whether access to alternative savings matters for the choice of one of the two pension products. Intuitively, when someone already has savings (or is more financially secure), the lower liquidity associated with Pension 2 is less of a risk. Thus, we would expect demand by treatment Group2 (and, thus, demand for Pension 2) to be higher for farmers with access to other savings products; however, we find no evidence of this (column 2, Table 4a). Second, in addition to income diversification, the analysis also considers the effect of income shocks on adoption of pension accounts. The results show that the uptake of Pension 1 and/or Pension 2 is not higher for farmers who have experienced an unexpected shock with financial repercussions within the last year than for farmers who have not experienced such a shock. However, the uptake of Pension 1 for farmers who have not experienced a shock is significantly higher than the uptake of Pension 2 for farmers who have experienced a shock. Farmers who have experienced an unexpected shock with financial repercussions within the last year are significantly less likely to take up the more rigid pension product. We also expected farmers who have health insurance to be less affected by some of these income shocks and thus be more open to less flexible accounts. However, we found no significant uptake of either pension account for farmers with health insurance (column 5, Table 4a).

Remittances are another strategy a farmer may use to manage income fluctuation risks. For the group of farmers who receive no remittances, the most flexible pension product is taken up significantly more (column 1, Table 4b). This is in line with our expectation that farmers prefer to have more flexibility if they have fewer sources of income. Having a higher number of household members is also a way to diversify income, given that more household members means more labourers and, thus, income per household. However, if a greater number of those household members are children, income expenditures on education and health care are also higher.

Table 4a: Heterogeneous treatment effects

VARIABLES	(1) Gender	(2) Access savings	(3) Education	(4) Shocks	(5) Access insurance	Health
Female*pension2	-0.0926					
	(0.0897)					
(1-female)*pension2	-0.127					
	(0.118)					
Female*pension1	0.0865***					
	(0.0284)					
Sav*pension2		-0.143				
		(0.111)				
(1-Sav)*pension2		-0.137				
		(0.105)				
Sav*pension1		0.0124				
		(0.0497)				
Educ*pension2			-0.0492			
			(0.132)			
(1-Educ)*pension2			-0.121			
			(0.0918)			
Educ*pension1			0.0968*			
			(0.0517)			
Shock*pension2				-0.163*		
				(0.0891)		
(1-Shock)*pension2				-0.157		
				(0.0939)		
Shock*pension1				-0.0348		
				(0.0693)		
Hins*pension2					-0.149	
					(0.120)	
(1-Hins)*pension2					-0.0874	
					(0.140)	
Hins*pension1					0.00427	
					(0.0391)	
Constant	0.271***	0.296***	0.210**	0.309***	0.298***	
	(0.0425)	(0.0609)	(0.0782)	(0.0370)	(0.0765)	

Observations	695	701	701	701	701
Adjusted R-squared	0.107	0.098	0.103	0.099	0.099
Wald 1	0.37	0.75	0.25	0.75	0.11
Wald 2	0.08	0.22	0.22	0.39	0.18
Wald 3	0.10	0.21	0.02	0.43	0.49

Note: Cluster robust standard errors are in parentheses; Wald 1: p-value equality test A*Group2 = (1-A)*Group2; Wald2: p-value equality A*Group1 = A*Group2; Wald3: p-value equality (1-A)*Group1 = A*Group2, where A is female, sav, educ, and so on. The regressions do not include controls, other than STRATA dummies, to facilitate a simple interpretation of the results. Results including controls are similar and are available on request. *Female* = gender dummy equal to 1 for female; *Sav* = savings dummy equal to 1 for farmers who do have access to a formal savings account; *Educ* = education dummy equal to 1 if respondent's education level is higher than primary; *Shock* = dummy variable equal to 1 if the respondent experiences in the last 12 months drought, floods, bushfire, or landslides; *Hins* = binary dummy equal to 1 if the respondent has health insurance. The different dummies are interacted with either *Group1* or *Group2*, which leads to different groups. The 'missing' group is reflected by the constant. OLS regressions. The dependent variable is a binary uptake dummy equal to 1 if an account has been opened and 0 otherwise. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

However, we do not find any differences regarding household size. Income diversification through non-farming activities is also another way of managing income fluctuation. A Wald test (Wald 2) indicates that for farmers with income-generating activities other than farming, the uptake of the flexible pension product is higher than the uptake of the less flexible product—that is, for farmers who can diversify income through non-weather-dependent activities (column 3, Table 4b). This latter result may be due to higher incomes of those farmers. We therefore also conducted a heterogeneity analysis on annual income (column 4, Table 4b), which indeed shows that farmers with a relatively high income prefer the more flexible product while for farmers with a relatively low income, this is not the case. Finally, we ran a heterogeneity analysis on age. We tested the extent to which farmers below and above the retirement age differ. For farmers above the retirement age, the withdrawal restrictions no longer hold, such that the two pension products become similar. We indeed find that retired farmers have no preference for one of the pension products (see the non-significant Wald 2). For farmers who are not yet retired, we also do not find a significant difference at the 10% level. However, this group of farmers pefers the flexible pension product at the 15% significance level.

Our results show that especially women and farmers with income from non-farming activities have a stronger preference for Pension 1 in general. We also find a significantly lower uptake of Pension 2 than Pension 1 for farmers who have experienced an unexpected expenditure shock within the last year and for farmers who receive no remittances from others.

Table 4b: Heterogeneous treatment effects

VARIABLES	(1) Remittances	(2) Hhnumber	(3) Nonfarmactivities	(4) Highlowincome	(5) Retired
Remit*pension2	-0.126				
	(0.131)				
(1-remit)*pension2	-0.191*				
	(0.106)				
Remit*pension1	-0.0454				
	(0.0463)				
Hhnumhigh*pension2		-0.144			
		(0.128)			
(1-hhnumhigh)*pension2		-0.184			
		(0.105)			
Hhnumhigh*pension1		-0.0406			
		(0.0328)			
Nonfarma*pension2			-0.127		
			(0.112)		
(1-nonfarma)*pension2			-0.110		
			(0.109)		
Nonfarma*pension1			0.0698**		
			(0.0251)		
Incomelow*pension2				-0.129	
				(0.136)	
(1-incomelow)*pension2				-0.217*	
				(0.101)	
Incomelow*pension1				-0.0578	
				(0.0376)	
Retired*pension2					-0.0845
					(0.128)
(1-retired)*pension2					-0.159
					(0.0971)
Retired*pension1					0.0464
					(0.0343)
Constant	0.323***	0.320***	0.273***	0.320***	0.285***

	(0.0523)	(0.0532)	(0.0492)	(0.0450)	(0.0518)
Observations	701	701	701	701	701
Adjusted R-squared	0.104	0.101	0.104	0.108	0.105
Wald 1	0.16	0.27	0.30	0.23	0.15
Wald 2	0.53	0.40	0.10	0.56	0.33
Wald 3	0.14	0.17	0.13	0.10	0.07

Note: Cluster robust standard errors are in parentheses; Wald 1: p-value equality test A*Group2 = (1-A)*Group2; Wald2: p-value equality A*Group1 = A*Group2; Wald3: p-value equality (1-A)*Group1 = A*Group2, where A is remit and so on. The regressions include STATA dummies but do not include other controls to facilitate a simple interpretation of the results. Results including controls are similar and are available on request. Remit: binary dummy if the respondent obtained remittances; Hhnumhigh = binary dummy if household of respondent contains more than 5 members; Nonfarma = binary dummy equal to 1 if the respondent has non-farm business activities; Incomelow = binary dummy equal to 1 if the respondent has a total income below 5050 Cedis (the medium income in our sample); Retired = binary dummy equal to 1 if the respondent is older than 60 years (the official retirement age). The different dummies are interacted with either *Group1* or *Group2*, which leads to different groups. The 'missing' group is reflected by the constant. Linear probability regressions. The dependent variable is a binary uptake dummy equal to 1 if an account has been opened and 0 otherwise. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

3.7. Conclusions

Although the uptake of the two pension products on average does not differ significantly at the usual significance levels, our analysis suggests that a more flexible long-term savings product is preferred to the less flexible savings account. This conclusion is confirmed by our heterogeneity analysis, which shows that women and farmers with non-farming income–generating activities have a higher preference for Pension 1. By contrast, better income diversification does not translate into a higher uptake of the more rigid account, Pension 2. If anything, farmers who have experienced a financial shock within the last year and those who receive no remittances have a significantly lower uptake of this more rigid pension account.

These findings enable us to conclude two things. First, if pension flexibility is valued, farmers should choose the less rigid account. Farmers who have sufficient income to save for pensions, or, in other words, balance long-term consumption despite income fluctuations, are those who simply have more sources of income. The implication of this finding is that a 50% flexible product creates a better balance between current and future consumption needs. More rigid savings become impossible for farmers who have fewer sources of income, such as farmers who receive no remittances or those who are still recovering from financial shocks from last year. These subgroups of farmers are less likely to be able to balance current and long-term expenditure. Perhaps rigid pension savings are more desirable in Western countries where income fluctuation is generally less severe, partially because of existing government social security systems that are in place to protect their citizens. In Ghana, however, locking 70% of pension savings is simply not optimal to balance either current consumption or future consumption. This is not a matter of hyperbolic discounting versus exponential discounting discussed

previously—perhaps locking 70% of savings creates an opposite scenario of hyperbolic discounting, in which consumers would not discount future rewards—but the contrary, in which they would need to value their future rewards more than their current rewards. Such a scenario is simply not realistic, which is how we explain the lower uptake of Pension 2. Even under relatively 'ideal' circumstances in which farmers have income diversification strategies, receive remittances, and have not experienced any financial shocks within the last year, they still have a preference for the more flexible savings account. This is an indication that locking 50% of savings is more realistic in balancing current consumption with temptation. However, to what extent the more flexible pension accounts would protect farmers against their own behavioural biases remains unclear. A possible solution is to develop pension products with withdrawal restrictions, conditional on future financial shocks, so that both the behavioural biases and the potential liquidity shortages can be addressed. Future research might try to address this issue more carefully.

Second, women are usually the ones who take care of long-term well-being of all family members. The flexible pension accounts allow them to balance consumption demands of family and community members with long-term care of the household. Women in developing countries have historically been known to be responsible for the well-being of the family as a whole. It is normally women who make sure that children's school fees are paid and that there is enough food on the table for the whole household. This indicates high current expenditure costs. By contrast, women in many African countries, including Ghana, are still not allowed to inherit land titles. This means that they cannot lease their land in sharecropping agreements or use farm proceeds as retirement income, as older male cocoa farmers do. Because of the nature of land titles, women are not in a position to do that. Therefore, pension savings allow them to tailor income for their own old age as well as for current household needs and unexpected expenses.

A limitation of our study is that the number of communities in our sample is relatively small. For ethical reasons, we had to randomise at the community level. This also has advantages in terms of avoiding spillover effects. However, with the small number of communities, we may face problems in terms of only being able to pick up small effect sizes and thus incorrectly fail to reject the null or no significant differences. Future research using a larger group of communities would avoid these limitations.

Another limitation is that with the relatively small number of communities, we were not able to compare a larger variety of pension products, as this would have resulted in additional power problems. To better assess 'optimal' commitment levels, a larger variety of pension products (including one without any restrictions) should be considered. Finally, this study measures only the uptake of

different pension savings products. Additional research is necessary to identify the retention of long-term savings and how this changes over time.

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3.9. Appendix

Table A1: Uptake pensions

VARIABLES	(1) without controls	(2) with 2 controls	(3) all controls	(4) restricted sample	(5) restricted sample with 2 controls
pension1	0.140	0.141	0.141		
	(0.124)	(0.124)	(0.117)		
pension2	0.0169	0.0179	-0.0128	-0.147	-0.146
	(0.0697)	(0.0696)	(0.0632)	(0.110)	(0.110)
strata1	-0.0420	-0.0434	0.0407	-0.0375	-0.0411
	(0.0751)	(0.0760)	(0.0998)	(0.0523)	(0.0530)
strata2	-0.168**	-0.167**	-0.0843	-0.234***	-0.235***
	(0.0748)	(0.0742)	(0.0967)	(0.0749)	(0.0743)
strata3	-0.174**	-0.174**	-0.116	-0.237***	-0.236***
	(0.0749)	(0.0742)	(0.0991)	(0.0737)	(0.0719)
strata4	0.213	0.214	0.232	-0.0570	-0.0585
	(0.226)	(0.227)	(0.213)	(0.257)	(0.257)
strata5	-0.0482	-0.0484	-0.0325	-0.0114	-0.0109
	(0.114)	(0.114)	(0.110)	(0.166)	(0.165)
strata6	-0.0394	-0.0387	0.0332	-0.0441	-0.0410
	(0.100)	(0.0999)	(0.106)	(0.117)	(0.117)
Nr inhabit in com.			2.00e-05*		
			(9.94e-06)		
Gender			0.0199		
			(0.0273)		
Age			0.000625		
			(0.000646)		
Bank savings			0.00619		
			(0.0202)		
Total savings		-9.98e-07	-1.06e-06		-2.92e-06
		(1.64e-06)	(1.80e-06)		(2.06e-06)
Income Good month			5.58e-06		

			(1.12e-05)		
Income bad month			-8.22e-06		
			(2.73e-05)		
Income from other farming			-0.0226		
			(0.0372)		
Existing loans			-0.0135		
			(0.0141)		
Interest in pension			-0.0669		
			(0.0578)		
Years of schooling		-0.000991	-0.00227		0.000603
		(0.00216)	(0.00185)		(0.00259)
shock1			0.0116		
			(0.0235)		
shock2			-0.0199		
			(0.0141)		
Receive remittances			-0.0149		
			(0.0216)		
Constant	0.108	0.121	0.0893	0.302***	0.304***
	(0.0947)	(0.109)	(0.175)	(0.0454)	(0.0642)
Observations	1,169	1,169	1,137	701	701
Adjusted R-squared	0.139	0.138	0.172	0.101	0.100

Cluster robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.10; OLS regressions;

4. Do savings constraints inhibit farmers to choose the best technology? A meta-frontier analysis of cocoa farmers in Ghana[5]

4.1. Abstract

This chapter shows that cocoa farmers' with access to savings use different farming technologies from farmers without access to savings. To test that, we use the stochastic meta-frontier analysis to show how these two groups of farmers operate on different efficiency curves based on their inputs used. We also find that both groups operate close to their maximum efficiency respective of their inputs. However, farmers with access to savings operate a lot closer to optimal cocoa farming efficiency, defined by the meta-frontier. The results can be interpreted in 3 ways. First suggests that access to savings enables farmers to increase the adoption rate of technological innovations and/or increase input quality, and as a result, consequently, increase efficiency. Second argues that the indirect effect on savings is that they are an effective way of smoothening consumption, and, as literature shows, smoothening consumption leads to efficiency gains. The third alternative way of interpreting more optimal efficiency for farmers with access to savings is that they harvest whatever cocoa growing on trees with no additional inputs used, and instead, invest family labour and savings into other forms of income generation. Overall, this article adds to the increasing evidence of the importance of savings.

4.2. Introduction

Agricultural development is considered critical in ensuring food security and poverty alleviation (Dercon et al, 2009). Yet Africa, where two thirds of population depend on agriculture (Bureny & Nayolor, 2012) remains the most food insecure continent on earth (OECD/FAO 2016). Ensuring food security and reducing the number of people living in poverty in the coming century will require intensification of food production on existing land. Dzanku et al (2015) found that the use of agricultural technology such as hybrid seeds and fertilizer holds considerable promise to increasing both food production and yields and income for farmers. However, the adoption of fertilizer and hybrid seeds remains low among smallholder farmers even in light of government subsidies (Kos et al 2020). The literature proposes several reasons for the low adoption of new technologies in African agriculture. These include, lack of knowledge, limited availability of inputs, lack of farmers' trust induced by low-quality counterfeit inputs on rural markets (Bold et al. 2017), and/or more behavioural reasons (Foster and Rosenzweig, 2010).

Another important impediment for modernisation may be the result of being excluded from financial markets. Several studies have emphasized that access to insurance, which induces risk-averse farmers

[5] Based on an unpublished manuscript co-authored with Lensink, R. and Meesters, A.

to reduce adoption of risky new technologies, may encourage farmers to adopt new technologies (Miranda and Farrin 2012, p.391). Also, a lack of credit has been identified as an important reason for the low degree of modernization. In this paper, we aim to focus on yet another reason why uptake of new technologies remains low. That is, we draw attention to the important role that access to saving products may play in terms of encouraging modernization. More specifically, in this chapter we analyse the relationship between access to savings and technology adoption, by comparing the technical efficiency of farmers with and without access to a formal savings account. Technical efficiency and technological gaps have been addressed by many agricultural researchers to estimate farm performance (Anyanwu, 2011; Feder, 1985; Hernandez et al.,2005, Just & Zilberman, 1983, Kevane, 1996, Mariko et al. 2019). Some examples include the effect of farm size and technology adoption on productivity (Just & Zilberman, 1983); or technical efficiency of SMEs based on firm access to credit (Hernandez et al, 2005).

The contribution of our study is twofold. First, to the best of our knowledge we are the first who explicitly examine whether and to what extent access to savings induce farmers to adopt other and/or better technologies. We hypothesize that savings constraints create a technology gap. In other words, inability to save will inhibit cocoa farmers to choose the best technology available for them. Second, we use a metafrontier production function approach (Battese et al. 2004; Huan et al., 2014) to test our hypothesis. The metafrontier approach, in contrast for instance to a regular stochastic frontier analysis (SFA), enables us to test whether farmers with and without access to savings products operate under a different technology. Moreover, the metafrontier model allows for separation of technical efficiency scores for farmers with and without access to savings, as well as technical gap ratios for both groups of farmers relative to the best technology available.

There are several reasons why access to savings may induce farmers to adopt new technologies. Most importantly, by accumulating savings risk-averse farmers will have enough liquidity as insurance against potential risks, and hence may induce a “high-return, high-risk” technology adoption strategy (Karlan et al., 2017, Kristen and Mas, 2009, Dupas and Robinson, 2013). Thus, savings possibilities can help smallholder farmers to shield themselves from negative risks due to adverse shocks and thereby stimulate riskier, but also more productive, investments that improve food security. In addition, savings provide liquidity and insure farmers against potential health shocks, which translate to higher productivity of labour, even without adopting new technologies. Savings possibilities enable farmers to top up small loans to make larger investments. This indirect effect may be critical, as the small credits provided to smallholders rarely are substantial enough to finance larger, more productive, income-generating investment projects. Similar outcomes may of course be induced by insurance and/

or access to credit. However, due to issues such as trust for example, the uptake of insurance products by African farmers is extremely low. Moreover, by accumulating savings farmers will be able to self-finance new technologies or a healthy diet, which will in turn increase their productivity. Self-financing has the advantage over using credit since potential productivity gains need not to be shared with a bank as a result of interest charges on loans. Thus, while access to savings, like access to credit, provides liquidity to farmers to purchase modern technologies, the former doesn't suffer from potential high interest costs, and related debt problems. The latter is especially problematic in case of predatory lending practices, which are not uncommon even within the microfinance industry.

Savings can be accumulated in various ways, for instance, informally, via savings-groups, individuals (such as money lenders), via livestock investments; or otherwise formally – via a formal bank or post office account. Both formal and informal savings possibilities may help farmers to adopt modern technologies. Yet, in this chapter we focus on access to formal savings accounts as the informal savings possibilities often suffer from lack of safety, liquidity, reliability and privacy. In this study we focus on cocoa farmers in Ghana. Studying savings in the context of cocoa farmers is particularly interesting given the perennial nature of the crop, which implies biannual income for farmers. The nature of infrequency of income stream of perennial crops implies that savings are necessary to smooth consumption, manage investment risk and shocks.

The chapter is structured as follows: Section 2 elaborates on why savings are a good proxy for access to different technologies and thus the existence of different efficiency frontiers; and furthermore elaborates on the existing studies on technical efficiency using meta-frontier analysis (MFA). Section 3 elaborates on methodology and model of stochastic MFA. Section 4 presents the study context. Section 5 summarizes the results, and finally Section 6 provides conclusions.

4.3. Literature review: Consumption smoothing, investment risk and the role of formal savings accounts

Producers are predominantly risk averse and prefer to smooth consumption over time. Those who are better able to smooth consumption over time also have a greater capacity to absorb risk, regardless of their risk preferences (Eswaran & Kotwal, 1990). Producers' attitude toward risk is very important in input allocation decisions, and hence in output supply (Kumbhakar, 2002). Dupas and Robinson (2012) find that less risk averse individuals also save less, pointing to a possibility that savings accounts can be used for consumption smoothing. According to neoclassical consumption theory, wealthy individuals are better fitted to dissave or borrow to smooth consumption over time. When income is low, they can dissave or borrow; when income is higher, they can save or repay debt. A farmers'

capacity to bear risk is derived from the ability to stabilize consumption over time (Kumbhakar, 2002). In absence of wealth, formal bank savings can be used to smooth consumption (Dupas & Robinson, 2012). Fletschner et al (2010) find that risk averse farmers are 20% less efficient than the less risk averse farmers, and that risk aversion is lower for wealthier households. The authors find that stimulating insurance or other ways of managing risk does not only smooth consumption, but is one way of increasing efficiency. In absence of well-functioning insurance and credit markets in most developing countries, recent evidence sheds light on formal savings as the best way to manage investment risk and smooth consumption (Dupas & Robinson, 2012). Whereas Fletschner et al. (2010) find that smoothing consumption through wealth or credit increases efficiency, and Dupas and Robinson (2012) find that savings are an effective way of smoothing consumption, this chapter tests to what extent access to savings increases efficiency.

Savings can help smallholder farmers overcome three constraints that trap them in a vicious cycle of poverty. Firstly, accumulating savings allows farmers to make farm investments that will enhance farm productivity, or can help them to search for more productive forms of employment (Christen and Mas, 2009, Hulme et al. 2009). Secondly, savings allow farmers to smooth consumption over time and manage income fluctuations (Eswaran & Kotwal, 1990). Reducing barriers to formal savings accounts have proven to increase savings, asset accumulation, investments and consumption (Goldberg, 2014). Finally, accumulating savings can offset some of the unexpected yet inevitable income shocks and losses, such as draughts, floods, ill health etc., and therefore level income shocks in form of insurance. A few studies show that savings are more effective than access to credit for a couple of reasons. Firstly, studies exploring adoption of credit show low borrowing rates (Banarjee, 2009, Crepon et al, 2011, Dupas et al, 2012), and secondly, the evidence about the impact of credit on SME growth and investment has been mixed. Karlan and Zinman (2010a, b) find that microcredit has no impact on business investment, on the contrary, they even find negative investment for loan holders. Likewise, Kaboski and Townsend (2011) find that increased credit access enhances consumption, but not necessarily business investment in rural areas (Attanasio et al, 2012). On the contrary, in a randomized controlled trial of opening bank savings accounts, Dupas and Robinson (2013) show that market women in Kenya have 37% higher business expenditure than the market women in the control group. Note that in this chapter we do not look at how savings are being spent, but we do look at the ultimate effect of access to a savings account on overall efficiency.

Another issue that this study brings forward is the effect of inclusion in a formal financial system. Farmers accumulate savings in a number of ways, from hiding money in a mattress, through participating in rotating savings schemes (ROSCAs), saving money in a box with a lock, to accumulating

savings in formal bank accounts. However, none of them besides formal savings offers reliability, safety, privacy and liquidity (Christen and Mas, 2009). Hiding money in a mattress is susceptible to theft and obligation to share savings with others; saving in a box with a lock does not overcome time-inconsistent[6] consumption choices (Dupas and Robinson, 2012); ROSCAs have a strong commitment feature making it suitable for time-inconsistent preferences (Dupas ad Robinson 2013), but it is not flexible and liquid enough since group members are obligated to save regularly but also to wait for their turn to get their savings in a lumpsum. Besides the reliability, safety, privacy and liquidity, the advantage of formal savings accounts is access to a formal financial system. The main hurdles to financial inclusion in form of formal savings markets are minimum deposits and balances, and exclusion of poor people because of physical and social distances (Hulme et al. 2009, Christen and Mas, 2009). However, financial inclusion is prerequisite of economic inclusion. The poor, smallholder farmers in our case, must be connected to the national economy and global markets through financial systems if they are to fully contribute to and participate in economic growth (Christen and Mas, 2009). Furthermore, benefit of having access to a formal financial system in form of savings accounts is farmers' inclusion in a savings scheme which allows farmers to accumulate loan collateral, even without formal land titles. For this reason we compare efficiency frontiers of farmers with and without access to *formal* savings accounts, with the main focus on farmers' resulting difference in access to productive technologies.

4.4. Study context

4.4.1. Efficiency challenge of cocoa farmers in West Africa

This study focuses on technical efficiency analysis of smallholder cocoa farmers in Ghana. Efficiency of cocoa production has caught the attention of not only the main producing countries in West and Central Africa, but also of many Western countries. Cocoa cultivation is one of the most significant causes of disappearance of West African rainforest belt (Gockowski et al. 2000; Nkamleu and Ndoye 2003). The evident conflict between this environmental catastrophe and income generating opportunities it poses for the poor has called for more efficient use of land and other resources. Throughout the last couple of decades, governments of West Africa as well as numerous multi-stakeholder initiatives have attempted to increase productivity and efficiency of cocoa farms, some of which include Cocoa Hi-tech initiative programme (Onumah et al. 2010), Cocoa Disease and Pest Control Programme – CODAPEC (Onumah et al., 2013), followed by the private sector driven program Cocoa Quality and Sustainability Program (CPQP) among others. All of these programs have attempted to increase efficiency of existing farms or to change input technologies (Nkamleu et al. 2010). There

[6] For more information on time-inconsistent preferences, refer to Laibson, 1997.

are two ways of enhancing productivity of cocoa: by improving technical efficiency or by improving technological application. The former requires increasing output without additional conventional inputs and new technologies, but rather by improving farmer management practices. The later requires the use of different technologies, such as more productive hybrid seeds and application of chemicals to manage outbreaks of diseases that harm the crop productivity. Given the widespread problem of aging trees and breakout of diseases, policy makers decided to focus their farm rejuvenation efforts on both increasing efficiency and changing input technologies.

Given the importance of yields and efficiency of cocoa farmers in West Africa, it comes as no surprise that there are a number of existing studies on cocoa efficiency. Nkamleu et al. (2010) conducted a meta-frontier efficiency analysis of the major cocoa producing regions in West and Central Africa, namely Cote d'Ivoire, Ghana, Cameroon and Nigeria by estimating national technology gap ratios (TGR). Onumah et al (2013) compare the technical efficiency of organic versus conventional cocoa farmers in Ghana using meta-frontier analysis. They find that both poor technology and poor farm management influence farm efficiency. Poor management is referring to misuse of agrochemicals and other inputs, as well as aging trees on farms. A cocoa tree is most productive between the age of 6 and 15 (Nkamleuh et al. 2010), however, aging trees are a common problem among West African farmers, and are found to be positively correlated with technical inefficiency (Onumah et al 2013). Some government designed programs enhance both the problem of poor technology and poor management. However, Nkamleu et al. found that Ghana's technical efficiency is still the lowest in the region and that both technology transfer should be encouraged across the region, as well as improved farmer know-how. In response to that, the government of Ghana has encouraged adoption of technologies such as fertilizer and pesticides, and adoption of improved planting materials, such as hybrid seedlings (Nkamleu et al. 2010). Further efforts to enhance farm efficiency have addressed farmer management practices, namely Ghana has boosted their extension officer efforts in reaching out to more farmers and training them on good agricultural practices (Onumah et al. 2013).

Factors that were found to significantly reduce technical inefficiency were farmer experience, group support and extension visits (Onumah 2013). Besides aging trees, female farmers were also found to be less technically efficient, partially because they have multiple roles in a household and community, but also because they are more credit constrained than men in Ghana (Onumah et al. 2013). We can argue that our study on savings on the efficiency of cocoa farms can improve both the problem of aging trees and credit constraints of female cocoa farmers. If a tree takes 6 years to reach its full productivity, cutting down an old tree to plant a new one and wait for 6 years has a high opportunity cost to an old tree that still produces some income for a farmer. If a farmer has savings to smooth consumption over time, he might be in a better position to bare the risk of planting a new tree and forgo income from

replacing an old one. Likewise, if a female farmer is more credit constrained than their male counterparts, encouraging women to save could offset a part of this problem.

4.4.2. Cocoa farmers in this study

This study is conducted on a group of farmers from one cooperative from the Eastern Region of Ghana. This is one of the highest cocoa producing regions in the country, however, with decreasing returns to scale in conventional cocoa production (Onumah et al. 2013). The cooperative, Fanteakwa Union, has approximately 2,200 members dispersed over 25 communities. Fanteakwa Union is Fairtrade certified. This means that farmers have already gone through extensive training on good agricultural, environmental and social practices, which are designed to enhance efficiency, and social and environmental impact of cocoa production, respectively. Besides organizing farmer training through extension officers, Fanteakwa Union coordinates certification and value-chain collaboration, including access to enhanced input technologies. The cooperative is considered well managed relative to existing grouping mechanisms in Ghana. However, despite their organisation, access to productive inputs, such as hybrid seedlings and fertilizer subsidized from the government is still quite low. Fanteakwa Union received 165,600 free hybrid seedlings from Tree Global, Mondelez-subsidized improved seedlings between 2016 and 2018, which were delivered directly to farmers upon payment of transportation fees or pickup at the seedlings garden. Moreover, the cooperative also received 120,000 free hybrid seedlings from the government where, again, farmers had to either pick up the seedlings at a local seedlings garden or pay for transportation fees. Finally, the cooperative received only a few dozen bags and bottles of free fertilizer from the government, and those were delivered directly to the cooperative headquarters. However, not more than 26% of cooperative farmers have had any access to hybrid seedlings[7], and around 50% of cooperative farmers are estimated to have had access to some form of fertilizer[8]. One of the impediments to farmers' access to inputs was not meeting the requirements of inputs access. Namely, the government issued a policy for free access to hybrid seedlings only for farmers who have had their farms mapped and who have cleared sufficient land for new seedlings. Farm mapping is one of activities that is supposed to be taken up by the government extension officers, however, the availability of that service also varies significantly.

Looking at access to formal savings, we find that about 55% of Fanteakwa Union farmers are having access to a formal bank savings account. From those who have a formal savings account, almost 90% have some savings on that account. When asked about what they use the bank savings for, at least a third of the farmers responded that they use it for cocoa farming investments. The other uses of formal bank savings include savings for school tuition fees (16%), home improvements (12%), non-farming

[7] See the Appendix, survey Module 6 on Farmer services, question 611
[8] See the Appendix, survey module 6, questions 603 and 604

income generating activities (8%) and self-insurance (8%). Less then 1% reported they use bank savings to keep money in a safe place, away from other people. As suspected, savings accounts are predominantly used to generate lump-sum savings for cocoa or other investments, and in that way have the potential to replace the need for credit.

4.4.3. Survey, variables and descriptive table

From the 2200 farmers in Fanteakwa Union, we had randomly selected 1503 farmers dispersed over 22 communities based on a full list of farmers made available by the cooperative management. The farmer survey was conducted between February and April 2016. The survey consists of a few modules, namely household composition, assets and standards of living, financial and savings data, cocoa farming information, non-cocoa income-generating activities, services offered by the government and social capital. For more details, see the Appendix. Surveys were conducted in person in Twi, the local oral language.

4.4.1. Variables description

Table 1 below summarizes descriptive statistics of variables used in this study across the two groups of farmers – one with access to a formal savings account, and one without. *Demographics* refers to general control variables. Gender is a binary variable with 1 being woman. Age and faring experience are noted in years.

Table 1: Comparing farmers with and without access to formal savings

Independent variable means… *(n=1501)*	**… for farmers with access to savings *(n=822)***	**… for farmers without access to savings *(n=679)***
Demographics		
Gender	.28***	.39
Age (years)	.55	.55
Farming experience (years)	16.9***	14.6
Capital		
Labour expenditure (GhC)	893.3***	1074.5
Nr household members >18	3.6**	3.3
Access to seedlings[1]	.3***	.2
Access to fertilizer[1]	.6***	.4
Mist-blower	.3***	0.2
Knapsack sprayer	.8***	0.7
Farm size (acres)	8.0*	7.3
Mapped farm[1]	.34	.34
Uncleared land[1]	.13	.15
Nr of trees >25y	58.0*	26.1
Risk management strategies		
Other farming activities[1]	.82	.81
Non-farming activities[1]	.48***	.40

Health Insurance[1]	.92	.86
Total income (GhC)	6234.4***	5367.2
Shocks in the last year		
Drought, flood, bushfire etc. [1]	.38	.35
High levels of pests & diseases[1]	.44	.43
Debt		
Loan (general) [1]	.22***	.12
Bank loan[1]	.05***	.01
Group loan[1]	.01	.01
Money-lender loan[1]	.02	.02

*** p<0.01, ** p<0.05, * p<0.1. 1 - Binary variables. Source: own survey.

Capital Includes expenditure on capital, such as labour (hired labour is measured in local currency expenditure, and family labour in number of family members older than 18). *Access to seedlings* and *access to fertilizer* are binary variables defining whether farmers have access to hybrid seedlings and fertilizer, respectively, provided with subsidies through the government. Mist blower and knapsack sprayer are used for inputs pesticides application, measured as binary variables. Variable farm size is measured in acres. Mapped farm and uncleared land are binary variables measuring whether the farm has been mapped by extension officers, and whether the farmer has cleared the land to plant new seedlings, respectively. Finally, the number of cocoa trees is also a measure of farm capital; however trees older than 25 years yield few cocoa pods.

Risk management strategies refers to activities or assets that leverage income fluctuation. We use other farming activities, non-farming activities and health insurance, all as binary variable indicating availability of each. Total income is a measure of self-reported income in local currency across all income-generating activities.

Regional *shocks*, such as drought, bushfire, floods etc., as well as crop-specific shocks, such as disease outbreaks, are binary variables.

Finally, we look at *debt*. We first ask farmers whether they have an outstanding loan (loan general); then whether they have a bank loan specifically, or a group loan, a loan from local money lenders. They are all binary variables.

While we cannot draw any causal conclusions, Table 1 clearly shows that farmers with access to savings, as compared to farmers without access are more experienced , have better access to seedlings and fertilizer, have bigger farms, have more trees and have larger loans. As access to modern seedlings, fertilizer and loans may all contribute to more efficient and better technologies, this provides a first indication of a positive association between access to savings and technical efficiency.

4.5. Methodology

The stochastic metaproduction frontier model, defined as the "the envelope of commonly conceived neoclassical production functions" was first introduced by Hayami (1969), and Hayami and Ruttan (1970). The approach is theoretically attractive because it assumes that all firms potentially have access to the same technologies, but that each may choose a particular technology depending on for example endowments, relative prices and other specific circumstances. A metaproduction frontier approach thus allows for situations where several groups in a certain industry have different stochastic frontier production function models, which enables to differentiate between inter- and intra-type technological inefficiencies. Intra-type efficiency refers to the efficiency of a farmer relative to its own production frontier; intertype efficiency is the efficiency of the farmer relative to a best practice frontier. The technique also provides an estimate of the difference in technologies between a certain group of farmers and the metaproduction frontier. In our study, we hypothesize that cocoa farmers with access to formal savings use a different technology than cocoa farmers without access to formal savings, i.e. the stochastic frontier production function models vary for the two groups. The metafrontier approach is also empirically attractive because it allows for pooling of data from farmers with access to different resources and technologies, and thus production frontiers, and it attempts to create a common underlying production function while increasing the degree of reliability of the estimated production function (Lau & Yotopolous 1989). However, estimating a firm meta-frontier by pooling data from different groups of firms lacks justification, because the relative efficiency scores are evaluated based on different productivity frontiers (Huang et al. 2014). A methodology designed to overcome this problem has been elaborated by Battesse & Rao (2002), Battesse et al. (2004) and O'Donnell et al. (2008), where the authors propose a two-step approach to estimating the meta-frontier. First define the stochastic frontier of each group, and then estimate a group-specific frontier using linear or quadratic mathematical programming to estimate the meta-frontier. However, the linear or quadratic nature of this second step of meta-frontier analysis could result in no statistical properties (Huang et al. 2014). Moreover, this approach does not take into consideration different production environments or potential idiosyncratic shocks (Huang et al. 2014). In this chapter we use the two-step estimation approach, but in the second step we use the methodology developed by Huang et al. (2014), which proposes a mixed approach of deterministic meta-frontier programming approach. The benefits of using this methodology is that it applies maximum likelihood method to estimate the meta-frontier regression, as opposed to bootstrapping used in mathematical programming. Second, this proposed meta-frontier approach treats technology gaps as one-sided error term, which allows us to separate random shocks from technology gaps and environmental variables beyond firm control (Huang et al. 2014).

We now apply this in the context of cocoa smallholder farmers to test how access to formal savings enhances access to a different sets of productive technologies, by using meta-frontier analysis. Access to technology in this case is defined by the type of inputs used and how they are converted into outputs. Our first step is to split our sample into two groups, one with access to a formal savings account and one group without access. For each group we estimate a production function of the form:

$$ln(y_{i,g}) = ln(x_{i,g})\beta_g + \epsilon_{i,g} \quad (1)$$

where *y* is the output, *x* a vector of inputs, beta the parameters of interest, and epsilon the error term. Groups and individuals are denoted with *g* and *i* for farmers with access to a formal savings account and farmers without access, respectively. Since technology can change per group, the beta is estimated per group. This equation looks similar to an OLS equation. However, the error term epsilon in our case is composed out of two parts, a symmetric error and a non-negative technical inefficiency term, as originally proposed by stochastic frontier function (Aigner et al 1977, Meeusen & van den Broeck, 1977):

$$\epsilon_{i,g} = v_{i,g} - u_{i,g} \quad (2)$$

where *v* is normally distributed in line with the Ordinary Least Squares (OLS) regression with all observations close to average. Contrary to OLS, the *u* term has a non-negative distribution. Since *u* is always positive and it is subtracted, it captures the possibility of inefficiency where some individuals are producing less output due to inefficient use of inputs.

The equations above allow us to estimate the production frontiers and efficiency level per individual, which further enables us to check whether the estimated betas of the two groups differ. If betas are different across the two groups, we can conclude that the groups use different technologies. However, this does not tell us if one technology is indeed (partially) superior to the other technology. The methodology developed by Huang et al (2014) provides insight into the superiority of one meta frontier, or technology, over another. The idea behind this is to construct a frontier that envelopes both production frontiers of the two groups. The first step is to take the expected production of individual farmer groups using their respective inputs and estimated betas; and then regress those expected productions against its inputs for both groups together.

The newly established meta frontier allows us to check how far each individual is from the overarching meta-frontier technology. If one group is closer to the meta frontier than the other, it is highly likely that the group is using a superior technology. We firstly specified the equation form (1), and assumed a Cobb Douglas production function that is constant returns to scale. I.e. if all inputs double so does output.

As pure inputs we have chosen the number of adults per household and the total area of land used. As a technology changing factor, we have the availability of a blower and quantity of fertilizer used (both in kilograms and litres). We avoided using cutlasses and pod breakers, which were used by Onumah et al. (2013) in their cocoa meta-frontier study, as we gave those inputs out to farmers interviewed as a token of appreciation for participating in the survey. The reason why we decided to exclude the type of planted seedlings (self-grown versus hybrid seedlings) in the technology changing factor is that we only have information on the type of seedlings that were planted the year before farmers were interviewed. The type of seedlings planted over the last year will not differ in output because neither bares any fruit the first minimum 2 years of planting. As such, we cannot use them to measure the impact of different technologies on efficiency, but we can add them to control variables, because planting seedlings negatively impacts land productivity the first couple of years at least, due to old trees being cut down with low, but some productivity, and due to less labour available. The latter is under assumption that labour consists of the number of adults per household. Furthermore, instead of log-functions of fertilizer, we used translog functions because there were a lot of zero-values. The translog function and the graph below assume constant returns to scale.

The output is measured by the number of kgs of cocoa per number of adults in the household. Formally our estimated equation looks like this:

$$\ln(cocoa/adults) = \beta_0 + \beta_1 \ln(surface/adults) + \beta_2 blower + \beta_3 \ln(surface/adults) * blower + \beta_4 fertilizer_{bottles} + \beta_5 fertilizer_{bags} + \beta_6 \ln(surface/adults)^2 + \beta_7 \ln(surface/adults)\, fertilizer_{bottles} + \beta_8 \ln(surface/adults)\, fertilizer_{bags} + \epsilon, \quad (3)$$

where β_0 is the constant, $\ln(surface/adults)$ is the translog function of farm size per adults in a household; and the rest is self-explanatory.

After estimating equation (3) for both groups of farmers and their respective meta frontier, we can estimate the technical efficiency (TE) of each farmer relative to the group frontier, as depicted in the graph below:

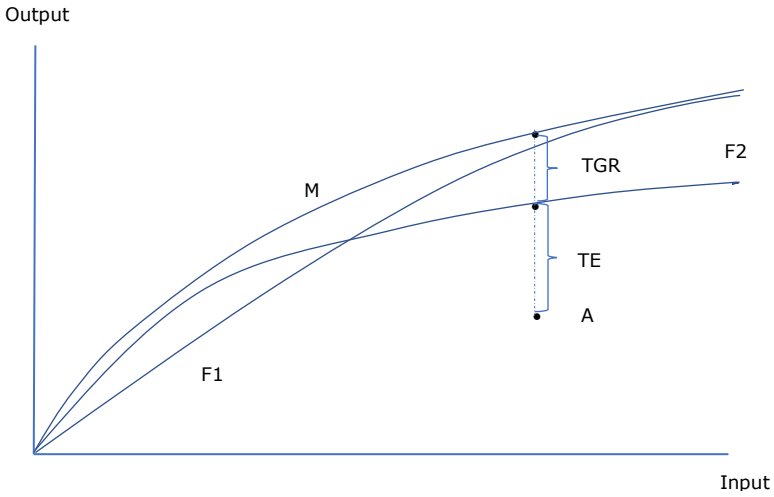


Figure 1: Technical efficiency

The graph above depicts two curves with different inputs. Assuming capital as input, curve F1 shows the maximum possible output for farmers who have access to a savings account, and consequently access to a different set of technologies. F2 depicts the maximum production function for the group of farmers who are savings constrained. A farmer can produce at most the quantity determined by this production function. In cases of inefficiency a farmer can of course produce less, which is depicted by point A in the graph. Both production functions start at the origin, which is implied by a Cobb Douglas or Translog production function. M is the meta-frontier that envelopes both production functions.

There are three important variables to determine:

(1) *Technical efficiency of a farmer in group j relative to the stochastic production frontier of group j (TE)*.

In our case, technical efficiency of a farmer with (without) access to savings relative to the stochastic production function of farmers without (with) access to savings. More formally it is defined as the actual output that is produced over the output that could have been produced if the farmer is fully efficient, calculated by:

$$E\left(e^{-u_{i,g}}|\epsilon_{i,g}\right) \quad (4)$$

We need to estimate this based on epsilon, since we do not observe -u in equation (2) directly. We take the exponential of -u since we measure the outputs in logs. TE is 1 if a farmer is at his maximum fully efficiency within the given set of technologies/ inputs used. and theoretically zero if infinitely inefficient. In Figure 1 the graphical representation of this is given by the difference between point TE and the production function F2. The farmer that stands at point A is producing at a suboptimal point,

less than what could have been produced according to production function F2. The technical efficiency as provided in Equation (4) is equal to one over the distance of point TE and the point on frontier F2.

(2) *The ratio of the output for the production function for the jth group relative to the potential output defined by the metaproduction function, for given inputs, the Technical Gap ratio (TGR)*.

TGR thus measures the distance between a farmer's production function and the meta frontier. In our case, the distance, between the production function of farmers with (without) access to savings and the meta frontier. Formally TGR is calculated like equation (4) but now the epsilon is based on the second step where we used the fitted values to estimate equation (1). TGR value will be equal to 1 if the frontier the farmer is using is identical to the meta frontier; and move towards 0 the further the two frontiers are from each other**.** In Figure 1 this is graphically represented by the two points close to label TGR. The definition of TGR is identical to 1 over the distance between these two points.

(3) *The technical efficiency of farmer j relative to the metafrontier, the metatechnology efficiency (MTE)*.

In our case, the technical efficiency of a farmer with (without) access to savings relative to the metafrontier. Formally it is estimated by the following formula:

$$MTE = TE * TGR \quad (5)$$

In Figure 1 this is represented by one over the distance between the point labelled with TE and the corresponding point on the metaproduction function M.

4.6. Results

Before we focus on the technical efficiencies, the technology gaps and meta efficiencies of the two groups of farmers, we need to check whether the two groups of farmers operate on the same efficiency frontier. Only if the two groups of farmers do not operate on the same production function, the metaproduction function approach is relevant. We test this by estimating a frontier for each group separately and a frontier for both groups together. We apply a likelihood ratio test to check the likelihood of the pooled frontier, and the combined likelihoods of the frontiers of the constrained and unconstrained farmers. The first likelihood test shows that we can reject the null hypothesis at one percent level, meaning that the farmers do not operate on the same frontier[9]. We do want to emphasize that efficiency (u) plays an important role for determining the deviation of a farmer from the frontier. However, there is also quite some noise (v) involved. Moreover the frontiers of the two groups are significantly different from each other (at 1 % level) based on a likelihood ratio test.

[9] The results of the frontiers are provided in the Appendix.

The results of the combined, meta efficiency analysis are given in Table 2. In order to compare technical efficiency (TE), the technology gap ratio (TGR), and meta technology efficiency (MTE) of the constrained and the unconstrained farmers, we provide several percentiles, the mean, min, and max of the several types of efficiency.

The table shows that the technical efficiency (TE) of farmers with or without access to savings is quite similar. All percentiles are close to each other. This suggests that having access to savings does not affect a farmers' ability to use the technology available to her more efficiently. In other words, a farmer with access to savings may use a different set of technologies than a farmer without access to savings, but both types of farmers have similar efficiency levels relative to their own stochastic production frontier. Yet, if we consider the "average" farmer for both groups, by comparing means than it appears that farmers with access to savings have a significantly higher TE than farmers without access to savings (t value of -2.4670).

Table 2: Meta efficiency results

	TE		**TGR**		**MTE**	
	Not-Access Savings	**Access Savings**	**Not-Access Savings**	**Access Savings**	**Not-Access Savings**	**Access Savings**
p1	0.394	0.399	0.583	0.780	0.248	0.365
p5	0.550	0.582	0.741	0.901	0.458	0.536
p10	0.618	0.640	0.782	0.915	0.525	0.601
p25	0.687	0.705	0.825	0.944	0.587	0.665
p50	0.748	0.758	0.890	0.960	0.654	0.718
p75	0.794	0.795	0.949	0.967	0.711	0.761
p90	0.820	0.826	0.978	0.974	0.754	0.793
p95	0.836	0.839	0.982	0.979	0.782	0.804
p99	0.858	0.865	0.987	0.985	0.826	0.836
mean	0.727	0.739	0.877	0.949	0.639	0.702
min	0.170	0.212	0.001	0.488	0.001	0.194
max	0.888	0.879	0.995	0.991	0.857	0.862
sd	0.096	0.087	0.098	0.042	0.109	0.089
N	627	776	627	776	627	776

However, and maybe more importantly, the table also shows that technology gap ratios (TGRs) are closer to one for farmers with access to savings relative to farmers without access to savings. This suggests that farmers with access to savings are using a technology that is closer to the optimal technology, as defined by the meta frontier. The mean of TGR for farmers with access to savings is also significantly higher than the mean of farmers without access to savings (with a t-value of -18.5).

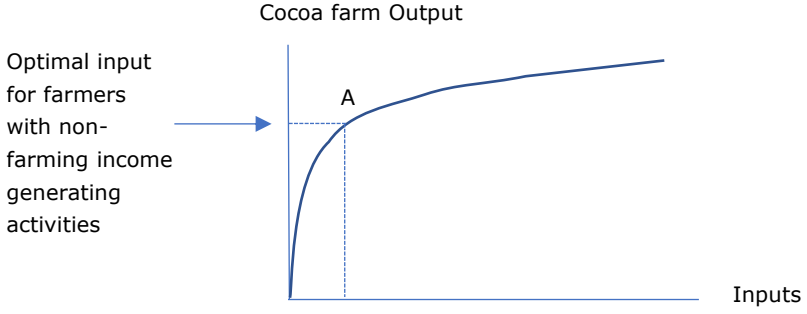
Not surprisingly, also the MTEs of farmers with access to savings are higher than those of farmers without access to savings. The mean of MTE for farmers with access equals 0.702, whereas that of farmers without access equals 0.639 (the difference is statistically significant with a t-value of -11.8).

4.7. Conclusions

In this chapter we have provided new evidence that cocoa farmers in Ghana with access to savings use different technologies than farmers without access to savings. The results suggest that access to savings, via various channels, enables farmers to increase the adoption rate of technological innovations and/or increase input quality. Overall, this article adds to the increasing evidence of the importance of savings.

Our findings can be interpreted in three ways. One is that farmers with access to savings operate closer to the optimal efficiency frontier which combines both input technologies used by farmers with access to savings and farmers without access to savings. Here we can argue that having savings allows farmers to purchase inputs and make farm investments necessary to increase output and efficiency close to optimal. This could mean that savings enable farmers to top up small loans to make larger investments on their farms. This indirect effect may be critical, as the small credits provided to smallholders rarely are substantial enough to finance larger, more productive, income-generating investment projects. Another indirect effect on savings could be in line with the findings of Dupas & Robinson (2012) who argue that savings are an effective way of smoothening consumption, while smoothening consumption leads to efficiency gains (Fletchner et al. 2010). These are both arguments in favour of farm investments.

The third, alternative way of looking at improved efficiency is that increased savings lead to a reduced output of cocoa farms but higher efficiency, which is also still in line with the theory. Lower productivity does not necessarily mean lower *efficiency* of production. The former is measured as total output in tons of cocoa beans produced, whereas the later as tons of beans produced *relative* to inputs used. As mentioned earlier in the literature review, savings can help farmers search for more financially rewarding forms of employment (Christen and Mas, 2009, Hulme et al. 2009). “By saving small amounts over time, [micro-entrepreneurs] can invest in new tools and businesses to improve their productivity, and can afford to search longer for more productive forms of employment” (p.276, Christen and Mas, 2009). Putting that in the context of cocoa farmers, access to savings allows farmers to either invest in improving the existing technologies on farms, like mentioned earlier, or alternatively,



invest minimum labour input to harvest cocoa from the existing trees, while focusing most of their remaining capital (savings, family labour etc.) on generating new sources of income. This option is quite viable, given that cocoa is a tree crop which produces some output even without farm maintenance. In that case, the crop is a source of income even when the only inputs involved are family labour and existing land. In this case, if a farmer diversifies his income to non-farming activities, his opportunity cost of having a cocoa farm is minimal given that he does not need land for alternative farming. In that case, our findings would show that increased savings actually reduce the output of cocoa, but still increase the efficiency of farmers' resources, given persistent output despite minimal input (see the figure below). Then the optimal point of production of cocoa is point A. Another quite viable and common option for divesting from cocoa farming and investing in more lucrative forms of employment is to lease the cocoa farm in share-cropping agreements. If a farmer leases land in share-cropping agreements, then the only input he has in his efficiency equation is land. Labour for farm maintenance and harvest are provided by the share-cropper, and the proceeds are split between the land owner (1/3) and the share-cropper (2/3)[10].

Further research is needed to better understand the reasons behind more optimal efficiency of farmers with access to savings accounts. When considering investing in input technologies to improve the efficiency of their cocoa farms, farmers do not necessarily look for ways to increase the efficiency of cocoa production – rather, they look how to optimize the efficiency of their total resources – on farm and off farm. This study only addresses the efficiency frontiers of cocoa farmers' *cocoa* output based on access to savings. It would be useful for policy makers within the cocoa sector to look at a broader picture of income-generating activities of cocoa farmers. This more holistic view would take into consideration that farmers' main objective is not to increase efficiency or output of cocoa – their main objective is to increase income and well-being. All the existing initiatives geared towards increasing the efficiency of cocoa farms should rather look at farmers' available resources (including savings) to determine what changes are necessary to make cocoa more lucrative business for farmers – relative also to alternative farming or non-farming income generating activities. One especially important policy concern worth while studying in more detail is farmers' decision making process on whether to invest to produce more or divest from cocoa to switch to other income-generating activities. Looking at this in more detail would be of unprecedented value to policy makers, given that producing-country governments across West Africa, as well as a myriad of NGOs have been trying to increase the efficiency of cocoa farmers in the region for decades. Understanding this decision-making process

[10] There are also cases where the land owner provides land and input, and the share-cropper all the labour. In that case the proceeds are split 50%-50%.

would help them direct their policies more effectively towards achieving increased efficiency of cocoa farming.

We would also like to recommend further research to determine how share-cropping agreements affect efficiency of farmers with access to savings. Our current analysis lacks insight into that. While our results strongly suggest that access to savings indeed may help to improve the efficiency of cocoa farms, it should be noted that our identification strategy does not fully control for potential endogeneity issues, e.g. caused by reverse causalities. For example, is share-cropping the reason for savings, or are increased savings a reason why they go into sharecropping activities. This caveat should be taken into account when interpreting the results. Thus, our results should therefore not be interpreted as causal, but in terms of associations. We also face another limitation in our model due to incomplete data, especially in relation to the group support in cocoa farming and extension visits which enhance farmer knowledge on good agricultural practices. These may both be important elements in cocoa efficiency which have not been captured by our data, but have been included in some cocoa farmer meta-frontier analysis. We did, however, look at years of cocoa experience, which is a good proxy to farmer knowledge of good agricultural practices.

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4.8. Appendix

Appendix Table 1. Likelihood ratio test: Are the 2 groups of farmers on the same frontier?

	(1) Pooled	(2) Credit constrained	(3) Credit unconstrained
VARIABLES	lyl	lyl	lyl
lkl	0.387***	0.346***	0.461***
	(0.0202)	(0.0292)	(0.0290)
Assets_blower	0.264***	0.238**	0.259***
	(0.0558)	(0.0938)	(0.0693)
lkl_assets_blower	0.0102	0.0567	-0.0198
	(0.0286)	(0.0510)	(0.0348)
fertilizer_bags	0.0327***	0.0271**	0.0340***
	(0.00646)	(0.0119)	(0.00739)
fertilizer_bottles	0.0413***	0.0356***	0.0747***
	(0.00782)	(0.0113)	(0.0127)
lkl2	0.0690***	0.0597***	0.0816***
	(0.00475)	(0.00704)	(0.00643)
lklferba	-0.00419	0.00429	-0.00804**
	(0.00328)	(0.00590)	(0.00371)
lklferbo	0.00529	0.00760**	-0.0175**
	(0.00349)	(0.00344)	(0.00693)
Constant	4.744***	4.720***	4.678***
	(0.0599)	(0.0979)	(0.0874)
Sigma_v	0.546	0.565	0.529
Sigma_u	0.131	0.121	0.115
Observations	1,403	627	776

Standard errors in parentheses
***** p<0.01, ** p<0.05, * p<0.1**
p value of difference of frontiers = 0.005890

Appendix Table 2: Comparison of means

Two-sample t test with equal variances					
	Credit	**Credit constrained**	**diff**	**P larger > 0**	**P != 0**
TE	0.7394543	0.7274209	0.0120334	0.0069	0.0137
TGR	0.9485113	0.8785515	0.0699598	0	0
MTE	0.7016798	0.6389946	0.0626852	0	0

The group with access to savings has a significantly higher technical efficiency. They also have a significantly higher technology ratio and meta efficiency[11].

[11] based on 1 one sided t-test, at the one percent level.

5. The role of social capital in adoption of risky versus less risky subsidised input supplies: an empirical study of cocoa farmers in Ghana[12]

5.1. Abstract

This study evaluates the effect of social capital on farmers' adoption of subsidised seedlings and fertilizer for cocoa farmers in Ghana. We distinguish three types of social capital: network social capital, relationship social capital, and community social capital. Network social capital refers to the peer-to-peer information flow about product benefits reaching farmers, therefore closing the information asymmetry that prevents farmers from social learning about crop risk management through inputs adoption. Relationship social capital considers the role of social status in getting facilitated access to inputs through connections with extension officers who facilitate information dissemination about input benefits, and moreover potentially help bypass the government criteria in getting access to inputs themselves. Finally, community social capital concerns the community collective income, community size and reachability relative to the cooperative main office.

We find that network social capital has a significant effect on adoption of subsidised seedlings, to an extent where it allows farmers to bypass subsidy qualification criteria for access to seedlings imposed by the government. This applies even more so for group and village leaders. Subsidized fertilizer uptake, on the other hand, is less dependent on social capital. We explain this difference by the risk involved in adopting seedlings versus fertilizer. In the case of seedlings adoption, relying on information provided by the social network promotes sharing of benefits of hybrid varieties, and thus reduces the risk of its application. Adoption of fertilizer, on the other hand, is not correlated with social capital because fertilizer application is less risky to farmers. They can easily switch from using fertilizer to not using fertilizer. Access to both inputs is influenced by government inputs' eligibility criteria, namely having mapped farm. However, we find that 15% and 29% of farmers respectively have access to seedlings and fertilizer, even though their farms are not mapped. Our findings suggest that for governments to stimulate uptake of substantive inputs, such as seedlings, subsidies should coincide with attention to social capital and fair distribution of inputs.

[12] This chapter is based on a manuscript currently under review at the Journal of Rural Studies, co-authored with Lensink, R and Meuwissen, M.

5.2. Introduction

Differences in technology adoption across countries are amongst the main explanatory factors for differences in income per capita worldwide (Caselli and Coleman, 2001; Comin and Hobijn, 2004). Poverty reduction and sustainable development require an increase in productivity in the agricultural sector given that three out of four of the World's poor live in rural areas (Brune et al 2016; World Bank 2008). Increasing productivity sustainably rests its foundation on enhancing efficiency of production, especially technical efficiency. The most important factors affecting farmer technical efficiency were improved access to input technologies and improved farmer know-how (Nkamleu et al. 2010), as well as group support and extension visits (Onumah 2013). Adoption of modern technologies in agriculture, such as fertilizers and improved seeds, can significantly increase productivity (Besley & Case 1993; Just & Zilberman 1983; Simtowe 2006). Nakano et al (2018) find that adopting hybrid varieties can help farmers across Sub-Saharan Africa increase yields and reduce that productivity gap.

However, the adoption of modern inputs among African farmers remains extremely low (Foster and Rosenzweig, 2010, Gollin et al. 2005). There are many barriers resulting in low demand for agricultural technologies adoption for African farmers (see literature survey of Anderson 2003; Dercon and Christiaensen, 2011; Foster & Rosenzweig, 2010; and Magruder, 2018). Low demand for technology adoption can range from heterogeneity in perceived benefits and profitability (Foster and Rozenweig, 2010), time and risk aversion (Chetty & Looney, 2006, Dercon & Christiaensen, 2011, Emerick et al. 2016, Foster and Rozenweig, 2010, Yesuf & Bluffstone, 2012; Yu & Nin-Pratt, 2014), psychological costs of changing habits (Banerjee & Duflo, 2007), lack of liquidity, especially through the lack of availability of credit (e.g., Foster and Rozenweig, 2010, Karlan 2014, Magruder, 2018; Yesuf & Bluffstone, 2009), etc.. These were examples of adoption barriers which inhibit demand for technology adoption, and all them except lack of liquidity can be influenced by farmer sensitization through farmer training on the benefits of the use of novel farm technologies. However, farmer training is one of the supply-side driven impediment to technology adoption. The scientific literature identifies inefficient agricultural extension systems as the major supply-side related impediment to technology adoption (Dorward, 2009 and Takahashi et al., 2020). Agricultural extensions refer to both the logistical aspect of inputs delivery, as well as extension officer farmer visits to sensitize farmers on the benefits of the use of input technologies (Dorward, 2009 and Takahashi et al., 2020). The aim of this study is to test how social capital can facilitate both information and inputs dissemination.

There are a number of studies that focus on influencing the demand for farm technology adoption through social (peer to peer) learning (e.g. Barr 2000, Boahene et al. 1999, Coleman et al., 1966, Deaton, 1997, Grootaert and Bastelaer, 2002, Ryan et al. 1943). These can help farmers understand

the perceived benefits of technology adoption, overcome risk aversion, and psychological costs of changing habits, as indicated earlier. However, no studies to the authors' knowledge studies the impact of social capital on adoption of *subsidized* farm technologies. Our study focuses on adoption of subsidized cocoa seedlings and fertilizer in Ghana. Subsidizing productive inputs can potentially be important in enhancing technology adoption given that the subsidy is an equivalent to lifting farmers' credit constraints related to the adoption of inputs (Magruder, 2018). This is primarily interesting because we see the value of social capital in inputs adoption under circumstances where credit constraints on input adoption have been lifted. Lifting the financial constraints will likely result in increased demand for inputs. Social capital can then become important in dealing with the supply-side driven impediment to inputs adoption. Due to extension inefficiencies described earlier, access to inputs becomes a privilege of a few who get access to information about the benefits of using novel farm technologies, as well as timely delivery of the actual farm technologies themselves (Dorward 2009). Social capital can help with both information dissemination through peer-to-peer contact (horizontal connectedness) and getting access to the scarce subsidies at the right time through value-chain connectedness (vertical connectedness), as we will see in more detail later. Secondly, separately comparing the effect of social capital on adoption of subsidized seedlings and fertilizer is interesting for two reasons: both are free goods that require no capital investment; however, planting new seedlings has a higher risk than applying fertilizer because it requires more effort (labour hours) in clearing land and waiting for the new seedlings to bear fruit. The novel cocoa seedlings take at least 12 months to bear first cocoa pods[13]. As much as social capital has the potential to overcome extension inefficiencies by effectively disseminating information about the product benefits , the effect of social capital on adoption can depend on the risks involved and the effort required for the investment. Bonjean (2019) argues that individual utility function is a profit function that is positively correlated with production and negatively with effort. As such, farmer's utility is strictly proportional to the increase in quantity produced (no scale economies). The risk associated to planting new seedlings is sacrificing less productive old trees to plant new seedlings that take time to bear fruit, involve high effort (labour costs) and raise opportunity costs of an alternative crop that bears fruits sooner than 18 months. Fertilizer application, on the other hand, does not involve a high risk, neither does it force farmers to exert a high level of effort to increase productivity.

Another interesting reason for studying seedlings and fertilizer adoption separately is that the government banned commercial sale of seedlings, but not of fertilizer. Thus, we do not know whether there is demand for more seedlings beyond what is being provided for free, but we do find a number

[13] Information provided by seedlings suppliers. The regular pods take about 18 months, and even then are less productive than the hybrid seedlings.

of commercial fertilizer suppliers in various communities, which indicates either that the demand for fertilizer is higher than what is offered by government subsidies, or that the subsidies are not delivered effectively. If governments directly intervene in inputs markets through supply of subsidized inputs, there is a risk that the inputs do not arrive in time, in good quality, or in sufficient quantities (Dorward, 2009). Problems of timely delivery of modern inputs is seen as the most decisive hurdle to the diffusion of innovations (Bonjean 2019). It is therefore important to examine whether social capital influences adoption of subsidized inputs, assuming that farmers would adopt these farm technologies only if they arrive in time and in good quality at least, otherwise they are of little use to farmers.

Social capital is a broad concept that can be measured in various ways. In this paper, we focus on network social capital, social status, and community social capital. Network social capital refers to information flow or farmers' proximity and frequency of interaction with other individuals within a community. This type of interaction enhances peer-to-peer information sharing about the benefits of new technology adoption. As such, it can play a great role in enhancing demand for subsidized inputs, especially in helping farmers understand the *perceived benefits of technology adoption, overcome risk aversion, and psychological costs of changing habits.* Status refer to the social status and the strength of relationships across community and across the value chain[14], and their resulting access to resources. Status in this case has the potential to overcome extension inefficiencies in distributing inputs, which will help them get timely access to the right inputs. Finally, community social capital refers to the capital associated with belonging to a community, with a special focus on the community geographical location and accessibility. Both information dissemination and actual inputs dissemination can be faster in dense groups, and group location and proximity to main roads might determine accessibility to extension officers. These are explained in more detail in the theoretical framework and visualised in Figure 1 below.

[14] Value chain refers to the process of value addition from raw materials to finished product. In this case, value chain refers to the chain of actors who facilitate farmers' access to inputs and markets. Value chain actors range from input suppliers, certification managers, to produce buyers and processors.

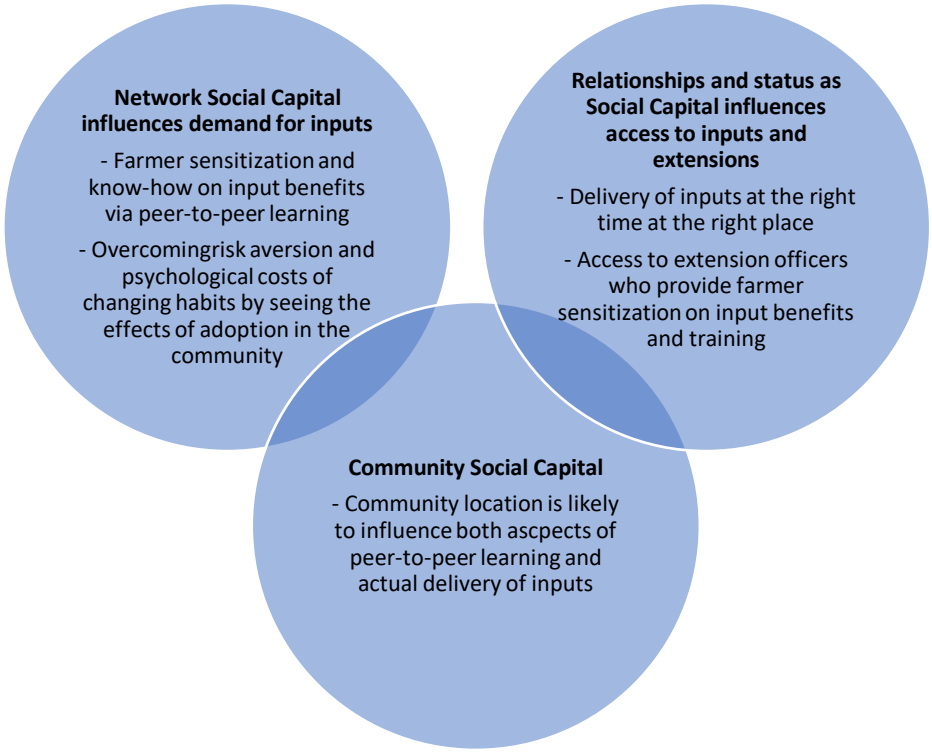

Figure 1: The expected effect of social capital on access to input supplies

Our study investigates cocoa farmers in Ghana, the second largest producer of cocoa beans in the world. An estimated 30% of Ghanaian population depends on cocoa for their income (Gockowski et al., 2011). The production of cocoa in Ghana has historically been dominated by unorganised smallholder farmers (Gordon, 1976) with averages farm sizes of 2-3 hectares (Baah et al., 2012). The large number of smallholder farmers makes the administration of input subsidies a challenge for the government. The government regulatory organisation of the cocoa industry, Cocobod, and private sector partners joined forces in Public-Private Partnerships (PPPs) to increase productivity of cocoa farmers on existing land and to increase income of Ghanaian cocoa farmers (Bitzer et al. 2012). These PPPs in various forms provide farmers with access to subsidized input supplies, like fertilizer and seedlings, and also with services, like pest control (farm spraying) and farm mapping[15]. While the government regulations and subsidies aim to enhance adoption of improved inputs, there is no evidence that these policies actually increased input use.

This chapter is divided as follows. In Section 2 we describe the existing theory of social capital and form hypotheses based on that theory; Section 3 describes the context of the study; Section 4 discusses the model, methods and variables used; Section 5 summarizes the results, Section 6 presents conclusions and policy recommendations.

[15] Measuring the exact farm size and location with a GPS device.

5.3.Theory and hypotheses

Social capital arises from non-market interaction between parties, but has an economic effect on individuals (Coleman 1994). More precisely, social capital enables individuals to access and use resources embedded in social networks to gain surplus value from their economic activities (Lin, 2017). The main sociologists that stand out in this arena of research are Coleman Putnam, Burt, Marsden and Flap, which are summarized in a recent literature review of Lin (2017) and explain agents' investment in- and economic payoffs of social capital. The study also defines social capital as a crucial part of capital, framing it as a part of neo-classical capital theory, termed "neocapital theory" by Lin (2017). Similarly to Coleman, neocapital theory describes social capital in terms of social relations that enhance access to and use of resources embedded in social networks, where the capital itself is investment in social networks.

*Network or information access as social capital. A number of researchers show that the probability of agricultural innovation adoption increases as farmers interact more and get more information about the agricultural innovation (*Banerjee et al. 2013; Conley & Udry, 2001; Dercon and Christiaensen, 2011; Feder et al. 1985, Foster & Rosenzweig, 2010; and Magruder, 2018*).* Information allows agents to discover opportunities and choices that they would have otherwise not known about. Grootaert and Bastelaer (2002) defined this positive information flow as 'cognitive social capital' which facilitates and potentially lowers transaction costs of a particular agricultural innovation. Transaction costs related to making informed choices is likewise reduced. *This information can be conveyed through observation of neighbouring farms, other group members or through extension officers.* A few economists have highlighted the importance of education and training offered by extension officers in hybrid crops adoption (Azhar, 1991; Birkhaeuser et al., 1991; Lin, 1991). However, f*armers' ability to decipher and process this information depends on the level of their skill (Hilbert 1974), which can be measured by years of experience in farming or years of education. F*armers who lack the means or capacity to acquire or decipher information through education or training turn to their social networks for information (Boahene et al. 1999, Coleman et al., 1966). Ryan et al. (1943) found that social network, specifically neighbouring farms, have a high influence on hybrid corn seed uptake in the US. Young (2009) further breaks down the influence of neighbouring farms on inputs adoption to contagion, social influence and social learning. Contagion refers to a phenomenon of people being more likely to adopt hybrid seeds if they have come in contact with others who have adopted it, a phenomenon elaborated in more detail by Centola & Macy (2007). Social influence, on the other hand, refers to farmers adopting hybrid seeds based on seeing a growing number of other people adopt it. Finally, social learning refers to adopting seeds once having seen evidence that the hybrid seed actually delivered the promised

improved yield. Nakano et al. (2018) show that farmer-to-farmer learning increases both the adoption of hybrid varieties of crops and productivity of their respective farms. Improved farmer know-how (Nkamleu et al. 2010) and group support (Onumah 2013) were also linked to higher technical efficiency.

One could argue that farmers grouped in a cooperative already have high network social capital, because of regular community meetings of the cooperative where they raise awareness of the existence and the use of farm inputs (see for e.g. Bertolozzi-Caredio et al., 2021). Moreover, all farmers in our study have already been trained on good agricultural practices as part of their certification scheme, where the benefits of using productive seeds and fertilizer are communicated to all farmers. However, one of the impediments to seedlings' adoption is higher risk aversion (Chetty & Looney, 2006, Dercon & Christiaenson, 2011), which makes farmers less willing to undertake activities and investments even when they have high expected returns (Lipton 1968; Rosenzweig & Binswanger 1993). There might be some uncertainty about the yields of hybrid seedlings, which can be overcome if farmers have more information from their peers. Given the riskiness of the investment and the opportunity costs associated with it, farmers might rely on their social networks for information before they make a decision to (re)plant a tree. Banerjee et al. (2013) highlighted the influence of "centrality" of a social network position for the information flow on access to services. They highlight that communities where leaders (self-help group chairs, shopkeepers etc.) occupy central positions in the village network, the adoption of microcredit was higher. Deaton (1997) defines social capital in terms of quality and frequency of social interaction, which can improve allocative efficiency through knowledge copying and knowledge pooling. Copying can be a one-way (non-reciprocal) communication where one group member acquires knowledge from higher-ranked members in a grapevine group model. According to Collier (2002), in smallholder farmer setting, copying is very common, as information between similar groups of people flows fast. Knowledge pooling, on the other hand, depends on reciprocal social exchange of information caused by frequent interaction with different networks (Barr 2000). Our first hypothesis tests whether increased exposure to information flows generated through frequency of interaction with various farmer groups improves inputs' adoption.

Relational status as social capital. Whereas network social capital refers plainly to the frequency of interaction with and exposure to other farmers, and seeing inputs adoption of neighbours, the relationship capital refers to the strength and nature of relationships which influences access to scarce economic goods. Whereas the former looks at frequency of interaction, the later looks at the nature of the relationship. Social capital, defined as a mix of structural, relational and cognitive dimensions of

relationships (Khayesi & George, 2011), is found to be a primary mechanism that enables individuals to mobilize resources (Adler & Kwon, 2002; Nahapiet & Ghoshal, 1998). Structural social capital looks at the types of relationships in a network, such as for example the proportion of family ties or kin members in the network (Renzulli, Aldrich, & Moody, 2000). Putnam (2000) defines 'structural social capital' as bonding and bridging capital. Bonding refers to horizontal ties (within community), whereas bridging refers to vertical connections which include ties outside the immediate community. In the context of this study, vertical connections refer to connections with other the value chain actors, for example input suppliers, cooperative management, buyers or government extension officers. Relational social capital refers to increase access to assets as a result of relationships ties (Nahapiet & Ghoshal, 1998), and reflects the form of close relationships in the network (Bolino et al. 2002). Finally, cognitive social capital arises when individuals can raise more resources as a result of relationships with individuals with shared identities, meanings and norms (Khayesi & George, 2011). Whereas network capital is associated to higher learning about a product, strong social ties can facilitate access to both inputs and information about inputs through extension officers, thereby facilitating adoption. Bourdieu (1986) defines social capital in the context of social relations that increase the ability of an actor to advance her/his interests. Ajuha (1998) measures social capital in rural Cote d'Ivoire in terms of ethnic heterogeneity Coleman (1994) explains how hierarchy, originally referred to as grapevine organisational structure, plays a critical role in decision making. There are clear signals that this form of social capital should be present in our study, given that the cooperative management distributes subsidized input supplies. Therefore, we have to take into consideration that being a member of the cooperative management team will probably significantly affect access to extension officers and inputs' benefit information. Here we see how structural, relational and cognitive aspects of social relationships as defined by Khayesi & George (2011) come together: structural from being the part of the same cooperative management team; and as such, having affective relationships within the cooperative; and cognitive by sharing the same values and identity as other cooperative management members. Putnam et al. (1994) show that greater social capital, defined as the degree of horizontal relationships, improves government efficacy in delivering services. Translated to the context of smallholder cocoa farmers in Ghana, we hypothesise that relational social capital measured in terms of social status within a community and the farmer cooperative increases adoption of input supplies (seeds and fertilizer) within the cooperative because of improved information delivery (second hypothesis). The effect of social status on fertilizer adoption is expected to be lower because it is a less risky investment.

Community social capital. One of the variables that was greatly undermined until recently, was the distinction between individual social capital and group social capital. In this recent study on social

capital theory, Lin (2017) distinguishes individual versus group social capital. This could have direct implications on access to input supplies, through both flow of information and through relationships. For example, in the context of information flows, bigger communities have a clear advantage to their smaller counterparts, because they have a broader flow of information and more agents (farmers and extension officers) involved in the information flow. On the other hand, Jackson (2010) find that group size alone does not determine information flow in the community, but rather its connectedness to external networks. If the group itself is geographically disconnected from an external network which is the source of information, information aggregation within the group remains quite ineffective. Beaman and Dillon (2018) show that less connected communities are excluded from new information diffusion.

In the context of relationships, Lin shows that collective capital within a group is more important than farmers' individual capital. Narayan and Pritchett (1999) also separate individual social capital to community social capital, arguing that "social capital may facilitate greater cooperation in the direct provision of services that benefit all members of the community" (p.4). This goes in hand with Bourdieu's (1986) structural view that social capital is represented by aggregating (1) the size of the group or network and (2) the volume of capital possessed by members (Bourdieu 1986, p. 248). However, the main assumption of Bourdieu is that community members maintain strong and reciprocal relations (a completely dense or institutionalized network), arguing that the strength of relationships within the community does not enter the equation, but rather, that it is a given. We however argue that both community social capital as well as individual relationships are important determinants of farmers' adoption of inputs. Furthermore, there are infrastructural advantages to some communities versus others, which are of course not related to individual strength of relationships, but they are community effects which influence social capital. We thus hypothesize that high community social capital increases the likelihood of adopting subsidized seedlings and fertilizer (third hypothesis). Because of lower risk of fertilizer, the effect of social capital on fertilizer adoption is expected to be lower.

5.4. Methodology and Empirical Application

5.4.1. Study context

This section summarizes the industry context to better understand the source of subsidies from Cocobod, the government cocoa regulatory agency in Ghana, and compliance criteria to getting access to inputs subsidies. Cocoa prices in Ghana have been managed by Cocobod since 1947 (Kolavalli & Vigneri, 2011, Laan, 1987, Quarmine, 2013, Ruf 2009). However, Cocobod's level of involvement with farmers in service provision as well as government tax revenue extracted from cocoa bean sales has varied over time. Government agencies have historically been involved in guaranteeing the market for

every cocoa bean produced and fixing annual cocoa prices annually (Gordon, 1976, Quarmine, 2013). This implies that the government guarantees to purchase all cocoa produced, and moreover ensures price stabilisation to protect farmers from world market-price fluctuations. Furthermore, the government has incentivized programs that increase productivity of farmers and quality of their beans. In the last decade, these efforts have been a combined effort of government and private-sector efforts (Shapiro & Rosenquist 2004). These Public-Private Partnership (PPP) programs intend to enhance farmers' adoption of inputs, such as hybrid cocoa seedlings and fertilizer, and services, such as farm mapping and spraying (pest control). The price farmers pay for receiving these services has varied to a great degree over the years. For instance, in the late 1960s, the price Ghanaian farmers received for their cocoa was less than half of the world market cocoa price (Simmons, 1976). Today, farmers receive on average around 70% of the world cocoa price (Cocobod.org, 2018; Quarmine, 2013) in return for having a guaranteed market for their beans, a fixed farm-gate price and access to free farm services, such as farm mapping and pest control, and free farming goods, such as access to free hybrid seedlings and fertilizer (Cocobod.org, 2018). However, availability of these services provided by extension officers, and availability of goods provided vary per region and even per community.

To facilitate buying of cocoa beans across the country, Cocobod issued cocoa buying licences to 28 Licenced Buying Companies (LBCs, Ministry of Agriculture, 2018[16]), but the top 10 covers 96% of the market (Baah et al. 2012). The top-10 LBCs also include the largest cocoa trading companies in the world which expanded vertically by acquiring a buying licence from Cocobod. Examples of those LBCs are Armajaro (Armajaro was taken over by Ecom in 2013[17]), Olam Ghana Limited, and *Cargill* Kokoo Sourcing Ltd. LBCs send Purchasing Clerks (PCs) directly to farm gates to purchase cocoa[18]. Cocobod Marketing Company (CMC) pays a fixed percent-based fee to LBCs, LBCs likewise pay a percent-based fee to Purchasing Clerks, and PCs pay farmers in cash, based on a fixed price set by Cocobod. The purchase system has received praise by international communities and multilateral organisations for successfully managing a complex value chain, improving farmer organisation, productivity and incomes, and limiting corruption (Kolavalli & Vigneri, 2011). This is, however, an ongoing challenge since only 12.5% of all cocoa farmers are actually organised in an association or farmer cooperative (Baah, 2012). For that reason, LBCs often play the role of a farmer group. For example, LBCs which are interested in buying sustainably certified cocoa group farmers under the umbrella of the LBC. Here farmers receive training and support in implementation of good agricultural, social and environmental practices, which ultimately helps the LBC to obtain a sustainability certificate.

[16] http://mofa.gov.gh/site/?p=11406
[17] https://www.ft.com/content/020b18d2-4ad8-11e3-8c4c-00144feabdc0
[18] For a complete list of all 28 LBCs, refer to http://mofa.gov.gh/site/?p=11406

5.4.2. Cocobod subsidiaries and their roles

Cocobod has a few subsidiaries designed to service cocoa farmers: Cocoa health and Rehabilitation Department (CHED), Cocoa Research Institute of Ghana (CRIG) and Seed Production Division (SPD). (CHED) is the unit of Cocobod concerned with control of Black Pod Disease and Swollen Shoot virus. Black pod disease is reported to cause on average about 40% of annual pod losses in Ghana (N'Guessan 2013), while Swollen Shoot virus could substantially reduce yield by about 70% (Ameyaw et al. 2014). The role of CHED is to send extension officers to train farmers on good agricultural practices, to detect and treat (spray) diseased farms, and assist farmers with replanting treated farms with disease tolerant and improved hybrid varieties (Cocobod.org, 2018). In practice, however, farmers receive only training from extension officers at best, and farmers are expected to pay a fee for training. Farmer trainings are often paid for by the LBCs from certification premiums. Certification training has also received a significant amount of foreign attention and aid in the last couple of years by a number of NGO.

CRIG and SPD develop and distribute hybrid seedlings, respectively. The distribution of seedlings takes place through one of the 27 SPD service centres across the country (Cocobod, 2018). In some cases, LBCs – usually large trading companies – finance opening and expansion of SPD service centres and scaling up of hybrid seedlings distribution. These service centres also provide a one-stop-shop for farmers where farmers can buy all their input supplies, from rubber boots and cutlasses to fertilizers and fungicides. However, farmers purchase these inputs at a cost. Only hybrid seedlings have consistently been provided for free. Farmers only had to pay for transportation costs of seedlings from the service centres to farms. Government policy on fertilizer subsidies has varied over the years, but even in years when fertilizer was subsidized, there were limited quantities of free fertilizer available, limiting farmers' access to it (Bymolt et al, 2018).

5.4.3. Cocoa farmers in this study and their access to inputs

This study investigates a cooperative of Fairtrade-certified farmers in Fanteakwa district in the Eastern region of Ghana. The cooperative, Fanteakwa Union, has approximately 2,200 members across 25 communities, with a management team which groups farmers, and coordinates certification and value-chain collaboration, including access to inputs. Fanteakwa's main long-term buyer has been Mondelez, one of the top three biggest chocolate manufacturers in the world. However, farmers do not sell produce to the cooperative or to Mondelez directly, but to LBCs of their choice. The role of the cooperative is to organise farmers and help them obtain a voluntary standard certificate (Fairtrade). To ensure certification it is necessary that all farmers within the cooperative have access to certification training on good agricultural practices, and traceability and origin paperwork. Training farmers as well as providing free hybrid seedlings is a blend of PPP efforts. Extension officers are

commissioned to train farmers by private sector partners. The role of the cooperative is further to ensure that farmers comply to extensive certification requirements of Fairtrade, and to ensure correct use of input supplies, as defined by Fairtrade requirements.

A trustworthy cooperative and good relationship with value chain partners is a classic example of high structural social capital which positively influences agricultural innovation diffusion (Putnam, 2010). However, even though the cooperative is well managed, access to hybrid seedlings and fertilizer is still very low. In the period between 2016 and 2018, Fanteakwa Union received 165,600 free hybrid seedlings from Tree Global, Mondelez-subsidized improved seedlings, which were delivered directly to farmers upon payment of transportation fees or pickup at the seedlings garden. Moreover, the cooperative also received 120,000 free hybrid seedlings from CHED where, again, farmers had to either pick up the seedlings at the CHED seedlings garden or pay for transportation fees. Finally, the cooperative received only a few dozen bags and bottles of free fertilizer from CHED, and those were delivered directly to the cooperative HQs in Osino. However, not more than 26% of cooperative farmers have had any access to hybrid seedlings[19], and around 50% of cooperative farmers are estimated to have had access to some form of fertilizer[20]. One of the impediments to farmers' access to inputs was not meeting the requirements of inputs access. Namely, Cocobod issued a policy for free access to hybrid seedlings only for farmers who have had their farms mapped and who have cleared sufficient land for new seedlings. Farm mapping is one of those PPP activities that is supposed to be taken up by Cocobod extension officers, however, the availability of that service also varies significantly.

By taking a broad look at our survey, we can obtain some preliminary information about the reasons why farmers don't have access to (more) seedlings.[21] It appears that 25% of farmers do not want more seedlings, meaning they either have sufficient access or they are not interested in uptake at all. This implies that 75% of the farmers want more seedlings. We asked all farmers who want to have more seedlings "is there something that prevents you from getting (more) seedlings?" Surprisingly, of the 75% farmers who want more seedlings, 43% answered this question with a "no". Hence, a considerable group of farmers seemingly wants to have access to (more) seedlings, but at the same time there are no clear reasons as to why they do not have access to (more) seedlings. We can only speculate about the underlying reasons. Maybe they misinterpreted the question; it may also be the case that our survey made them aware of the potential advantages of using these seedlings. If so, these farmers simply lacked information to make the optimal decision. It is also surprising that only 15% answered "Yes, but seedlings were not available." Hence, only a small group of farmers who want to have access,

[19] See the Appendix, survey Module 6 on Farmer services, question 611
[20] See the Appendix, survey module 6, questions 603 and 604
[21] See the Appendix, survey Module 6, question 611

do not get access because of a supply constraint. A larger group of farmers did not get access because either their land is not cleared (18%) or their farms are not mapped (15%). [22] This implies that around 25% of all farmers do not comply to government criteria for getting access to seedlings, by either not having mapped their farm or by not having cleared their land. However, it should be noted that the survey also shows that 15% of the farmers that have access to seedlings and 29% of the farmers that have access to fertilizer, have not mapped their farms. Somehow, these farmers found ways to come around the government requirements for access. Perhaps social capital has played a role.

5.4.4. Survey design and data collection

Our survey sample consists of 1,503 farmers from 22 communities of Fanteakwa Union cocoa cooperative in the Eastern Region of Ghana. Communities and farmers were randomly selected based on a full list of farmers made available by the cooperative management. The farmer survey was conducted between February and April 2016. The survey consists of a few modules, namely household composition, assets and standards of living, cocoa farming information, services from Cocobod, social capital, non-cocoa economic activities, and financial and savings data. For more details, see the Appendix. Surveys were conducted in person in Twi, the local oral language.

Besides the farmer survey, we also conducted at least one community-level survey per community with village chiefs or elders to get better insight into community-level characteristics, like the number of inhabitants in the community, availability of services in the community, like schools and hospitals and accessibility by road to the cooperative headquarter office. We also collected GPS coordinates of a central farmer gathering point in every community, to be able to determine distance to the cooperative headquarters.

5.4.5. Analytical model

In this paper, we use Linear Ordinary Least Squares (OLS) regression, and logit regressions to test for robustness. Our model looks as follows:

$$Y = \alpha + \beta N + \Upsilon S + \delta C + \zeta I + \phi F + \varepsilon \qquad (1) \text{ for OLS and,}$$

$$P = F(Z) = \frac{1}{1+e^{-z}} = \frac{1}{1+e^{-(\alpha + \beta N + \Upsilon S + \delta C + \zeta I + \phi F + \varepsilon)}} \qquad (2) \text{ for Logit.}$$

where Y is the dependent variable which refers to either access to hybrid seedlings or access to fertilizer. P stands for probability of getting access to seedlings and fertilizer in the Logit equation, and α is a constant. N refers to network social capital, obtained via factor analysis (see below), S is a set of

[22] Note that there is a small group of farmers that either did not respond to the question, or answered with "other reasons", which explains that the sum does not add up to 100%

binary variables denoting farmer status within community, C is a vector of community social capital, I represents a vector of farmer individual characteristics, and F denotes factor loading of farm variables (see explanation below).

5.4.6. Variables description

Seeddum and *Fertilizerdum* are dependent, binary variables defining whether farmers have access to seedlings and fertilizer respectively.

Network social capital is measured with a variety of variables: in terms of *frequency of interaction with 1) village chief and elders; 2) spiritual leader; 3) farmer group leader; 4) certification manager,* measured as interval variables with values 1 for "hardly ever"; 2 for "less than once a month"; 3 for "at least once a month"; 4 for "at least once a week"; 5 for "at least once a day"; and "." for "not applicable". These variables were then combined in one factor, using factor analysis. We assumed that all the individual variables have the same weight given that they are all important players indicating high status, or high structural social capital in hierarchical societies.

Relationship variables are measured by community status binary variables and refer to *Farmer* (only), *Village chief, Community elder, Spiritual leader, Coop executive member* (member of the executive board of the cooperative)*, Immigrant* (binary variable with values 0 for indigenous, and 1 for 1st or 2nd generation migrant). Village chiefs, community elders and cooperative executive members score high on structural social capital.

Community social capital variables used in this study are *distance* from cooperative main office (measured in kilometres via GPS coordinates), *accessibility* of these communities (dummy indicating how reachable they are by a motor vehicle), *size* of community (number of inhabitants) and total *community income*. We made a *Reachability* interaction variable from *Distance* and *Accessibility* variables, which are used as community effect proxies for community effect on social capital. This data comes from the Opinion Leader Survey – a community-level survey conducted on one or two community elders in every community where farmers were surveyed (see end of SM 4, module 1 Community Level Survey for more detail). For more details on the community distances and differences in means of access to seeds and fertilizer per community, we refer to SM 1. The other community social capital variables are *community income* and *number of inhabitants.* Community income is a sum of the cocoa income of all cocoa farmers surveyed in the village. The number of inhabitants of each community is extracted from the Opinion Leader survey.

In order to avoid omitted variable bias and to reduce selection biases, we add control variables. The control variables refer to individual characteristics, like *Gender* (0=male, 1=female), *Vehicle possession*

(binary variables defining whether a farmer has a bicycle, car, pick-up or other transportation on wheels) and *Cocoa experience*, (years of experience with cocoa farming. Furthermore, we control for *cost of labour* and *cost of inputs* specifically for land preparation before planting seedlings. Finally, we control for farm characteristics, starting with government criteria for getting seedlings, namely *Mapped farm* (0-no, 1=yes, regardless of whether the government or the farmer has mapped the farms); *Uncleared land* is a binary variable (0 – land ready, 1 – land not cleared) referring to farmers who did not get seedlings because they have not cleared land from weeds, bushes etc. This was used as a proxy to asking farmers whether they have cleared their land for seedlings. Finally, *Farmfactor* variable groups a number of farm capital correlated variables into one factor using factor analysis: cocoa farm size (measured in hectares), number of cocoa farms, total income and proportion of income from cocoa into one component. These variables were then combined in two factor variables to avoid covariance issues. See methods below.

5.4.7. Descriptive statistics of farmer and community data

Table 1 summarizes descriptive statistics of variables key to this study. Our survey shows that 26% of farmers interviewed had received hybrid seedlings, and 56% fertilizer. These figures, however, are not referring to whether these were sufficient quantities from an agronomic point of view. The table compares means of a number of independent variables for those who take up each input (seedlings, fertilizer, or both), relative to those who do not (column "did not adopt both"). Using t-tests, we found a high number of variables with significantly different means that could potentially explain farmers' adoption of seedlings, fertilizer or both. We find that the mean of all of the network and social status variables are significantly higher for those who adopt both seedlings and fertilizer. So far this is in line with our first and second hypothesis. We also find that immigrant status is associated with higher adoption of seedlings, and a significantly lower adoption of fertilizer for immigrants. This can be explained by the fact that immigrant farmers are commonly not land owners, but rather farm labourers. According to the sharecropping system in Ghana, farm labourers can take anywhere between 1/3 and 2/3s of total crop output, but they are in charge of farm maintenance, which includes acquiring seedlings for planting or replanting[23]. As for community social capital variables, we find that higher community income is associated with higher adoption of seedlings, but not fertilizer. Surprisingly, communities with smaller income are associated with higher adoption of fertilizer. Another finding contrary to our expectations is that smaller communities adopt more seedlings, but the community size has no effect on fertilizer adoption. There might be some bias in our findings given that we only have 22 communities in our sample[24].

[23] Information provided by cooperative management.
[24] There are a total of 25 communities within the cooperative.

Table 1: Descriptive statistics of farm and network, relationships and community social capital variables

Independent variables	**No seedlings (n=1115)**	**Adopted seedlings[1] (n=386)**	**No fertilizer (n=746)**	**Adopted fertilizer[1] (n=755)**	**Did not adopt both[1] (n=1271)**	**Adopted both[1] (n=230)**
- Frequency of interaction with:						
Chief	1.49	1.85***	1.5	1.67**	1.52	1.95***
Spiritual leader	2.63	2.75**	2.63	2.70	2.64	2.76*
Coop leader	2.24	2.47***	2.23	2.36**	2.26	2.52***
Certific.mngr	.92	1.04*	.85	1.06***	0.92	1.13***
- Farmer status[1]:						
Chief	1%	2%**	8%	12%***	1%	3%***
Elder	7%	12%***	7%	10**	1%	1%***
Spiritual leader	7%	10%*	6%	9%**	8%	9%
Coop leader	1%	4%***	1%	3%***	1%	6%***
Immigrant	48%	53%**	51%	47%*	49%	49%
- Community Social Capital:						
Distance (km) (min 0, max 24.82)	8.98	12.85***	9.62	10.33***	9.59	12.09***
Accessibility[1]	52%	53%	61%	44%***	47%	54%**
Community income	548,656	749,214***	732,767	663,004**	588,604	797,207***
Nr inhabitants in community	4827	3626***	4617	4422	3834	4960***
- Individual characteristics:						
Gender[1] (1-female)	36%	25%***	40%	26%***	35%	22%***
Cocoa farming experience	15.92	15.65	14.91	16.77***	15.59	17.28**
Vehicle (bike, car, pickup)	12%	16%**	12%	14%***	12%	17%**
- Farm attributes:						
Tot. farm size (ha)	7.30	8.72***	6.97	8.34***	9.38	6.77***
Nr farms	2.11	2.24**	2.03	2.25***	2.44	2.06**
Cocoa income	5245	6483***	4241	6870***	8009	4242***
Proportion cocoa income from total income	0.71	0.65***	0.67	0.73***	0.69	.68
Labour cost landprep	186.3	326.5***	172.6	272.0***	354.1	142.2***
Inputs cost landprep	118.8	170.0**	97.0	166.9***	192.7	86.56***
Mapped farm[1]	31%	41%***	25%	3%***	32%	47%***
Land not cleared	15%	10%***	13%	15%*	14%	13%

*** p<0.01, ** p<0.05, * p<0.1

1 - Binary variables

As for demographic control variables, we see a significantly lower inputs adoption for women, than for men. This could be explained by general division of tasks between men and women in cocoa, where for instance, fertilizer application is generally considered men's duty on cocoa farms (Nkamleu et al, 2007). Looking at farm-level control variables, we find that higher mean of most farm capital variables (total farms size, number of farms, total income from cocoa) is associated with higher adoption of both

seeds and fertilizer. This could imply high transportation costs of seedlings from seedlings centres to farms, or hidden fees in both seedlings and fertilizer adoption[25].

Our findings show that farmers who are slightly less dependent on income from cocoa, relative to other sources of income, have a higher adoption of seedlings and a lower adoption of fertilizer. This might be an indication that farmers who diversify income more are more willing to take the risk of planting new seedlings. We also see that immigrants have a significantly higher access to seedlings relative to indigenous farmers. Immigrants often work on other people's farms as sharecroppers, or it could be that they are turning a piece of unused land into a cocoa farm, for which they need seedlings.

Another important variable from a logistical perspective is possession of a vehicle, indicating that those with a vehicle are more likely to adopt seedlings. Finally, the only official criteria for getting seeds and fertilizer from the government (Cocobod) are having farms mapped and land cleared for seedlings. Indeed, our findings confirm that adoption of seedlings is significantly higher for farmers who have their farms mapped. Cleared land seems to be more relevant for getting access to seedlings than to fertilizer.

We find a very limited group of people who have access to both seedlings and fertilizer (n=230). It seems, however, that the means of almost all tested social capital variables is significantly different for that group of farmers. They score significantly higher on all social capital variables, with an exception to distance to community relative to the cooperative HQ. finally, higher access to both seedlings and fertilizer is associated with lower income from cocoa alone (implying potentially higher income diversification), lower labour costs and lower land preparation. These indicators should result in lower uptake of both, but the means tests show otherwise. This is an indication of the importance of social capital.

We have five groups of explanatory variables: summarized in Table 2. The choice of control variables chosen are meant to minimize the effects of factors other than the one being tested.

[25] An alternative way to explain this phenomenon is that they have higher income because they have adopted inputs in the past years and are now enjoying the benefits of higher productivity and thus, income. However, we do not have time-series data from previous years to control for this potential causality problem.

Table 2: Access to fertilizer and hybrid seedlings

Social capital variables			**Control variables**	
Network variables: Frequency of interaction with: • community chief • spiritual leader • farmer group leaders • certification manager	*Relationship variables:* • community status defined by 12 binary variables	*Community variables:* • Distance to main coop office, • Accessibility by road	*Farmer individual attributes:* • gender, • years of experience in cocoa farming, • possession of a vehicle)	*Farm attributes*: • farm capital (factor variable for farm size, nr of farms, income from cocoa farming, proportion of cocoa income relative to total income) • farm expenditure • farm map

5.4.8. Factor analysis and Principal Component Analysis (PCA) for network social capital and farm variables

As shown above, we use a variety of proxies for network social capital, who are (highly) correlated. We therefore use factor analysis to derive an index of Network social capital. We proceeded as follows. First, we conducted Bartlett's test of sphericity and Kaiser-Meyer-Olkin (KMO) test to see how suited the network variables are for factor analyses. Bartlett's test of sphericity tests the hypothesis that the correlation matrix between variables for factor analysis is an identity matrix, meaning that variables are unrelated and unsuitable for structure detection (Snedecor & Cochran, 1989). This hypothesis is rejected (X^2= 375.334, p-value = 0.000), implying that the data is indeed suitable for factor analysis. Second, we conduct a KMO test. The KMO test measures the sampling adequacy for each variable in the factor model as well as the complete model, as it measures the proportion of common variance among variables within a group. Our KMO test returns value 0.64 (>0.6), which confirms that the sampling is adequate. Third, after conducting factor analysis, we look at Eigenvalues, which is a measure of how much of the common variance of the observed variables a factor explains. If the eigenvalue ≥1 the factor explains more variance than a single observed variable. We decided to select the number of factors based on the eigenvalues greater than or equal to one, which is a common procedure (Kaiser, 1960). Our factor analysis shows that there is only one factor with an eigenvalue

close to 1 (0.78). Consequently, we only took this factor.[26] We use the standard orthogonal rotation to rotate the factor to get the best explanation on factor loadings with as few factors as possible. Finally, we use the factor loadings of the factor 'network1' as a single variable used to describe the network effect on adoption of inputs in our regression model.

Following the same method of factor and PCA analysis, we grouped *farmfactor* variables using factor analysis (with eigenvalue of 1.29). KMO value of 0.625 and Bartlett's test of sphericity (X^2= 911.663, p-value = 0.000) confirm that the farm variables were suitable for factor analysis.

5.5. Results

The results of the OLS regression using factor analysis are summarized in Table 3 below[27]. We present OLS results in the main text, for ease of interpretation, and Logit results in the Appendix. Qualitatively they provide similar results. When looking at social capital variables alone (columns 1-3 in Table 3), we find that indeed all three types of social capital are associated with higher adoption of both seedlings and fertilizer. However, when we add farmer individual characteristics and especially farm characteristics, our findings change as elaborated below.

5.5.1. Adoption of seedlings: significance of social capital and other factors influencing adoption

The network variable, measured as frequency of interaction with different community members, significantly increases farmers' adoption of seedlings. We find that among relationship variables, only being a cooperative leader is significant.

Our findings regarding the distance are surprising: we see a significantly higher access to seedlings for some communities that are further away from the cooperative headquarters, contrary to our expectations. For more details on access to seedlings per community, refer to Figure 2 and Community means tests table in the Appendix which depict which communities have significantly higher and which significantly lower access to seedlings[28]. During data collection, we also observed very poor roads for the three communities marked red in the areas close to the cooperative headquarters.

[26] Note that there are other criteria that can be used to select the factors, such as e.g. a scree plot, the proportion of variance explained by the factors, or likelihood-ratio tests. We decided to use eigenvalues as it is the most common selection mechanism. Moreover, it is a straightforward and simple method to apply. The main potential problem of using eigenvalues as the selection measure is that with many variables there is a risk of overestimating the number of factors. However, this doesn't seem to be the case for our study where only one factor has an eigenvalue of approximately 1.

[27] The OLS analysis using PCA components is summarized in Table 2a in the Appendix; The Logit analysis is presented in Table 2b in the Appendix.

[28] We also observed community-level variables grouped in one component, but found relatively weak covariance between community variables, and no significant impact on access to either input supplies.

Table 3: OLS regression results with one factor network variable

VARIABLES	(1) seeds no control vars	(2) fertilizer no control vars	(3) both no control vars	(4) seeds demograp. controls	(5) fertilizer : demogr. controls	(6) both: demog . Control	(7) seeds: incl. farm controls	(8) fertilizer : incl. farm controls	(9) both: incl. farm controls
network[1]	0.04**	0.06***	0.03**	0.04**	0.05**	0.03**	0.04**	0.03	0.02
	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)
Chief	0.12	0.12	0.24	0.11	0.08	0.22	0.10	0.17	0.20
	(0.18)	(0.17)	(0.19)	(0.19)	(0.15)	(0.19)	(0.23)	(0.22)	(0.23)
Elder	0.08**	0.09*	0.12***	0.06	0.04	.09***	0.04	0.02	0.07*
	(0.04)	(0.05)	(0.03)	(0.04)	(0.05)	(0.03)	(0.05)	(0.05)	(0.04)
Spirituallead	0.05	0.08	0.02	0.03	0.05	-0.01	0.03	0.05	0.00
	(0.05)	(0.06)	(0.05)	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.04)
Cooplead	0.44***	0.21**	0.38***	0.42***	0.17*	.35***	0.42***	0.11	0.29***
	(0.09)	(0.09)	(0.10)	(0.09)	(0.09)	(0.10)	(0.09)	(0.12)	(0.10)
Immigrant	-0.01	-0.00	-0.02	-0.01	0.01	-0.02	-0.02	0.02	-0.02
	(0.03)	(0.05)	(0.03)	(0.02)	(0.05)	(0.03)	(0.03)	(0.05)	(0.03)
Reachability	0.01**	-0.01*	0.00	0.01*	-0.01	0.00	0.01*	-0.01	0.00
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
community income	-0.00**	-0.00	-0.00	-0.00**	-0.00	-0.00	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
nr. Inhabitants	0.00	0.00	-0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Gender				-0.05*	-0.12***	-.04**	-0.03	-0.08**	-0.03
				(0.03)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)
cocoa exper.				0.00	0.00**	0.00*	-0.00	0.00	0.00
				(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
vehicle[2]				0.07*	0.03	0.07*	0.01	-0.01	0.03
				(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.03)
cost_labor							$3*10^{-4}$***	0.00	$2*10^{-4}$***
							(0.00)	(0.00)	(0.00)
cost_inputs							$-1*10^{-4}$***	0.00	$-8*10^{-5}$***
							(0.00)	(0.00)	(0.00)
farmcapital[3]							-0.01	0.11***	0.02
							(0.02)	(0.02)	(0.02)
mapped_farm							0.08**	0.16***	0.09***
							(0.03)	(0.03)	(0.02)
Unclearland							-0.11***	0.04	-0.02
							(0.03)	(0.05)	(0.03)
Constant	0.24***	0.56***	0.16***	0.26***	0.54***	.15***	0.18***	0.45***	0.09**
	(0.05)	(0.06)	(0.03)	(0.05)	(0.07)	(0.03)	(0.05)	(0.06)	(0.03)
Observations	1,312	1,312	1,312	1,297	1,297	1,297	1,066	1,066	1,066
Adjusted R-squared[29]	0.09	0.03	0.04	0.09	0.05	0.05	0.11	0.10	0.07

[29] Observe that the adjusted r-square is rather low. However, note that we were not mainly interested in getting the best explanatory power of the equation, but mainly in the relevance of the variables of interest. Note also that even when the R-square is very low, the regression model may have statistically significant explanatory power. In social sciences, where it is very difficult to specify complete, well-specified models, low R-squares are common. This is even more the case if data are

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
1.The number of observations of social status variable in question
2. Binary variable for whether farmer owns a car, bike or other means of transportation on wheels
3. Factor variable comprised of cocoa farm size (+), number of cocoa farms (+), total income (+) and proportion of income from cocoa (+)

Our findings confirm our hypothesis. Indeed, farmers adoption of subsidized seedlings is higher for those farmers who are more exposed to their network. Furthermore, we find that farmers with higher adoption of seedlings have significantly higher labour costs and lower inputs costs for land preparation. Clearing land and planting new seedlings does require significant labour, but does not require any additional inputs such as fertilizer, unlike old unproductive trees. Community distance from the HQ seems little to do with access to seedlings.

5.5.2. Adoption of fertilizer: social capital not significant

Looking at our fertilizer analysis, we find that none of the three defined social capital variable categories has a significant influence on adoption of fertilizer. Contrary to our hypothesis, neither social status nor accessibility enhance adoption of subsidized good despite potentially facilitated access to it. Unlike with adoption of seedlings, social network is less relevant when farm investments are not risky. We also find that farmers with mapped farms and higher farm capital (factor variable comprised of cocoa farm income, farm size, number of farms and proportion of cocoa income from total income) have higher access to fertilizer. The implications of these findings suggest that the government criteria for getting access to fertilizer are still more important than social capital in getting access to subsidized fertilizer. The importance of farm capital is somewhat surprising, given that the fertilizer is distributed for free. There are two ways of explaining this. On the one hand, farmers with higher farm capital own more land and therefore have greater demand for fertilizer. On the other hand, there could be hidden costs to fertilizer access, including fees and gifts to extension officers for both mapping farms and distributing fertilizer which wealthier farmers are more likely to be able to pay. Once these two variables, 'farm capital' and 'mapped farm' are added to the model, all social capital variables become insignificant. Finally, looking at other control variables, we find that women are less likely to adopt fertilizer, probably because fertilizer application is traditionally a man's job (Bymolt et al., 2018).

based on primary data collections with questionnaires. It is, for instance, well-known that studies with primary data have much lower R-square values than studies with secondary data (Reisinger, 1997).

5.6. Conclusions and policy recommendations

The aim of this study was to evaluate the effect of social capital on farmers' adoption of subsidised input supplies, namely hybrid seedlings and fertilizer. Government subsidies are an equivalent to lifting part of the credit constraints related to inputs adoption. We measure the effect of three types of social capital on adoption: network social capital, referring to the frequency of interaction that enhances information flow between farmers within a community; relationship social capital, which looks at the role of social status in distribution of government-subsidized input supplies; and finally the community social capital, evaluated through community income, size and reachability from the cooperative headquarter office.

This study has three major conclusions and policy recommendations. First, we find an important role for social capital in enhancing the adoption of inputs. However, the effect of social capital plays a more important role for seedlings than for fertilizer. We argue that this result is intuitive as seedlings involve higher risks than fertilizer. Fertiliser adoption does not pose a high level of risk as farmers can always switch back from using fertilizer at no risk, and they sacrifice no short-term income. On the other hand, whereas farmers can get free seedlings from the government for planting or replanting trees, even the hybrid seedlings take at least 1.5 years to start bearing fruits, during which farmers have no income from that particular seedling, or square meter of productive land. As mentioned earlier, one of the main seedlings adoption impediments is high risk aversion (Chetty & Looney, 2006, Dercon & Christiaenson, 2011), which makes farmers less willing to undertake activities and investments even when they have high expected returns (Lipton 1968; Rosenzweig & Binswanger 1993). The uncertainty about the yields of hybrid seedlings and its reaction to weather conditions, maintenance requirements etc. present an objective source of uncertainty, which can be overcome if farmers have more information. Given the riskiness of the investment and the opportunity costs associated with it, farmers are bound to rely on their social networks for information before they make a decision to (re)plant a tree. The existence of network social capital which improves information diffusion and social learning about the benefits of planting hybrid seedlings is bound to improve farmers willingness to adopt them. In this case, information from other farmers from the network plays a role of de-risking the investment and getting a more objective picture about its benefits before making a final decision.

Implications of this for policy makers highlights the importance of an enhancement of government extension efforts at promoting seeds through highly connected social figures in communities – individuals who will promote and "de-risk" adoption of seedlings by showing how productive these hybrid seedlings are. Network learning is a powerful way of enhancing seedlings adoption. The government could also consider alternative options to de-risking seedlings adoption – like for example introduction of subsidized insurance for farmers who plant seedlings. So far there is mixed evidence

on whether subsidized insurance is beneficial adoption (Karlan, 2014, Perez-Viana, 2019), but such intervention calls for further research for cocoa farmers specifically.

Second, we see that social status does not facilitate adoption of either seedlings or fertilizer, and neither does location of the farmer. This implies that there is little selective distribution of inputs due to distribution inefficiencies of extension officers for instance. This further illustrates that despite subsidies, reasons for low adoption remain demand driven. On the contrary, the government criteria for inputs' adoption add another hurdle to inputs adoption, and that is compliance to farm mapping and land clearing criteria. Several farmers don't have access to inputs simply because they did not comply to the government requirements. Land clearing is the responsibility of a farmer himself. However, farm mapping is a service commonly provided by extension officers. Probably, the process of farm mapping lags behind. Therefore, one policy implication encouraged would be to actively stimulate the process of mapping cocoa farms by enhancing investments in mapping farms.

Third, our regression results show that adoption of subsidized fertilizer is positively correlated with farm capital. This suggests that farmers with higher farm capital (wealthier farmers) tend to have better access to subsidized fertilizer. Partly, this may be due to demand-side effects: bigger farms need more fertilizer. However, it also signals that fertilizer subsidies may end up with the richer farmers, and indirectly may have a negative effect on income equality in cocoa communities. We also find that some farmers get access to both inputs even though their farms are not mapped. Finally, being a cooperative leader appears to be important for getting access to inputs. A well-needed policy implication of this would be stricter and more reliable accounting system of subsidies distribution in order to avoid that input subsidies primarily end up with cooperative leaders and/or the wealthier farmers. In our view, the government should play an important role in improving the accountability of the distribution of input subsidies.

5.6.1. Novelty of findings of the study

This study contributes to the existing body of literature on the role of social capital in diffusion of innovations in rural communities. High cost of innovations, or access to finance to acquire them, have always been important impediments to innovation adoption, but our study shows that uptake can be low even when the innovation is completely subsidized. Finally, our findings show the significance of social capital in de-risking of even subsidized innovations which have "hidden costs" embedded in time it takes to bear fruit of the initial investment of planting new seedlings. Finally, finding that fertilizer subsidies reach wealthy farmers opens a whole other debate about the efficiency of subsidy delivery systems in rural Ghana, which is a fruitful ground for future research on the subject.

5.6.2. Study limitations

Our study was based on a limited sample of cocoa farmers in one cooperative. It is questionable to what extent the findings can be generalised to cocoa farmers in West Africa in general. We did however look at a cooperative which is Fairtrade certified and sells cocoa directly to Mondelez. That means that they are a well organised cooperative, highly connected to buyers and markets, and are more likely to get access to seedlings and fertilizer subsidies. Many cocoa farmers in West Africa remain unorganised in cooperatives, meaning that they have an even more limited access to government resources such as subsidies.

Secondly, our findings are inconclusive with regards to causality. We cannot claim that access to seedlings is higher as a result of social capital – we can only say that they are correlated. This is because our analysis is based on a cross-sectional survey. A time series data set would contribute significantly in reducing some of the identification issues which make the findings inconclusive regarding causality. A cross-sectional dataset only allows us to observe associations or correlations between different factors.

Finally, we have limitations with regards to identification of social capital variables. Namely, our network variable is made up of a group of individual variables related to the frequency of interaction. As such, we cannot interpret individual effects of each one of these variables on access to input supplies. Also, our definition of social capital includes no references to trust. Trust creates reciprocity and voluntary associations, and reciprocity and associations strengthen and produce trust. These factors were not included in our research partially because trust is really difficult to measure. Nevertheless, future research deserves a more thorough investigation of that which our study did not address, due to data limitations.

Another data limitation to our research was assessing where the community seedlings gardens are. It could be that access to seedlings is more dependent on the location of the seedling community centres than the location of the cooperative headquarters. As such, distance to community centre could be a community social capital variable which is currently omitted. Also, a farmer's exact location in a community might have an effect on centrality of a network and consequent access to inputs subsidies. To test that, we would need to know the exact location of every farm. Unfortunately, we did not have access to that level of granularity of data.

5.7. References

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5.8. Appendix

1. Community variables means tests

Distance variable is based on distance of every community to the central community (Osino). Distances are calculated based on GPS coordinates collected at a central community gathering point in every community. Distances is measured by air, not kilometres of road.

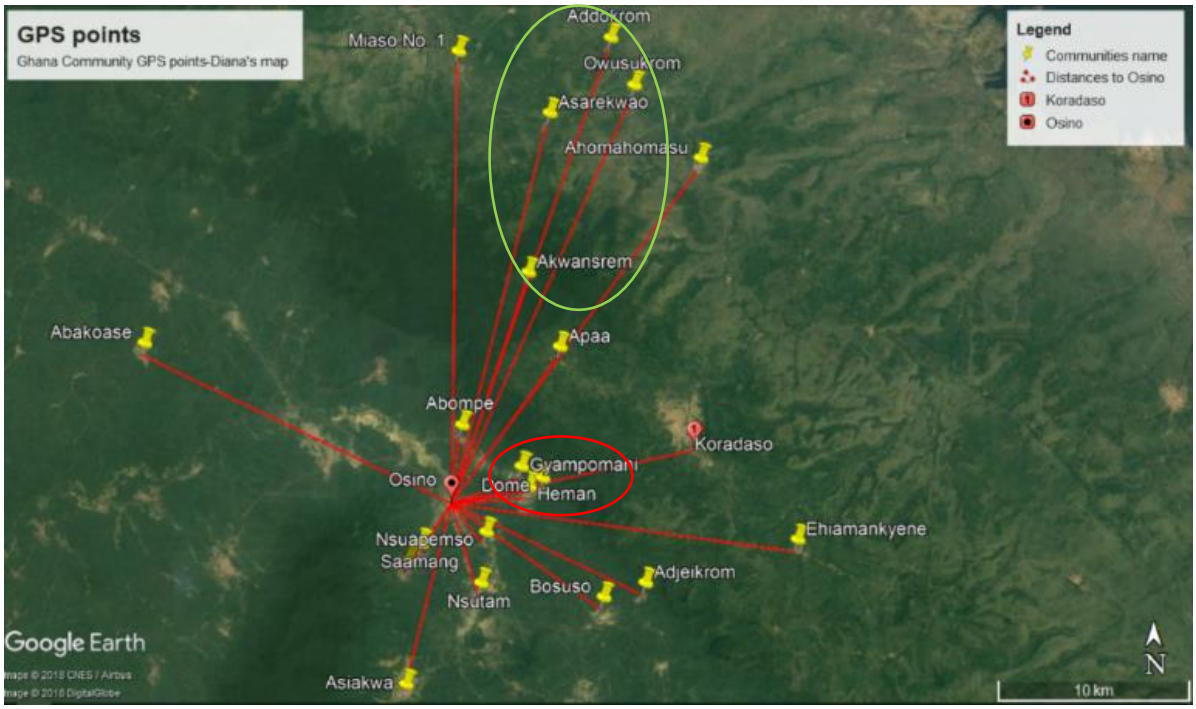
Table 1: Community means tests table

	Mean adoption of inputs per community			Accessibility[3]		Adoption of seeds		Adoption of fertiliser		Adoption of both	
	Community	Distance (km) to Osino[1]	Nr inhabitants	0[4]	1	0[4]	1	0[4]	1	0[4]	1
1	Abakoase	17.87	3092	136	0	.26	.26	.49	.63***	.15	.2*
2	Abompe	3.45	2405	0	31	.26	.23	.51	.39*	.15	.1
3	Addokrom	24.82	917	0	32	.25	.56***	.51	.25***	.15	.19
4	Adjeikrom	10.99	1340	.	.	.26	.24	.49	.70***	.15	.18
5	Ahomahomasu	21.44	1944	0	31	.26	.35	.5	.55	.15	.1
6	Akwansrem	11.95	722	0	26	.25	.54***	.5	.42	.15	.23
7	Apaa	9.26	1028	0	37	.25	.35*	.51	.38*	.14	.19
8	Asarekwao	20.16	1250	0	45	.25	.62***	.5	.73***	.16	.53***
9	Asiakwa	10.29	9172	38	0	.26	.21	.5	.55	.15	.08*
10	Bosuso	9.48	4878	159	0	.26	.27	.48	.73***	.16	.2**
11	Dome	4.62	683	0	50	.26	.18	.5	.52	.15	.1
12	Ehiamankyene	18.01	1480	91	0	.25	.34**	.51	.46	.16	.22**
13	Gyampomani	3.70	592	0	26	.26	.08**	.50	.54	.18	.04**
14	Heman	3.88	~9250[2]	0	332	.30	.12***	.54	.37***	.15	.08***
15	Juaso	4.31	1139	0	41	.26	.17*	.51	.39*	.15	.15
16	Koradaso	12.90	22421	26	0	.26	.31	.5	.65*	.15	.19
17	Miaso No. 1	22.80	796	0	30	.26	.07***	.50	.47	.16	.03**
18	Nsuapemso	2.66	633	40	0	.26	.13**	.51	.38*	.16	.05**
19	Nsutam	4.93	4722	80	0	.26	.16**	.49	.68***	.15	.14
20	Osino	__	7490	41	0	.25	.37*	.51	.41	.15	.22
21	Owusukrom	22.97	736	0	63	.24	.68***	.51	.27***	.15	.19
22	Saamang	3.19	2944	62	0	.26	.19	.51	.40*	.15	.11

1- Osino is the location of the coop main office, located on the main highway connecting Accra to Kumasi, biggest cities in Ghana
2- Estimation based on the relative number of cocoa farmers in every community to the total community population
3- Chi-sq. tabulation of number of farmers per community
4- 0 for poor access, 1 for decent access.

Figure 2: Community (air) distance to the cooperative headquarters

Communities with a significantly higher average access to seedlings are highlighted with a green circle. Communities with a significantly lower access to seedlings are highlighted with a red circle.



2. OLS using Principle Component Analysis

Table 2a. OLS with network capital reflected by two PCA components

VARIABLES	(1) seeds no control vars	(2) Fertilizer no control vars	(3) both no control vars	(4) seeds demograph. controls	(5) fertilizer: demogr. controls	(6) both: demogr. controls	(7) seeds: incl. farm controls	(8) fertilizer: incl. farm controls	(9) both: incl. farm controls
pcanetwork1	0.02***	0.03***	0.02***	0.02***	0.03**	0.02**	0.02**	0.02	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
pcanetwork2	0.01	0.04*	0.02**	0.01	0.03	0.01*	0.02	0.01	0.01
	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
chief	0.13	0.13	0.24	0.12	0.08	0.22	0.11	0.17	0.21
	(0.18)	(0.17)	(0.19)	(0.19)	(0.16)	(0.19)	(0.23)	(0.22)	(0.24)
elder	0.08**	0.09*	0.12***	0.06	0.04	0.09***	0.04	0.02	0.07*
	(0.04)	(0.05)	(0.03)	(0.04)	(0.05)	(0.03)	(0.05)	(0.05)	(0.04)
spirituallead	0.05	0.09	0.02	0.03	0.05	-0.00	0.03	0.05	0.01
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.04)
cooplead	0.44***	0.19**	0.37***	0.42***	0.16*	0.34***	0.42***	0.10	0.28***
	(0.09)	(0.08)	(0.10)	(0.09)	(0.09)	(0.10)	(0.09)	(0.12)	(0.10)
immigrant	-0.01	-0.00	-0.02	-0.02	0.00	-0.02	-0.02	0.02	-0.02
	(0.03)	(0.04)	(0.03)	(0.02)	(0.04)	(0.03)	(0.03)	(0.05)	(0.03)
reachability	0.01**	-0.01*	0.00	0.01*	-0.01*	0.00	0.01*	-0.01	0.00
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
comm_income	-0.00**	-0.00	-0.00	-0.00**	-0.00	-0.00	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
nr_inhabitants	0.00	0.00	-0.00	0.00	0.00	-0.00	-0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
gender				-0.04	-0.11***	-0.04*	-0.03	-0.07**	-0.02
				(0.03)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)
cocoa_exper				0.00	0.00**	0.00	-0.00	0.00	0.00
				(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
vehicle				0.07*	0.03	0.07*	0.01	-0.01	0.03
				(0.04)	(0.04)	(0.04)	(0.03)	(0.05)	(0.03)
cost_labor_landprep							0.00***	0.00	0.00***
							(0.00)	(0.00)	(0.00)
cost_inputs_landprep							-0.00***	0.00	-0.00***
							(0.00)	(0.00)	(0.00)
farmcapital							-0.01	0.11***	0.02
							(0.02)	(0.02)	(0.02)
mapped_farm							0.08**	0.16***	0.09***
							(0.03)	(0.03)	(0.02)
unclearland							-0.11***	0.04	-0.02
							(0.03)	(0.05)	(0.03)
Constant	0.24***	0.56***	0.16***	0.25***	0.53***	0.15***	0.18***	0.45***	0.09**
	(0.05)	(0.06)	(0.03)	(0.05)	(0.07)	(0.03)	(0.05)	(0.06)	(0.03)
Observations	1,312	1,312	1,312	1,297	1,297	1,297	1,066	1,066	1,066
R-squared	0.09	0.04	0.05	0.09	0.05	0.05	0.11	0.10	0.07

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

3. Logit output table with Factor Analysis

Table 2b: Logit output table using factor analysis for the network variable

VARIABLES	(1) seeds no control vars	(2) fertilizer no control vars	(3) both no control vars	(4) seeds demograph. controls	(5) fertilizer: demogr. controls	(6) both: demogr. controls	(7) seeds: incl. farm controls	(8) fertilizer: incl. farm controls	(9) both: incl. farm controls
network1	0.21**	0.23***	0.27**	0.21**	0.20***	0.26**	0.27**	0.12	0.28*
	(0.09)	(0.08)	(0.11)	(0.09)	(0.08)	(0.11)	(0.12)	(0.09)	(0.16)
Chief	0.62	0.49	1.35	0.55	0.32	1.20	0.57	0.76	1.31
	(0.82)	(0.71)	(0.85)	(0.84)	(0.66)	(0.85)	(1.15)	(1.00)	(1.23)
Elder	0.40**	0.38**	0.78***	0.28	0.17	0.57***	0.19	0.10	0.54**
	(0.17)	(0.19)	(0.17)	(0.17)	(0.19)	(0.15)	(0.25)	(0.22)	(0.26)
spirituallead	0.27	0.33	0.18	0.16	0.19	-0.04	0.17	0.22	0.04
	(0.24)	(0.23)	(0.39)	(0.24)	(0.21)	(0.35)	(0.27)	(0.21)	(0.38)
Cooplead	2.00***	0.90**	1.89***	1.89***	0.76	1.69***	2.04***	0.48	1.61***
	(0.45)	(0.45)	(0.39)	(0.45)	(0.47)	(0.40)	(0.43)	(0.54)	(0.47)
Immigrant	-0.07	-0.00	-0.16	-0.09	0.02	-0.16	-0.12	0.08	-0.24
	(0.16)	(0.19)	(0.26)	(0.15)	(0.19)	(0.23)	(0.18)	(0.21)	(0.29)
reachability	0.05**	-0.04*	0.01	0.05**	-0.04*	0.01	0.05**	-0.03	0.01
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
communityincome	-0.00**	-0.00	-0.00	-0.00*	-0.00	-0.00	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
nr_inhabitants	0.00	0.00	-0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
sex_Respondent				-0.28**	-0.49***	-0.41***	-0.19	-0.34***	-0.27
				(0.14)	(0.09)	(0.15)	(0.18)	(0.12)	(0.22)
cocoa_Exper				0.00	0.01**	0.01*	-0.00	0.00	0.00
				(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Vehicle				0.36**	0.12	0.53**	0.04	-0.05	0.24
				(0.17)	(0.17)	(0.21)	(0.22)	(0.22)	(0.24)
cost_labor_landprep							0.00***	0.00	0.00***
							(0.00)	(0.00)	(0.00)
cost_inputs_landprep							-0.00**	0.00	-0.00***
							(0.00)	(0.00)	(0.00)
farmcapital							-0.05	0.49***	0.24
							(0.12)	(0.10)	(0.15)
mapped_farm							0.46***	0.69***	0.76***
							(0.16)	(0.11)	(0.18)
unclearland							-0.77***	0.16	-0.27
							(0.23)	(0.20)	(0.32)
Constant	-1.12***	0.24	-1.67***	-1.06***	0.15	-1.73***	-1.54***	-0.24	-2.27***
	(0.26)	(0.24)	(0.26)	(0.30)	(0.30)	(0.28)	(0.33)	(0.27)	(0.33)
Observations	1,312	1,312	1,312	1,297	1,297	1,297	1,066	1,066	1,066

standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6. General Discussion

6.1. Introduction

The starting assumption of this thesis was that failing institutions inhibit farmers from getting access to what they needed most to thrive as farmers – technology and capital. In the introduction chapter I laid out the socio-economic factors rooted in culture and anthropology and post-colonial weaknesses in place, inferior institutions being one of them. The problem of failing institutions, especially in the regulatory and financial sector, has a direct impact on growth and advancement of the agricultural sector in Africa.

My research questions were centred around finding solutions to improve access to technology and capital within the realm of influence of smallholder farmers – in other words, despite failing institutions. We looked specifically how digital technologies can help farmers bypass failing institutions, in a way that they can get access to markets, finance and productive input supplies to become more efficient and increase income. This conclusion chapter consists of six sections. I will start with the synthesis chapter, followed by policy and business recommendations in sections 6.3 and 6.4. respectively. Section 6.5. elaborates on limitations of my research followed by recommendations for future research in section 6.6. Finally, section 6.7 summarizes my main conclusions.

6.2. Synthesis

Access to capital and technology for smallholder farmers are complex processes within food value chains. Looking at my thesis I can broadly divide the failure of smallholder farmers' access to capital and technology in two categories. The first one is addressing the issue of *supply*, or availability, of capital and technology. As such, it is of macroeconomic nature, and sheds light on institutional failures to facilitate equitable access to technology and capital for its citizens. The second reason for smallholders' failure to access capital and technology is of *demand* nature, or willingness to adopt capital and technologies. This is of more behavioural nature, and sheds light on farmers' personal choices that affect their well-being. I will proceed to elaborate on both.

6.2.1. The supply side of capital and technology: Institutional failures to create transparency

In the introduction chapter, I outlined that poor institutions result in poor management of resources, red tape, persistent corruption, conflict, etc., and are a common justification of poverty across farmlands in Africa (North, 1989, Acemoglu et al, 2005). My research sheds light specifically on institutional failures to regulate access to digital technologies and information in chapter 2, and access to subsidized fertilizer in chapter 5. But essentially, both are an issue of *transparency*. In the former case, digital technologies that I describe in chapter 2 are meant to enhance objectified transparency

of supply chains, but also smallholders' produce, operating practices, assets etc. In chapter 5, we found that subsidies reach wealthier farmers more than poor farmers, which could be an indication that institutions fail to regulate supply chain *transparency* in a way that the subsidies reach those who need them, as opposed to a few selected wealthy individuals. The institutions could also do better to improve transparency in terms of information dissemination – of, for example, the benefits of adopting subsidized inputs, where to access them and how to use them. That way they would not have to rely solely on social networks to acquire information on the value of using subsidized inputs. Furthermore, looking at chapter 5 on inputs access, we can see how transparency has the potential to create more inclusive opportunities for smallholder farmers. For example, in chapter 5 we saw how input subsidies only reach farmers with higher status. Having transparency of subsidies delivery could allow a more complete understanding of supply chain inefficiencies in the process of getting access to inputs. Having this transparency could create opportunities to enhance public service delivery across supply chains.

Furthermore, access to information increases efficiency of individual farmers, by helping them optimize the use of inputs and better manage farm risks, but also get access to the right inputs at the right time. Examples of technologies that can optimize farm management are soil sensors which collect and share soil nutrient data to a central farm management system in real time, allowing farmers to use scarce inputs more efficiently. Furthermore, even simply digitalizing data in a central database could add immense value to farmers in terms of sharing this data with potential buyers, certification auditors, lenders etc. thereby getting access to markets and finance. Transparency simply opens opportunities for farmers to be included in markets – trade markets and financial markets. And finally, blockchain can be used to increase the transparency of market transactions.

In chapter 4, we also saw how farmers operate on a higher efficiency frontier as a result of access to savings alone. If farmers could benefit from getting access to capital through savings (chapter 3), access to timely information about input supply subsidies (chapter 5), combined with transparency of for instance digital land titles, or digital certification, or blockchain for transactions (chapter 2), it is not hard to imagine that the efficiency gains could push these farmers on an even higher efficiency curve. Having more transparency in global commodity supply chains would reduce the information asymmetry between farmers and markets, enhancing efficiency. Farmers would benefit from having an opportunity to access more markets, inputs and finance which is likely to not only increase their own operating efficiency, but potentially also increasing markets efficiency by enhancing food security and reducing food waste.

More transparency is needed to establish an inclusive business environment for farmers to thrive as farmers – this includes access to timely information about existing input subsidies but also access to

markets to match supply and demand more efficiently. If we want to farmers to stay on farms, we have to create inclusive opportunities for smallholders to be integrated into markets in a way that their economic activities can benefit the business community while enabling the poor to move out of poverty. This means helping farmers to become competitive in local or international markets through more transparency in marketing, enhancing smallholders' production capacity and reducing farming cost by facilitating access to input subsidies and thus enhance farm efficiency..

6.2.2. The demand side of capital and technology: the willingness to adopt capital and technologies

Insufficient access to capital and technology is not only a result of failing institutions or unregulated markets. My research sheds light on some reasons why farmers choose not to adopt input technologies which would enhance their well-being, even when these input technologies are available. Poor institutions and opaque food supply chains are not within smallholders' realm of power. Adoption of mobile banking – on the other hand – is, together with novel seedlings, fertilizer, and savings accounts. In chapter 3, we studied the uptake of pension savings accounts in regions without existing public pension schemes. Furthermore, we saw how the government provides free (subsidized) hybrid seedlings engineered to enhance productivity of cocoa farms; yet, their adoption remains low.

I discussed the potential of digital technologies as a beacon of hope for the African continent, as they have the power to overcome information asymmetries and concentrated market power. However, technology adoption, whether we are talking about digital technologies, or high-yielding seedlings, or savings accounts, is a result of complex individual, social, cultural and economic factors which influence farmer decision-making in a given context. In an effort to better understand farmers' adoption of innovation, I'd like to bring forward a marketing theory of product adoption stages: the theory of reasoned action – TRA – first developed by Fishbein & Ajzen in 1967. TRA argues that the process of adoption of anything (product, technology…) is a process which consists of two stages: first stage is referring to how individuals acquire information and form an *attitude* about a product through their network of friends; and second, how that attitude of informed individuals endorses actual *behaviour* towards product adoption. In chapter 5 where we analysed the effect of social capital on adoption of input subsidies, I evaluated exactly the aspect of *attitude* formation about a product/innovation, in this case, seedlings. We saw the significance of social networks in innovation adoption which entail certain risks and opportunity costs. Current literature continues to emphasize the importance of social network targeting in product adoption, especially in developing country context (e.g. see for example Kim et al., 2015). The social context allows farmers to build an informed opinion about a product, and according to Krishnan & Putnam (2013), these social contexts determine adoption of fertilizer and seeds more than efforts of extension agents.

If the first step described by TRA is influencing the *attitude* of consumers (smallholder farmers in our case), the second step is influencing *behaviour* (i.e. product/technology adoption). In chapter 3, where we discuss the long-term savings, we evaluated the second stage of innovation adoption of the Theory of Reasoned Action, which is the actual act of adoption behaviour. This is where the reasons behind low adoption rates of more microeconomic nature become evident, namely farmers' lack of incentives, optimization of scarce resource in face of uncertainty, and consequently, inertia to move towards a positive change. I will proceed to describe each in more detail.

Lack of incentives. In chapter 2, we see that farmers with access to diversified source of income and existing savings have a higher likelihood of adoption of a flexible pensions' savings account. It makes sense that this particular group of farmers has higher adoption rates, given that they have more income diversification, but also needs to maintain flexibility in managing income shocks by choosing a flexible savings account. We also see how farmers who have experienced a severe financial shock and those who receive no remittances have less incentive to open a locked pensions savings account, simply because they hardly have any income left for present consumption. This could be an indication that their income is insufficient to meet present consumption needs, let alone future consumption needs. Then the bigger question is not whether the farmer will adopt long-term savings account, but, whether the farmer is able to save anything at all. Perhaps a similar question of incentives brings me to the findings of adoption of hybrid seedlings in chapter 5, where social capital seems to incentivise farmers to adopt innovations with uncertain outcomes. While pondering on the question of incentives, I looked at some summary statistics on income from cocoa and adoption of hybrid seedlings of the cocoa farmers from my survey (the same survey was used for chapters 3-5). Given how little income farmers get from cocoa, it comes as no surprise that cocoa farmers are not able to save or that they would think twice before investing precious labour resources to plant new cocoa seedlings on their farms. The table below summarizes income from cocoa of the farmers we surveyed. I created income categories comparable to a local minimum wage in Ghana, a low-wage equivalent in town ($100/month), and a taxi driver wage equivalent in town ($200/month).

Table 1: Total annual income from cocoa (GhC)[1]

	Income equivalent in US$	***Frequency***	***Percent***
< 2851	Below minimum wage ($1,8/day)	598	39.79
2851 – 4,447	Min. wage - $100/month	442	29.41
4,448 – 8,896	$100/month - $200/month	344	22.89
8,896 – 22,346	$200/month - $400/month	92	6.12
0	Missing responses	83	5.52
5,890	Average (excl. missing response)	1,503	100.00

[1] The minimum wage and exchange rate was adjusted to the year when the data was collected – 2015.

Income from sales of cocoa is surprisingly low, especially given that these farmers are Fairtrade certified. Despite certification, almost 40% of the surveyed farmers live below the absolute poverty line (US$1.9 per day). Now let us put that in the context of adoption of long-term savings accounts and adoption of novel hybrid cocoa seedlings. Farmers with income from other sources have a higher uptake of flexible pension savings because they have more income, but because they are poor, a flexible account allows them to balance current and future consumption needs better. Likewise, in chapter 5, it makes sense that convincing farmers to invest in novel hybrid seedlings has to come from seeing that it works for other farmers. Taking the chance of adopting novel technologies and forgoing current income (in a form of old tree productivity) or existing family labour, is a high risk to bare when living below- or at- minimum wage. i

Optimization of scarce resources in face of uncertainty is another impediment to technology adoption. Though risk aversion was not a hypothesis we tested directly in any of the chapters, chapter 5 gives us an indication that social capital enhances investments that require a certain risk on farmers' end without certainty of a higher return. In the case of seedlings, the required investment is primarily labour, and the return on that investment is uncertain. It is worthwhile considering that perhaps social capital might also influence adoption of other digital technologies, as discussed in chapter 2. For as long as there is an opportunity cost to adopting a new technology, farmers might need to get information first-hand from neighbours who are in a similar economic situation. This is especially the case with low-income generating farmers who cannot afford to fail, simply because then they are left with nothing. In chapter 5 we saw that the opportunity cost of cutting down old trees and planting new seedlings is low, given that existing old cocoa farm trees bear little fruit, but they are still an important source of income for farmers. Replanting them means temporary loss of that income, and yet, additional labour hours spent at no output from that specific piece of land for a minimum of 18 months. Undertaking any economic activity has opportunity costs, and it does not take an educated farmer to understand that.

Inertia. We briefly discussed farmers' resource optimization in face of risk and low income. We have seen how social capital helps to take that risk, but we also see from the table above that almost 40% of cocoa farmers live in absolute poverty based on cocoa income alone. One could argue that the same risk aversion that prevents farmers from adopting hybrid seedlings or locked savings accounts, also prevents farmers from moving into more lucrative forms of business. Poor farmers are more likely to stay in cocoa farming and complement income with other farming or non-farming activities that come at little or no opportunity cost to existing land and labour available within the family. And that is how

we can explain inertia. It is the status quo that smallholder farmers get locked in as a consequence of low income, lack of incentives and careful optimization of scarce resources in face of uncertainty.

It is highly likely that increased income is likely to solve some of the demand-related factors related to adoption of flexible long term savings accounts, as indicated by higher uptake by those who receive remittances. It is also likely that adoption of new technologies on farm level are likely to be enhanced by adoption of those same technologies by neighbours. It is worth-while considering to what extent increasing income or income diversification, as well as social capital, will influence demand for novel technologies. In this pool of mixed supply (access) and demand (willingness to adopt) driven impediments to technology adoption, perhaps enhancing information transparency and increasing income for farmers is a starting point. Once farmers have more negotiation power and opportunities in food supply chains, they are more likely to adopt innovations and consider long-term saving choices.

6.3. Policy recommendations

The question of increasing information transparency of global agricultural commodities and increasing the income of farmers lies predominantly on the shoulders of policy makers. I will discuss some recommendations on how enhancing information transparency through the use of technology can enhance both.

In chapter 2 we saw that increasing transparency of supply chains, by for example estimating global productivity patterns, reduces informational noise from supply shocks and futures market trading on commodity demand and spot prices (Kamilaris et al., 2017, Sockin & Xiong, 2015, Wolfert et al., 2017). If for instance, all commodity producing governments would use satellite and drone data to accumulate information about their countries' agricultural commodities output and further gather precise information about their farmers location and output, they would stabilize market price fluctuations by disincentivising stock market speculation. Market speculation is based on opaque information about crop supply and predicted output. If policy makers hire experts to make predictions about a given commodity output in different climate conditions and make that available publicly, they close the information gap which enhances market speculation on soft commodities like cocoa on stock markets. In the example of the cocoa industry, it would be enough if two countries enhance such transparency efforts. Cote d'Ivoire and Ghana alone produce more than 60% of global supply of cocoa. If they acquire more detailed information about their farmers location and output data, and pair that with satellite and weather data, they can make accurate forecasts public.

In chapter 5 we also saw that fertilizer subsidies seem to reach the more wealthy farmers. Enhancing transparency of subsidy delivery systems would allow policy makers to identify inefficiencies in input

delivery and act on those inefficiencies accordingly, so that input subsidies reach the right target groups.

Furthermore, chapter 3 shows a significantly higher uptake of flexible long-term savings accounts for women and farmers who diversify their income. I also showed that income of cocoa farmers from cocoa alone is very low, as shown in the table earlier in this chapter. On top of that, women in Ghana are not allowed to inherit land titles. This is a significant disadvantage of female cocoa farmers. Normally, cocoa land-owning farmers enter share-cropping agreements in old age once they are no longer able to work on the farm themselves. They use the proceeds from share-cropping as old age income. If women are not able to own land, it makes sense that they have to find alternative sources of income at old age. And given that they are poor, as we have shown earlier, they prefer a flexible savings accounts. However, what about women who do not get remittances? Their source of income at old age is at risk. This has severe economic consequences on women's economic wellbeing, which should urgently be addressed with more favourable land policies. Furthermore, governments can enhance a more holistic benefits package for cocoa farmers, where they not only provide input supplies, but look at the well-being of cocoa farmers not only from the perspective of cocoa farming alone. Perhaps training farmers in income diversification would give them an opportunity to generate farm income from a diverse range of crops. This could be a sound practice for income fluctuation management, as well as additional income generation. Perhaps then farmers would be more likely to open a long-term savings account. As we saw in chapter 4, access to savings places farmers on a path of more optimal farming efficiency, which emphasizes the importance of savings on farming efficiency. I would also encourage policy makers to look into how farmers who do have access to savings spend those savings – what is more optimal farming efficiency: investing in more productive inputs for enhanced mono-cropping or using the existing cocoa trees as a cash cow for some income while using the remaining resources to diversify income (as indicated in ch. 4)? I think there is much to be learned from the entrepreneurial skills of smallholder farmers in maximizing their resources. Understanding how farmers use their available resources helps in tailoring more effective policies, especially when it comes to allocating extension efforts or input subsidies. Either way, if farmers continue making as little from cocoa farming as they currently do, they are unlikely to stay in cocoa farming. For a country highly dependent on cocoa exports, Ghana should consider this a high GDP risk. Furthermore, if low farming income continues as a trend, governments will continue to see an increase in migration to towns, which not only puts higher pressure on infrastructure of towns, but also puts in question the local food security in question.

6.4. Business recommendations

Cocoa farmers are many, and despite their low purchasing power, there are business opportunities which could benefit both farmers and businesses. For financial institutions offering long-term savings products, I would recommend offering a product which gives farmers more flexibility in withdrawing their savings. Also, the fact that women have higher adoption rates of flexible pension-savings products than men could be an indication that these two groups have different needs for uptake of financial products. As women in Ghana are not able to inherit land titles, this is indicative of a potential to reach female farmers with different financial products than men.

For businesses offering novel technologies for smallholder farmers, working through the social network of smallholder farmers seems to be an efficient way of encouraging adoption. Convincing a few well-connected farmers per community to adopt an innovation might create a desired ripple effect across communities.

As for cocoa value chain players, the financial sustainability of cocoa farming is jeopardized at the moment. If a majority of cocoa farmers cannot make and equivalent of minimum wage with cocoa farming, then the sustainability of the entire crop is put to question. If farmers continue making so little from cocoa farming, they will gradually move to growing other crops or focusing on off-farm income generating activities. Perhaps now is the time to reconsider the value addition in supply chains and give a fairer share of the income pie to the farmers.

6.5. Research limitations and recommendations for further research

There are some limitations to my research. First of all, my analysis of the 3 quantitative chapters focuses on a narrowly defined group of cocoa farmers in one region in Ghana, and not a very representative group either. Namely, cocoa farmers are often not organised in cooperatives – rather, they are organised by commodity traders. That implies that the conclusions that I draw from the subset of the cocoa farmers in my sample might not be representative of the cocoa farmers in Ghana or West Africa, let alone cocoa smallholder farmers globally. However, this group of “exemplary” farmers who are organised and certifies defined by my research does shed light on the fact that organising farmers in an independent cooperative or getting certified does not solve the problem of poverty of cocoa farmers based on their farming income alone. Furthermore, the advantage of using a single sample of cocoa farmers in 3 chapters allows me to look at the farmers from different angles, using different methodologies as well. As such, I could draw deeper insights into their economic well-being.

Furthermore, my thesis starts off with a literature review chapter where I introduce the use of technologies to benefit smallholder farmers. However, a great part of these finds were not yet

empirically tested on smallholder farmers. The paper sets the ground for further research, where there is still much room for empirical testing of the use of digital technologies and their benefits, especially cost-benefit-feasibility aspect of implementation of such technologies in a smallholder setting of the countries of the Global South. There is also a research limitation to adoption of ICT technologies in general. Despite the number of dispersed ICT initiatives in an effort to enhance farmer inclusion, empirical evidence remains mixed, like in the case of mobile phones, or limited with regard to other technologies. Trust in information quality and usability of technologies in different contexts also need further testing in empirical economics.

Furthermore, on the subject of limitations, the analysis behind chapters 3-5 is based on a cross-sectional survey, which indicates possible endogeneity related to interpretations on causality. As much as we tried to control for that (for example, in chapter 3 we conducted an RCT), some endogeneity issues remain. A time series data set, or at least an end-line survey, would contribute significantly in reducing some of the identification issues which make my findings inconclusive in determining the causality. However, identification of correlations of access to savings and farmer efficiency, or social capital with access to inputs, is already significant contribution to the existing literature. A cross-sectional dataset only allows us to observe associations or correlations between different factors, but not causality..

In chapter 3 on long-term savings, one limitation of our study is that the amount of communities in our sample is relatively small. We had to randomise at the community level for ethical reasons. This has advantages in terms of avoiding spill-over effects. However, due to the small amount of communities, we may face problems in terms of only being able to pick up small effect sizes, and thus incorrectly fail to reject the null of no significant differences. Fruitful future research should therefore be done on a larger group of communities. This would allow us to compare a larger variety of pension products, including one without any restrictions, .in order to better assess “optimal” commitment levels.. Nevertheless, this study measures the take-up of different pension savings products, which sets the ground for future research on retention of those long term savings, and assessing farmers’ savings behaviour and influences over time.

Chapter 4 findings have data quality limitations, especially in relation to the group support in cocoa farming and extension visits, or details about share-cropping arrangements farmers have, or identification of mono-cropping versus crop diversification on existing land. These may be important elements in cocoa efficiency which have not been captured by our data, but have been included in some cocoa farmer meta-frontier analysis sporadically. As part of the future research agenda, as mentioned in the policy recommendations, it would be good to consider farming efficiency not of

cocoa alone, but of all farming and even non-farming activities together. After all, the same family labour and/or land is used for different income-generating activities, on- or off-farm. A more holistic measure of efficiency relative to all inputs and all outputs produced by a farmer will give a richer overview of economic well-being of cocoa farmers, as well as their investment choices, and savings behaviour. Looking at a complete range of income-generating activities of cocoa farming households will allow us to interpret the inputs available and the efficiency of cocoa farming a bit more holistically – relative to other crops on farm, or income generating activities generated by the same family labour on or off farm The fact that farmers operate on a higher *cocoa* efficiency curve tells us little about economic decisions a farmer undertakes on or off cocoa farm if he has access to savings. This is definitely a fruitful topic for future research, very relevant to policy makers and the cocoa industry as a whole.

Finally, as for chapter 5, due to data limitations, we do have a narrowly defined definition of social capital which includes no references to trust. Trust creates reciprocity and voluntary associations, and reciprocity and associations strengthen and produce trust. The literature shows that trust is very difficult to measure, and as such deserves more attention, especially in light of economic outcomes (such as access to subsidies). Also, a farmer's exact location in a community might have an effect on centrality of a network and consequent access to inputs subsidies. We did control for farmer location on community level, which is a good starting point in determining the influence of geographical location to access to input supplies, but farm distance within community might also be relevant to consider with future research.

In continuation of the limitations of my research, I would recommend conducting a time-series study on the uptake of long-term savings accounts and input supplies. This would help us determine the causality and therefore enhance the conclusiveness of our findings beyond correlations. For example, does access to savings increase productivity, or how does retention of long-term savings shape farm efficiency and uptake of inputs. I would also recommend using a more diverse set of cocoa farmers across more communities and diverse groups of cocoa farmers (organised and unorganised) to have a more representative sample of cocoa farmers in West Africa at least. I would highly recommend randomized experiments of uptake of digital technologies highlighted in chapter 2 to determine their feasibility and cost effectiveness in the context of smallholder farmers. Furthermore, the questions which remain open for further research are whether access to these technologies would really open doors for smallholders to access more markets and consequently increase the prices paid to farmers; and whether land titles, if adopted, would help farmers to either diversify income generating activities completely or scale up farming (get them out of the status quo I defined in section 6.2).

Chapter 3 finds that women have different saving preferences to men. These gender dynamics in light of women's inability to inherit land titles in Ghana should be studied in more detail. Also, due to our sample limitation, our pensions savings study only assesses two pension products, which is quite limiting. Assessing the optimal pension savings commitment levels requires testing a larger variety of pension products with varying flexibility of withdrawing savings, including one without any restrictions, and then assessing how uptake differs per gender. Finally, this study only measures the take-up of different pension savings products, but future research is needed to identify the retention of long term savings, and how this changes over time and relative to income levels and income diversification strategies of farmers.

In chapter 5, we have seen how social capital can help reduce risk aversion of cocoa farmers and plant the seedlings with a view of the future benefits. Perhaps future research can address how social capital can affect take-up of other technologies as well – including long-term savings, or digital technologies. Undertaking any economic activity has opportunity costs. Further research is needed to better understand how to help farmers objectively evaluate those costs and benefits. This can be done through the use of social networks, but perhaps not social networks exclusively. The important component of that is firstly understanding farmers' perspective on opportunity costs, and then to help farmers objectively evaluate those costs and benefits of adopting any new product or technology.

6.6. Main conclusions

The main objective of this thesis was to assess to what extent smallholder farmers can influence their economic well-being by relying on existing market conditions, as opposed to failing economic systems common across the African continent. I identified transparency, access to savings and social capital as potential solutions to help farmers get access to markets, information, finance and subsidies. Here I summarize my main conclusions.

- Digital technologies enable hyper-transparency through real-time, automated data collection and analysis, (chapter 2).
- Potential benefits of hyper-transparency for smallholders are improved access to services and markets (chapter 2).
- Existing concerns for smallholders include lack of data access and skills, and new power relations around data access and use (chapter 2).
- The uptake of locked long-term savings accounts is greatly influenced by farmers ability to separate current consumption needs in presence of high income volatility, with the investment capital needs or old-age capital needs. This finding sheds light on income scarcity to save at all (chapter 3).

- We find a significantly higher uptake of long-term flexible savings products for female farmers and farmers with income diversification in non-farming activities. This implies that flexibility is more valued by women who are not able to inherit land and lease it in share-cropping arrangements at old age, and those who have additional income (chapter 3).
- We also find a lower uptake of the flexible account for farmers who have experienced a severe financial shock last year and those farmers who receive no remittances from family members. This means that farmers who are financially constrained in the present cannot be expected to lock a higher proportion of their income for retirement than what they consume today (chapter 3).
- Farmers with access to a formal savings account use completely different input technologies, and as a result operate on a different efficiency curve from farmers without access to savings (chapter 4).
- Even though both farmers with access to savings and farmers without access to savings operate close to optimal efficiency given their respective input technologies, we find that farmers with access to savings operate much closer to the optimal efficiency curve defined by their combined efficiency curve, the meta-frontier (chapter 4).
- Farmers' ability to operate on a higher efficiency curve does not give us an indication into inputs choices a farmer makes. A farmer could choose to invest in hybrid inputs and spend more labour on producing more cocoa, or (s)he could diversify income by using minimum inputs to harvest whatever cocoa pods the trees give, and instead focus family labour on other income generating activities (chapter 4).
- When looking at access to subsidized seedlings and fertilizer, we conclude that the adoption of seedlings, a more risky input which includes costs of land preparation, is significantly more influenced by social capital than fertilizer, which requires no additional labour costs from farmers (chapter 5).
- Social capital, specifically frequency of interaction with other farmers, helps farmers acquire information and adopt a new technology (chapter 5).
- Farmers with higher income have higher access to free fertilizer, which puts to question the efficiency of fertilizer delivery and the effectiveness of the subsidy itself (chapter 5).
- The failure of access to capital and technology for smallholder farmers is divided in supply-side and demand-side impediments. The supply side is referring to the availability of both capital and technology, which sheds light on institutional and market failures to facilitate equitable access to both. The demand side is referring to farmers' willingness to adopt capital and technologies, which is influenced by lack of incentives, prudent use of available resources, and inertia (overall conclusion).

Summary

This thesis attempts to assess some practical solutions to help smallholder farmers in Africa bypass dysfunctional government institutions and enhance welfare. I focus specifically on access to technology and capital as market tools to help alleviate farmers out of poverty. The main question my thesis aims to address is what can farmers do, within their realm of power, to get access to these technologies and capital. Both are necessary to help farmers optimize farm productivity, increase income and give them a choice and economic opportunities.

The first study looks at a range of digital technologies available to enhance farmers' access to markets, capital and information, as opportunities to create stronger market positioning and negotiation power. The main opportunity to enhance farmers' use of digital technologies available is demand for transparency – created by produce buyers, consumers, and regulatory bodies. The potential benefits of hyper-transparency for smallholders are improved access to services and markets. The actual impact of digital technologies on smallholder farmers, however, remains questionable. Some important challenges remain, which are limited access to these technologies for smallholders and new power relations that emerge around access, use and control of data. More empirical studies are required to look at how to enhance the adoption of these technologies in a smallholder setting, and more importantly, how to optimize the potential opportunities they may create.

The other chapters of this thesis focus on access to capital or technologies specifically for cocoa smallholder farmers in Ghana. My second study examines smallholder farmers' access to capital. Access to credit has always been a challenge for smallholder farmers due to collateral-, among other, requirements. One intermediate solution for that is enhancing savings, and the starting point is looking at smallholders' take-up of savings accounts. In this study, I conduct a Randomized Control Trial to assess the intertemporal choice preference for long term savings of cocoa farmers in Ghana. We test the uptake of two pension products. With one, famers are free to withdraw half of their savings with no penalties prior to retirement age; and with the other, they were only allowed to withdraw 30%. Neoclassical economic theory will argue that rational individuals want to even out consumption over their lifespan, thus having preference for flexible saving, especially in the face of high income shocks and fluctuations. However, an increasing body of behavioural economics literature shows that people have hyperbolic preferences – meaning that they would prefer to lock their savings to avoid their own spending or spending by family members. When testing the uptake of both the more and the less flexible savings account, we find a higher uptake of the more flexible pensions account, especially for women. This is quite interesting as women cannot inherit land titles in Ghana and thus cannot enter share-cropping agreements as assurance for old age income. We also find a higher uptake of flexible

accounts for farmers who are able to diversify their income through non-farming activities. This could be an indication of higher income or less income fluctuation. We also find a significantly lower uptake of the less flexible accounts for farmers who have experienced a severe financial shock in the last year, and those who receive no remittances from their family members. That brings us to a conclusion that a more flexible account is a more suitable choice for farmers, as it allows them to balance current and future consumption needs, while still having a possibility to lock away their savings from other household members. Finally, the low uptake of a less flexible savings account is in line with neo-classical theory – financially constrained farmers cannot lock a higher proportion of income for retirement than they consume at present.

My third study builds on savings theory, and argues that farmers who have access to savings have access to capital to make different investment choices. The study shows that cocoa farmers with access to savings use different farming technologies from farmers without access to savings. To test that, the stochastic meta-frontier analysis was used to show how these two groups of farmers operate on different efficiency curves based on inputs used. The findings also indicate that both groups operate close to their maximum efficiency relative to their inputs. However, farmers with access to savings operate a lot closer to optimal cocoa farming efficiency, defined by the meta-frontier which shows the optimal efficiency frontier for both groups of farmers. The results can be interpreted in three ways. If farmers have savings (proxy used for access to capital), access to savings enables them to increase the adoption rate of technological innovations or increase input quality efficiency. The second option is that the indirect effect on savings is that they are an effective way of smoothening consumption, and smoothening consumption leads to efficiency gains. The third alternative way of interpreting more optimal efficiency for farmers with access to savings is that they harvest whatever cocoa is growing on trees with no additional inputs used, and instead, invest family labour and savings into other forms of income generation. Overall, this chapter adds to the increasing evidence of the importance of savings.

The last study in this thesis evaluates the effect of social capital on farmers' adoption of subsidised input technologies, more specifically, hybrid seedlings and fertilizer for cocoa farmers in Ghana. Three types of social capital were distinguished: network social capital, relationship social capital, and community social capital. Network social capital refers to the peer-to-peer information flow about product benefits reaching farmers, therefore closing the information asymmetry that prevents farmers from social learning about crop risk management through inputs adoption. Relationship social capital considers the role of social status in getting access to inputs technologies through connections with extension officers who facilitate information dissemination about technology benefits, and moreover potentially help bypass the government criteria in getting access to them. Finally, community social capital concerns the community collective income, community size and reachability relative to the

cooperative main office. The network social capital was found to have a significant effect on adoption of subsidised seedlings, to an extent where it allows farmers to bypass subsidy qualification criteria for access to seedlings imposed by the government. This applies even more so for group and village leaders. Subsidized fertilizer uptake, on the other hand, is less dependent on social capital. The difference can be explained by risk involved in adopting seedlings versus fertilizer. In the case of seedlings adoption, relying on information provided by the social network promotes sharing of benefits of hybrid varieties, and thus reduces the risk of its application. Adoption of fertilizer, on the other hand, is not correlated with social capital because fertilizer application is less risky to farmers. They can easily switch from using fertilizer to not using fertilizer. Access to both inputs is influenced by government inputs' eligibility criteria, namely having mapped farm. However, our findings show that 15% and 29% of farmers respectively have access to seedlings and fertilizer, even though their farms are not mapped. This suggests that for governments to stimulate uptake of substantive inputs, such as seedlings, subsidies should coincide with attention to social capital and fair distribution of inputs.

Finally, looking back at the objective of this research, there is hope for smallholders to enhance welfare through access to technologies and savings. Technologies offer significant hope in linking farmers to market and capital. Savings enhance farmers' efficiency, and social capital influences adoption of 'risky' inputs which require farmers' labour and land investment. However, this research sheds light on the fact that failing institutions are not the only reason why farmers have poor access to technology and capital. Addressing the issue of *supply*, or availability, of capital and technology sheds light on institutional and market failures to facilitate equitable access to technology and capital for farmers. However, the remaining challenge is of *demand* nature, or smallholders' willingness to adopt capital and technologies. This is of more behavioural nature, and sheds light on farmers' personal choices for not adopting these technologies. These include 1) lack of incentives to adopt, given that cocoa farming is not very profitable for a majority of farmers; 2) prudent use of scarce resources in face of uncertainty; and consequently, 3) inertia to move towards adoption.

Baseline Survey

FILL OUT THE LINES WITH !!! IN FRONT OF THEM BEFORE TALKING TO THE RESPONDENT

		Name			ID	Date		
	Enumerator code				⌊_⌊_⌋	D D	M M	Y Y Y Y
	Community number				⌊_⌊_⌋			
	Household code				⌊_⌊_⌊_⌊_⌊_⌊_⌊_⌋			
	Respondent's full official name							
	Cellphone number (exclude 1st zero)				⌊_⌊_⌊_⌊_⌊_⌊_⌊_⌊_⌊_⌊_⌋			
	Circle ID type and write the ID number	1) Voter ID 2) NHIS	3) Identity Card 4) Passport	5) Driving license 6) No ID available	⌊_⌊_⌊_⌊_⌊_⌊_⌊_⌊_⌊_⌊_⌋			
	Data clerk 1				⌊_⌋	D D	M M	Y Y Y Y
	Data clerk 2				⌊_⌋	D D	M M	Y Y Y Y

Hello. My name is _____ and I am working with CRIG.

We are conducting a survey of the economic activities and financial situation of cocoa farmers in this area. The survey will take about one hour. Participation in this survey is voluntary, and if we should come to any question you don't want to answer, just let me know and I will go to the next question; or you can stop the interview at any time. However, we hope that you will participate in this survey since your views are important.

To show you how important your answers are to us we would like to give you a small gift for your cooperation throughout the questionnaire.

At this time, do you want to ask me anything about the survey?

May I begin the interview now?

IF YES HAND OUT THE INFORMED CONSENT FORM AND BEGIN THE INTERVIEW

Module 2 Household composition

NO	201	202	203	204	205	206	207	208
	What are the names of the people who usually live and share the meal in your household? START WITH HOUSEHOLD HEAD, FOLLOWED BY RESPONDENT'S NAME IF DIFFERENT	Is [NAME] male or female?	How old is [NAME] now?	What is the relationship of [NAME] to the head of the household? EXAMPLE: IF [NAME] IS THE MOTHER OF THE HOUSEHOLD HEAD, ENTER 6	What is the highest education level [NAME] ever completed?	How many total years of schooling did [NAME] complete in total? EXCLUDE REPEATED YEARS	Can you read easily in English? EXAMPLE: NEWSPAPER	Can you write easily in English? EXAMPLE: LETTER
1	_____	⌊_⌋	⌊_⌋⌊_⌋	⌊_⌋	⌊_⌋	⌊_⌋⌊_⌋	⌊_⌋	⌊_⌋
2	_____	⌊_⌋	⌊_⌋⌊_⌋	⌊_⌋	⌊_⌋	⌊_⌋⌊_⌋		
3	_____	⌊_⌋	⌊_⌋⌊_⌋	⌊_⌋	⌊_⌋	⌊_⌋⌊_⌋		
4	_____	⌊_⌋	⌊_⌋⌊_⌋	⌊_⌋	⌊_⌋	⌊_⌋⌊_⌋		
5	_____	⌊_⌋	⌊_⌋⌊_⌋	⌊_⌋	⌊_⌋	⌊_⌋⌊_⌋		
6	_____	⌊_⌋	⌊_⌋⌊_⌋	⌊_⌋	⌊_⌋	⌊_⌋⌊_⌋		
7	_____	⌊_⌋	⌊_⌋⌊_⌋	⌊_⌋	⌊_⌋	⌊_⌋⌊_⌋		
	RECORD ALL NAMES FIRST	0. Male 1. Female	RECORD AGE IN YEARS AND VERIFY COHERENCE	1. Head 2. Wife or husband 3. Son or daughter 4. Son- / daughter-in-law 5. Grandchild 6. Parent / Parent-in-law 7. Brother / sister / -in-law 8. Cousin/niece/nephew 9. Other: _____	0. None 1. Primary 2. Middle 3. JHS / JSS 4. SHS / SSS 5. Vocational 6. Tertiary	COMPLETED YEARS IN EDUCATION	0. No 1. Yes	0. No 1. Yes

209	How many years of experience do you have in farming cocoa?	⌊_⌋⌊_⌋	RECORD NUMBER OF YEARS		
210	What is your status within the community? SELECT MORE IF APPLICABLE	a. ⌊_⌋ b. ⌊_⌋ c. ⌊_⌋	0. Farmer only 1. Chief 2. Village elder / opinion leader 3. Women's leader	4. Spiritual leader 5. Savings group leader 6. Purchasing clerk 7. Fanteakwa executive member 8. Farmer's trainer	9. Certification manager 10. Assembly man 11. Formal sector employee 12. Community Chief Farmer 13. Other: _____
211	What is the main religion practiced in your household?	⌊_⌋	1. Christianity 2. Islam	3. Traditional 4. Other, specify _____	

212	What languages are normally spoken in your household?	a. Primary ⌊_⌋ b. Secondary ⌊_⌋	1. Twi 2. Fanti 3. Ga	4. Dagbani 5. Ewe 6. Krobo	7. English 8. French 9. Other, specify_____
213	Are you indigene of this community or a migrant?	⌊_⌋	1. Indigenous	2. First generation migrant	3. Second generation migrant

Module 3 Assets & standard of living

NO	QUESTIONS AND FILTERS	ANSWER	CODING CATEGORIES	SKIP
301	How many rooms in your home are used by your household?	⌊__⌋	RECORD TOTAL NUMBER OF ROOMS, INCLUDING LIVINGROOM BUT EXCLUDING BATHROOMS	
302	Does your house have access to electricity?	⌊_⌋	0. No. 1. Yes, Solar 2. Yes, generator 3. Yes, grid	
303	Do you or anyone in your household own any of the following? a. cellphone? b. radio? c. bicycle? d. motorbike/tricycle? e. car f. truck g. knapsack sprayer? h. mist blower? i. television? j. fridge?	a. ⌊_⌋ b. ⌊_⌋ c. ⌊_⌋ d. ⌊_⌋ e. ⌊_⌋ f. ⌊_⌋ g. ⌊_⌋ h. ⌊_⌋ i. ⌊_⌋ j. ⌊_⌋	0. No 1. Yes	
304	What proportion of your household income was spent on food in the last month?	⌊_⌋	1. Up to 1/4 2. Up to 1/2 3. Close to all income	

Module 4 Cocoa farming information

NO	**401**. What is the ownership situation of every **COCOA** farms you individually work on? START WITH MAIN FARM FIRST	**402.** How much do you pay for land lease per year?	**403.** What is the travelling time from home to your main farm (on foot)?	**404.1** What is the size of this farm?	**404.2** Unit of measure of farm size	**405**. Do you have a map of your farm?	**406**. How old is the oldest cocoa tree on this farm?	**407**. Which cocoa certification standards do you have?
1	⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋	⌊_⌋, ⌊_⌋⌊_⌋	⌊_⌋⌊_⌋⌊_⌋, ⌊_⌋	⌊_⌋	⌊_⌋	⌊_⌋⌊_⌋	a. ⌊_⌋ b. ⌊_⌋ c. ⌊_⌋
2	⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋		⌊_⌋⌊_⌋⌊_⌋, ⌊_⌋	⌊_⌋	⌊_⌋	⌊_⌋⌊_⌋	a. ⌊_⌋ b. ⌊_⌋ c. ⌊_⌋
3	⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋		⌊_⌋⌊_⌋⌊_⌋, ⌊_⌋	⌊_⌋	⌊_⌋	⌊_⌋⌊_⌋	a. ⌊_⌋ b. ⌊_⌋ c. ⌊_⌋
4	⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋		⌊_⌋⌊_⌋⌊_⌋, ⌊_⌋	⌊_⌋	⌊_⌋	⌊_⌋⌊_⌋	a. ⌊_⌋ b. ⌊_⌋ c. ⌊_⌋
5	⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋		⌊_⌋⌊_⌋⌊_⌋, ⌊_⌋	⌊_⌋	⌊_⌋	⌊_⌋⌊_⌋	a. ⌊_⌋ b. ⌊_⌋ c. ⌊_⌋

	0. Landowner → 403 1. Abunu (50-50) → 403 2. Abusa (1/3 – 2/3) → 403 3. Abunan (1/4 – 3/4) →403 4. Land lease → 402 5. Other: _____	ENTER GHANA CEDIS *PER YEAR*	IN HOURS AND MINUTES (E.G. 2, 35 = 2H AND 35 MINUTES)	RECORD THE NUMBER OF LAND UNITS	0. Hectares 1. Acres 2. Poles	0. No 1. No, but COCOBOD mapped my farm 1. Yes, compass 2. Yes, GPS	HELP FARMER RECALL OLDEST TREE. USE -99 IF UNKNOWN	0. None / none yet 1. Fair Trade 2. UTZ 3. Rain Forest Alliance 4. Organic 5. Armajaro traceable 6. Cocoa Abrabopa

Module 4 Cocoa farming information [continued]

408	How many bags of cocoa did you produce during the... CHECK FARMER'S PASSBOOK AND ASK FARMER ABOUT COCOA SALES NOT REGISTERED IN THE PASSBOOK	last main-crop season a. ⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋, ⌊__⌋ last light-crop season b. ⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋, ⌊__⌋	INSERT TOTAL NUMBER OF BAGS PRODUCED FOR ALL FARMS. ENTER -99 IF THE FARMER DOESN'T KNOW WHAT HE PRODUCED
409	How many of bags did you sell at certified *price*?	last main-crop season a. ⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋, ⌊__⌋ last light-crop season b. ⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋, ⌊__⌋	CHECK FARMER'S PASSBOOK AND ALSO ASK FARMER ABOUT COCOA SALES NOT REGISTERED IN THE PASSBOOK.
410	How do you get paid for the sale of your cocoa?	⌊__⌋	1. Cash immediately 2. Cash later 3. On a group account immediately 4. On a group account later 5. On a personal bank account immediately 6. On a personal bank account later 7.Via mobile money immediately 8 Via mobile money later 9. Cheque 10. Not applicable
411	How many cocoa trees do you have on your main farm?	⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	INSERT NUMBER TREES; ENTER -99 IF THE FARMER DOESN'T KNOW WHAT HE PRODUCED
412	How many cocoa trees older than 25 years do you have on your main farm? HELP ESTIMATE OLD TREES ON MAIN FARM	Older than 25 years ⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	INSERT NUMBER TREES; ENTER -99 IF THE FARMER DOESN'T KNOW WHAT HE PRODUCED
413	How many shade trees do you have on your main cocoa farm?	⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	INSERT NUMBER OF SHADE TREES; ENTER -99 IF THE FARMER DOESN'T KNOW

Module 5 Cocoa-related expenditures

NO		**501**	**502**
	Activity	How much did you invest in buying input supplies for [ACTIVITY] in the last year, for all cocoa farms?	How much did you spend on hired labour on [ACTIVITY] in the last year for all cocoa farms?
1	Land preparation and planting new seedlings	⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋
2	Weeding, weedicide and pruning	⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋
3	Pest, insect, disease and black pod control	⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋
4	Harvesting	⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋
5	Post-harvesting (pod breaking, fermentation, drying and transport to PC)	⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋

Module 6 Farmer services

NO	QUESTIONS AND FILTERS	ANSWER	CODING CATEGORIES	SKIP
601	In the last main season did the PC 'discount" the kilograms shown on the weighting scale?	⌊__⌋	0. no 1. yes	→ 603 → 602
602	What was the main reason for getting this discount'? (select multiple answers if applicable)	⌊__⌋ ⌊__⌋ ⌊__⌋	1. The water content/moisture content of beans was too high (too wet) 2. There was foreign matter (waste/soil/stones) in the bag 3. Other, specify _____	
603	How many bags of fertilizer did you receive from Cocobod in the last main season for all cocoa farms?	⌊__⌋ ⌊__⌋__⌋__⌋	INSERT NUMBER OF BAGS	
604	How many bottles of fertilizer did you receive from Cocobod in the last main season for all cocoa farms?	⌊__⌋ ⌊__⌋__⌋__⌋	INSERT NUMBER OF LITERS	
605	How much did you pay in total for fertilizer in the last main season, for all cocoa farms?	⌊__⌋ ⌊__⌋__⌋__⌋	INSERT VALUE IN GHANA CEDIS, INSERT 0 IF FARMER BOUGHT NO FERTILIZER	
606	How many seedlings did you receive in the last year for all your cocoa farms?	⌊__⌋__⌋__⌋	INSERT NUMBER OF POTS	If 0, skip to 609
607	How much did you pay for seedlings in the last year?	⌊__⌋ ⌊__⌋__⌋__⌋	INSERT GHANA CEDIS, INSERT 0 IF FARMER BOUGHT NO SEEDLINGS	
608	How many of these cocoa seedlings are still alive?	⌊__⌋ ⌊__⌋__⌋__⌋	INSERT NUMBER STILL ALIVE; ENTER -99 IF THE FARMER DOESN'T KNOW	
609	Would you want to get (more) seedlings?	⌊__⌋	0. No 1. Yes	If 0, skip to 612
610	How many (more*)* seedlings do you want to get?	⌊__⌋__⌋__⌋	INSERT NUMBER OF SEEDLINGS; ENTER -99 IF THE FARMER DOESN'T KNOW	
611	Is there something that prevents you from getting (more) seedlings?	⌊__⌋	0. No. 1. Yes, they are not available 2. Yes, my farm was not ready for seedlings yet (land not cleared) 3. Yes, my farm has not been measured yet by extension officer. 4. Other, specify _____	
612	How many seedlings did you raise and plant on your own farms last year, for all cocoa farms?	⌊__⌋ ⌊__⌋__⌋__⌋	INSERT NUMBER OF SEEDLINGS, INSERT 0 IF FARMER PRODUCED NO SEEDLINGS	
613	Did you keep written records of your farm inputs and expenditures in the last year? INCLUDE RECORDS WRITTEN OR RECORDED BY OTHERS	⌊__⌋	0. No 1. Yes	
614	Besides the passbook, did you keep written records of your farm output and sales in the last year? INCLUDE RECORDS WRITTEN OR RECORDED BY OTHERS	⌊__⌋	0. No 1. Yes	
615	Would you be willing to give a small contribution to receive information on prices of inputs and cocoa? FOR EXAMPLE 50 PESOAS OR SOME FOOD	⌊__⌋	0. No 1. Yes	
616	Would you be willing to give a small contribution to receive feedback on your inputs use, farming practices and productivity compared to other cocoa farmers in your area? FOR EXAMPLE 50 PESOAS OR SOME FOOD	⌊__⌋	0. No 1. Yes	

617	Have you ever attended the Farmer Business School training?	⌊__⌋	0. No 1. Yes	→ 701 → 614
618	Did you ever make use of the Farmer Business School workbook to record your farm activities?	⌊__⌋	0. No 1. Yes	
619	Did you receive the Farmer Business School training certificate?	⌊__⌋	0. No 1. Yes	

Module 7 Finances

NO	QUESTIONS AND FILTERS	ANSWER	CODING CATEGORIES	SKIP
701	How much income does your household generate from all your activities: INCLUDING FARMING AND NON-FARMING ACTIVITIES	In a good month? a. ⌊__⌋ ⌊__.__.__⌋ Ghana Cedis In a bad month? b. ⌊__⌋ ⌊__.__.__⌋ Ghana Cedis	IF THE RESPONDENT DOES NOT KNOW, ENTER -99	
702	How much money on average do you receive in remittances from migrated household members each month?	⌊__⌋ ⌊__.__.__⌋ Ghana Cedis	RECORD AMOUNT IN CEDIS. HELP FARMER APPROXIMATE MONTHLY. PUT -99 IF UNKNOWN	
703	How many lending institutions do you **know** that would lend money to people like you?	⌊__⌋	HELP RESPONDENT TO LIST THE TOTAL NUMBER OF BANKS OR MFI'S OR OTHER OFFICIAL LENDERS THAT HE/SHE KNOWS ARE ACTIVE IN THE AREA	
704	Do you or any of your household members have any debts or loans at the moment? [INCLUDE PRE-FINANCING, FORMAL, SUSU AND NON-MONETARY DEBT]	⌊__⌋	0. No 1. Yes	→ 720 → 705
705	How many debts or loans does your household have?	⌊__.__⌋	ENTER TOTAL NUMBER OF LOANS	

NO	**706**	**707**	**708**	**709**	**710**	**711**	**712**	**713**	**714**	**715**
	With which lender do you or other household members have an outstanding debt?	Which household member is responsible for repaying this debt?	What type of debt is it?	How big was this loan when you took it?	How much do you still have left to pay?	What was the main purpose of the loan?	Did this loan require collateral?	How frequent are the repayments for this loan?	What was the term for this loan? (nr of months from the date when you borrowed to the date when you have to repay)	What was the interest rate applied to this debt? MONTHLY / YEARLY
1	_____	⌊__.__⌋	⌊__.__⌋	⌊__⌋ ⌊__.__.__⌋	⌊__⌋ ⌊__.__.__⌋	⌊__⌋	⌊__⌋	⌊__.__⌋	⌊__.__⌋	⌊__.__⌋, ⌊__⌋
2	_____	⌊__.__⌋	⌊__.__⌋	⌊__⌋ ⌊__.__.__⌋	⌊__⌋ ⌊__.__.__⌋	⌊__⌋	⌊__⌋	⌊__.__⌋	⌊__.__⌋	⌊__.__⌋, ⌊__⌋
3	_____	⌊__.__⌋	⌊__.__⌋	⌊__⌋ ⌊__.__.__⌋	⌊__⌋ ⌊__.__.__⌋	⌊__⌋	⌊__⌋	⌊__.__⌋	⌊__.__⌋	⌊__.__⌋, ⌊__⌋
4	_____	⌊__.__⌋	⌊__.__⌋	⌊__⌋ ⌊__.__.__⌋	⌊__⌋ ⌊__.__.__⌋	⌊__⌋	⌊__⌋	⌊__.__⌋	⌊__.__⌋	⌊__.__⌋, ⌊__⌋
	STARTING FROM THE MOST RECENT DEBT	USE NUMBERS AND NAMES FROM HOUSEHOLD ROSTER	1. Bank loan 2. Individual MFI loan 3. Group MFI loan 4. Moneylender loan 5. SUSU loan 6. Cooperative loan	RECORD AMMOUNT IN GHANA CEDIS. IF RESPONDENT DOES NOT KNOW, ENTER –99	RECORD AMMOUNT IN GHANA CEDIS. IF RESPONDENT DOES NOT KNOW, ENTER –99	1. Cocoa farming 2. Other farming 3. Non-farm business 4.Home improvements 5. Food consumption 6. School fees	0. No 1. Yes	RECORD NUMBER OF WEEKS.	RECORD NUMBER OF MONTHS. IF RESPONDENT DOES NOT	RECORD PERCENTAGE. IF RESPONDENT DOES NOT KNOW, ENTER –99

	INCLUDE ALL INFORMAL LOANS		7. PC/LBC loan 8. Loan from input supplier 9. Acquaintance/family 10. Specify _____ _____			7. Social events 8. Certification 9. Pay debt 10. Health issues 11. Old age provisions 12. Other_____		FOR EXAMPLE, ENTER 4 FOR MONTHLY PAYMENTS, ENTER 24 FOR BI-ANNUAL PAYMENTS	KNOW, ENTER –99	

NO	**716**	**717**	**718**	**719**
	Would you have wanted to take a higher loan at the same interest rate?	How much more would you have wanted?	Why did you not receive what you wanted?	Have you found it difficult to repay this debt?
1	⌊__⌋	⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	⌊__⌋	⌊__⌋
2	⌊__⌋	⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	⌊__⌋	⌊__⌋
3	⌊__⌋	⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	⌊__⌋	⌊__⌋
	0. No →719 1. Yes →717	RECORD AMMOUNT IN GHANA CEDIS. IF RESPONDENT DOES NOT KNOW, ENTER –99	1. No collateral 2. They said I was not able to repay the loan 3. I had too many outstanding debts 4. Lending policy of the institution 5. Other, _____	1. Not at all 2. Yes, but I always made payments in time 3. Yes, I was sometimes late with payments 4. Yes, but I got another loan to cover my debt

NO	QUESTIONS AND FILTERS	ANSWER	CODING CATEGORIES	SKIP
720	Do you want to take a loan?	⌊__⌋	0. No. 1. Yes	→724 →721
721	How much do you want to borrow?	⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋ Ghana Cedis	RECORD AMMOUNT IN GHANA CEDIS.	
722	What do you need to borrow money for?	a. ⌊__⌋ b. ⌊__⌋ c. ⌊__⌋	1. Cocoa farming 2. Other farming 3. Non-farm business 4. Home improvements 5. Food consumption 6. School fees 7. Social events 8. Certification 9. Pay debt 10. Health issues 11. Old age provisions 12. Other_____	
723	Why did you not taken a loan?	⌊__⌋	1. No collateral 2. They said I was not able to repay the loan 3. Lending policy of the institution 4. No one came to offer me a loan 5. I know I would not get it 6. Other, _____	
724	Did you receive an in-kind loan (e.g. input supplies on credit, other goods or services on credit)?	⌊__⌋	0. No 1. Yes	→725 →724
725	What was the value of in-kind loan received in the last 12 months?	⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋ Ghana Cedis	RECORD AMMOUNT IN GHANA CEDIS. IF RESPONDENT DOES NOT KNOW, ENTER –99	
726	In the past 12 months did your household face severe financial difficulties because they needed to pay back a loan to: a. a bank d. a moneylender/SUSU	a. ⌊__⌋ d. ⌊__⌋ b. ⌊__⌋ e. ⌊__⌋ c. ⌊__⌋ f. ⌊__⌋	0. No 1. Yes	

	b. a microfinance institution (individual loan) e. a shopkeeper c. a microfinance institution (group loan) f. an acquaintance/family			
727	In the last 12 months, what was the total value of assets that you or your household had to sell in distress because of loan-related financial distress?	⌊__⌋⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋ Ghana Cedis	REPORT TOTAL VALUE OF ASSETS SOLD INCLUDE LIVESTOCK AND DURABLE GOODS. ENTER 0 IF NOT APPLICABLE.	
728	Suppose you are offered a loan of 1,000 Ghana Cedis to be paid back in 6 months. After 6 month you must pay back 1,500. Would you be willing to take up this loan?	⌊__⌋	0. No 1. Yes	
729	Suppose you are offered a loan of 1,000 Ghana Cedis to be paid back in 1 year. After 1 year you must pay back 1,300 Ghana Cedis. Would you be willing to take up this loan?	⌊__⌋	0. No 1. Yes	

Module 8 Savings

NO	QUESTIONS AND FILTERS	ANSWER	CODING CATEGORIES	SKIP
801	Do you or anyone in your household have a self-owned savings bank account? ONLY INCLUDE FORMAL BANK ACCOUNTS	⌊__⌋	0. No 1. Yes	→804 →802
802	What is the main purpose of that bank account savings? UP TO 3 MAIN PURPOSES IN ORDER OF IMPORTANCE	a.⌊__⌋ b.⌊__⌋ c.⌊__⌋	1. Cocoa farming 2. Other farming 3. Non-farm business 4. Home improvements 5. Food consumption 6. Education costs 7. Social events (Funerals, weddings) 8. Certification 9. Paying debt 10. Health issues 11. Old age provisions 12. Too keep family/friends from asking money from me 13. Self-insurance 14. Other:_____	
803	How much do you have in bank savings at the moment?	⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋ Ghana Cedis	RECORD AMOUNT. IF THE RESPONDENT DOES NOT KNOW, ENTER -99	
804	What is the main reason not to save money at a bank?	⌊__⌋	1. I don't have money to save 2. I don't trust banks 3. The bank is too far away 4. I want to open an account but don't know how 5. I want to open an account but I'm not allowed to 6. I want to open an account but it's too expensive to open 7. Other, specify _____	
805	What is the main purpose of your non-bank savings? INCLUDE SUSU, SAVINGS AT HOME AND ALL SAVINGS THAT ARE NOT ON A BANK ACCOUNT UP TO 3 MAIN PURPOSES IN ORDER OF IMPORTANCE	a.⌊__⌋ b.⌊__⌋ c.⌊__⌋	1. Cocoa farming 2. Other farming 3. Non-farm business 4. Home improvements 5. Food consumption 6. Education costs 7. Social (Funerals, weddings) 8. Certification 9. Paying debt 10. Health issues 11. Old age provisions 12. Too keep family/friends from asking money from me 13. Self-insurance 14. I don't have any savings 15. Other:_____	
806	Are you a member of a Fanteakwa savings group?	⌊__⌋	0. No 1. Yes	→811 →807
807	In the last year how much of your certification premium was saved at the Fanteakwa-savings group account?	⌊__⌋	0. I do not yet qualify for the certification premium 1. none 2. close to ½ 3. close to all premium money	
808	Does the group oblige you to save a certain amount periodically besides the certification premium?	⌊__⌋	0. no 1. yes every week 2. yes every month	→810 →809

			3. yes after every harvest	→809 →809
809	How much does the group oblige you to save periodically?	⌊__⌋⌊__⌋⌊__⌋ Ghana Cedis	RECORD AMOUNT OF CEDIS. IF UNKNOWN, ENTER -99	
810	What does the group use the savings for mostly?	⌊__⌋	0. no particular purpose 1. for emergencies 2. for equipment (sprayer, vehicle, drying machine etc) 3. rotating fund 4. invest in treasury bills 5. Seedlings garden / nursery 6. Members' other farming activities 7. Community works 8. I don't know	
811	Are you or anyone from your household saving with SUSU? INCLUDE SUSU MAN AND SUSU SAVING GROUPS	⌊__⌋	0. no 1. yes, SUSU individual savings 2. yes, SUSU saving group	→ 814 → 812 → 812
812	Does the SUSU oblige you to save a certain amount periodically?	⌊__⌋	0. no, I give him money when I have something to save 1. yes every day 2. yes every week 3. yes every month	
813	How much money do you have with the SUSU?	⌊__⌋⌊__⌋⌊__⌋⌊__⌋ Ghana Cedis	RECORD AMOUNT. IF UNKNOWN, ENTER -99	
814	Do you use mobile money services?	⌊__⌋	0. No 1. Yes	→ 818 → 815
815	How much money on average do you [Send/Receive] per month?	Send a. ⌊__⌋⌊__⌋⌊__⌋⌊__⌋ Receive b. ⌊__⌋⌊__⌋⌊__⌋⌊__⌋	RECORD AMOUNT. IF THE RESPONDENT DOES NOT KNOW, ENTER -99	
816	Do you have a mobile money account?	⌊__⌋	0. No 1. Yes	→ 818 → 817
817	How much do you have saved on your mobile money account?	⌊__⌋⌊__⌋⌊__⌋⌊__⌋ Ghana Cedis	RECORD AMOUNT. IF THE RESPONDENT DOES NOT KNOW, ENTER -99	
818	How much in total do you have in savings at the moment? INCLUDE ALL FORMAL AND INFORMAL SAVINGS	⌊__⌋⌊__⌋⌊__⌋⌊__⌋ Ghana Cedis	RECORD AMOUNT. IF THE RESPONDENT DOES NOT KNOW, ENTER -99	
819	Do you think about the time when you may not able to work anymore because of old age?	⌊__⌋	0. Never 1. Sometimes 2. Often	→ 901 → 822 → 822
820	Would saving money for old age be of interest to you?	⌊__⌋	0. No 1. Maybe in the future 2. Yes	

Module 9 Other farming activities

NO.	QUESTIONS AND FILTERS	ANSWER		CODING CATEGORIES	SKIP
901	Do you or your household farm any other crop besides cocoa? INCLUDE FOOD AND NON-FOOD CROPS, AND INTERCROPPING	⌊__⌋		0. No 1. Yes	→914 →902
902	Do you or your household pay a **land lease** on land for other agricultural activities?	⌊__⌋		0. No 1. Yes	→905 →903
903	On how much land does your household pay lease, not engaged in cocoa farming)?	⌊__⌋⌊__⌋⌊__⌋⌊__⌋	1. Hectares 2. Traditional Acres 3. Poles	RECORD SIZE AND UNIT. IF THE RESPONDENT DOES NOT KNOW, ENTER -99	

904	What is the annual rent cost for this land you lease, not engaged in cocoa farming)?	⌊_⌋⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋⌊_⌋ Ghana Cedis	RECORD YEARLY RENT VALUE
905	Do you or your household **own** land not engaged in cocoa farming?	⌊_⌋	0. No →906 1. Yes →907
906	How much land does your household **own**, not engaged in cocoa farming?	⌊_⌋⌊_⌋⌊_⌋⌊_⌋ Unit _____	RECORD SIZE AND UNIT. IF THE RESPONDENT DOES NOT KNOW, ENTER -99

NO	**907**	**909**	**910**	**911**	**912**	**913**
	After Cocoa, which other agricultural products is your household producing or did produce in the last 12 months? INCLUDE FOOD AND NON-FOOD CROPS, AND INTERCROPPING. START FROM MAIN PRODUCTS	How many times a year do you harvest [PRODUCE]?	How much of [PRODUCE] did you harvest in the last harvest time?	How much of the [PRODUCE] harvested last time did you sell?	At what price did you sell [PRODUCE] the last time? CEDIS / UNIT	Unit
1	⌊_⌋⌊_⌋	⌊_⌋⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋	_____
2	⌊_⌋⌊_⌋	⌊_⌋⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋	_____
3	⌊_⌋⌊_⌋	⌊_⌋⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋	_____
4	⌊_⌋⌊_⌋	⌊_⌋⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋	_____
5	⌊_⌋⌊_⌋	⌊_⌋⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋	_____
	1. Ground nut 7. Pineapple 14. Rice 2. Oil palm 8. Mango 15. Corn 3. Rubber 9. Paw-paw 16. Pepper 4. Cassava 10. Banana 17. Okra 5. Plantain 11. Passion fruit 18. Chilli 6. Yam 12. Potato 19. Voacanga 13. Tomato 20. Citrus 21. Other_____	RECORD PRICE	RECORD QUANTITY		RECORD GHANA CEDIS	RECORD UNIT USED IN QUESTIONS 910-912

NO.	QUESTIONS AND FILTERS	ANSWER	CODING CATEGORIES	SKIP
914	Do you or your household own any animals or fish?	⌊_⌋	0. No 1. Yes	→919 →915

	915	**916**	**917**	**918**
	Which animals did you own in the last 12 months?	How many [LIVESTOCK] do you currently own?	How many [LIVESTOCK] did you sell in the last 12 months?	At what price did you sell [LIVESTOCK] the last time?
1	⌊_⌋	⌊_⌋⌊_⌋⌊_⌋	⌊_⌋⌊_⌋⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋
2	⌊_⌋	⌊_⌋⌊_⌋⌊_⌋	⌊_⌋⌊_⌋⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋
3	⌊_⌋	⌊_⌋⌊_⌋⌊_⌋	⌊_⌋⌊_⌋⌊_⌋	⌊_⌋ ⌊_⌋⌊_⌋⌊_⌋

4	⌊__⌋	⌊__⌋⌊__⌋⌊__⌋	⌊__⌋⌊__⌋⌊__⌋	⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋
	1. Cattle 2. Goats 3. Poultry 4. Grass cutter 5. Guinea foul 6. Pigs 7. Sheep 8. Fish 9. Other: _____	RECORD NUMBER	RECORD QUANTITY	RECORD PRICE PER FULL ANIMAL

919	In the last 3 months, how much did you and your household earn from selling self-produced products such as:	Palm oil? a. ⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋ Ghana Cedis Ground nut paste? b. ⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋ Ghana Cedis Palm Wine? c. ⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋ Ghana Cedis Honey? d. ⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋ Ghana Cedis Bush Meat? e. ⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋ Ghana Cedis Firewood? f. ⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋ Ghana Cedis Local soap? g. ⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋ Ghana Cedis Other _____ h. ⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋ Ghana Cedis	RECORD EARNINGS IN GHANA CEDIS. IF NOT APLICABLE ENTER 0. IF THE RESPONDENT DOES NOT KNOW THE EXACT AMOUNT HELP TO APPROXIMATE TO THE MOST REASONABLE ESTIMATE. IF RESPONDENT DOES NOT KNOW, ENTER -99	

Module 10 Non-farm activities

NO.	QUESTIONS AND FILTERS	ANSWER		CODING CATEGORIES	SKIP
1001	Do you or your household have any non-farm business activities?	⌊__⌋		0. No 1. Yes	→ 1101 → 1002
NO	**1002**	**1003**	**1004**	**1005**	**1006**
	What kind of non-farm business activities did you or your household do in the last month?	Which household members are involved in [ACTIVITY]?	What was the total income from [ACTIVITY] activity in the last month? REPORT AMOUNT IN GHANA CEDIS	What were the total operating costs related to [ACTIVITY] in the last month? (eg. Labour, materials and other variable costs) EXCLUDE FIXED ASSET INVESTMENT COSTS	How much did you or your household need to invest to start up [ACTIVITY]? (e.g. machinery or other equipment) INCLUDE FIXED ASSET INVESTMENT COSTS
1	_____	a. ⌊__⌋ b. ⌊__⌋ c. ⌊__⌋	⌊__⌋⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	⌊__⌋⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	⌊__⌋⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋
2	_____	a. ⌊__⌋ b. ⌊__⌋ c. ⌊__⌋	⌊__⌋⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	⌊__⌋⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	⌊__⌋⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋
3	_____	a. ⌊__⌋ b. ⌊__⌋ c. ⌊__⌋	⌊__⌋⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	⌊__⌋⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	⌊__⌋⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋
4	_____	a. ⌊__⌋ b. ⌊__⌋ c. ⌊__⌋	⌊__⌋⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	⌊__⌋⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	⌊__⌋⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋
5	_____	a. ⌊__⌋ b. ⌊__⌋ c. ⌊__⌋	⌊__⌋⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	⌊__⌋⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	⌊__⌋⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋
6	_____	a. ⌊__⌋ b. ⌊__⌋ c. ⌊__⌋	⌊__⌋⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	⌊__⌋⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋	⌊__⌋⌊__⌋ ⌊__⌋⌊__⌋⌊__⌋
		USE NUMBERS FROM HOUSEHOLD ROSTER	RECORD VALUE. IF RESPONDENT DOES NOT KNOW ENTER -99	RECORD VALUE IN GH. CEDIS. IF RESPONDENT DOES NOT KNOW ENTER -99	RECORD VALUE IN GH. CEDIS. IF RESPONDENT DOES NOT KNOW ENTER -99

Module 11 Shocks

NO.	QUESTIONS AND FILTERS	ANSWER	CODING CATEGORIES	SKIP
1101	In the last 12 months, did your household experience drought, floods, bushfire, or landslides?	⌊__⌋	0. No 1. Yes	
1102	In the last 12 months, did your household experience unusually high level of pests and disease on your farms?	⌊__⌋	0. No 1. Yes	
1103	Does your household have one or more of these insurances? a. Crop insurance b. Livestock insurance c. Health insurance d. Funeral Insurance	⌊__⌋ ⌊__⌋ ⌊__⌋ ⌊__⌋	0. No 1. Yes	

Module 12: Social Capital

Group / Institution	**1201**	**1202**	**12**	**1204**	
	How frequently do you interact with [PERSON]	In the past 3 months did you **give** money or goods to [PERSON]?	How much did you give / what was the value of goods that you gave?	In the past 3 months did you **receive** money or goods from [PERSON]?	How much did you receive / what was the value of goods that you received?
Village chief and elders	⌊__⌋	⌊__⌋	_____	⌊__⌋	_____
Spiritual leader	⌊__⌋	⌊__⌋	_____	⌊__⌋	_____
Farmer group leaders	⌊__⌋	⌊__⌋	_____	⌊__⌋	_____
Certification managers	⌊__⌋	⌊__⌋	_____	⌊__⌋	_____
People in your community		⌊__⌋	_____	⌊__⌋	_____
	0. Hardly ever 1. Less than once monthly 2. At least once monthly 3. At least once weekly 4. At least once daily	0. No → 1204 1. Yes → 1203	HELP FARMER ESTIMATE THE AMOUNT OF MONEY OR THE VALUE OF GOODS GIVEN	0. No → End of survey 1. Yes → 1205	HELP FARMER ESTIMATE THE AMOUNT OF MONEY OR THE VALUE OF GOODS GIVEN

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The road to this “meagre booklet” of 150 pages was a fascinating journey of perseverance in face of adversities of professional and personal nature, some of which include: a failed business idea, an unsuccessful project, failed field experiment, thousands of research papers and books read ‘for nothing’, thousands of pages written and sent into the recycling bin, not to mention the countless lines of code which just wouldn’t run or wouldn’t yield anything interesting… to mention a few. Persevering through all that as a single mom, with a non-Economics background attempting a Ph.D. in Development Economics has been quite a challenge, to say the least. I really did beat the odds, but it took a village… I have so many people to thank for believing in me and supporting me throughout every step of the way. I will start with acknowledgments related directly to Ph.D. support directly, and end with purely emotional support.

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Education Certificate

Diana Kos
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	2015	1.0
Writing research proposal	WUR	2016	6.0
Research Data Management	WGS	2016	0.4
'Commitments versus flexibility regarding take-up of pension savings accounts: a randomised control trial on cocoa farmers in Ghana'	ICRS, Lima, Peru	2017	1.0
A2 Integrating research in the corresponding discipline			
Advanced Econometrics (YSS34306)	WUR	2016	6.0
Agricultural Economics & Policy	WASS	2016	2.0
Risk Analysis and Risk Management in Agriculture: updates on modelling and applications	WASS	2018	3.0
Communications with the media and the general Public	WGS	2018	1.0
Big Data course	WUR	2016	0.3
B) General research related competences			
B1 Placing research in a broader scientific context			
Efficiency summer school: Parametric Efficiency Productivity Analysis	WASS	2019	3.0
Experiments in Developing Countries: Methods and Applications	University of Groningen	2015	2.0
Qualitative Data Analysis	WASS	2017	2.5
B2 Placing research in a societal context			
Organising and moderating a working session on the use of technology to enhance SME inclusion in agricultural trade	WTO Public Forum 'Trade 2030'	2018	1.0
C) Career related competences/personal development			
C1 Employing transferable skills in different domains/careers			
Project and Time Management	WGS	2016	1.5
Brain Training	WGS	2016	0.3
Research Project management	NWO-WOTRO	2015-2018	2.0
Total			**33.0**

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

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