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The role of social capital in adoption of risky versus less risky subsidized input supplies: An empirical study of cocoa farmers in Ghana

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ABSTRACT

This study evaluates the effect of social capital on farmers' adoption of subsidized 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 subsidized 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 argue that this difference results from 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.

1. 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 et al., 2013). Adoption of modern technologies in agriculture, such as fertilizers and improved seeds, can significantly increase productivity (Besley and Case 1993; Just and 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

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Anderson 2003; Dercon and Christiaensen, 2011; Foster and Rosenzweig, 2010; and Magruder, 2018). Low demand for technology adoption can range from heterogeneity in perceived benefits and profitability (Foster and Rosenzweig, 2010), time and risk aversion (Chetty and Looney, 2006; Dercon and Christiaensen, 2011; Emerick et al., 2016; Foster and Rosenzweig, 2010; Yesuf and Bluffstone, 2009; Yu and Nin-Pratt, 2014), psychological costs of changing habits (Banerjee and Duflo, 2007), lack of liquidity, especially through the lack of availability of credit (e.g., Foster and Rosenzweig, 2010; Karlan et al., 2014; Magruder, 2018; Yesuf and 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; 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; 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. Boahene et al., 1999; Coleman et al., 1966; Deaton, 1997, Grootaert and Van Bastelaer, 2002, Ryan and Gross, 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, study 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 obtaining reliable information by observing behaviour of peers and/or by sharing knowledge with peers through peer-to-peer contact (horizontal connectedness). Social capital can also help 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.[1] 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 the individual utility function of a farmer 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 12 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 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,[2] and their resulting access to resources. In this case social capital has the potential to overcome extension inefficiencies in distributing inputs, which will help farmers to get timely access to the right inputs. Moreover, social status may be important in terms of eluding existing regulations, and thus may help to come around government requirements for access. Social capital may then even be used to bribe government officials and/or extension officers. 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 Fig. 1 below.

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 ha (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

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

[2] 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.

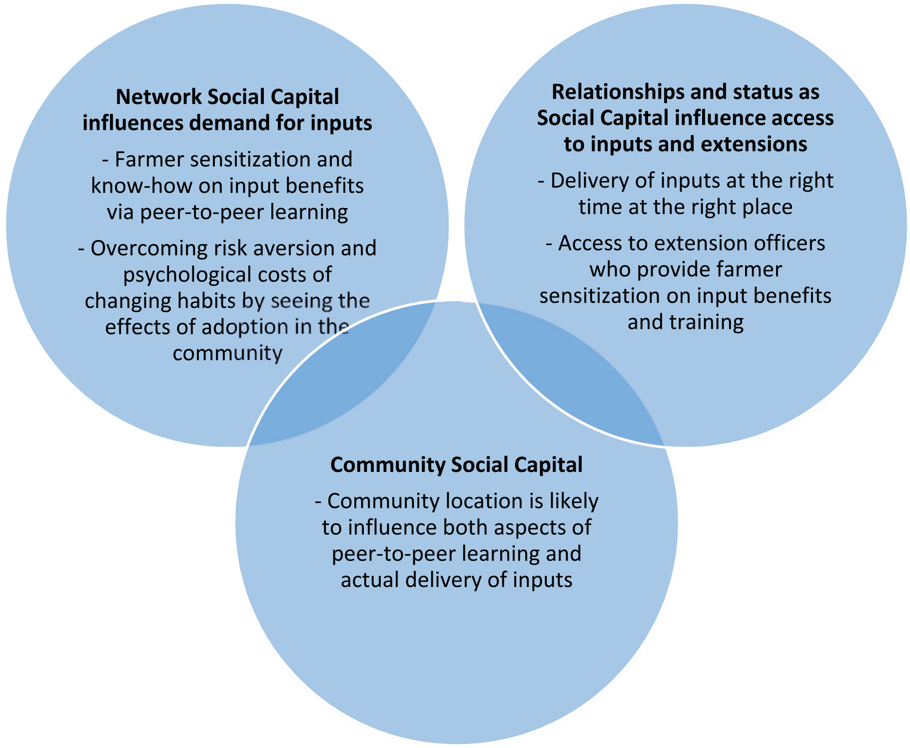

Fig. 1. The expected effect of social capital on access to input supplies.

farmers with access to subsidized input supplies, like fertilizer and seedlings, and also with services, like pest control (farm spraying) and farm mapping.[3] While the government regulations and subsidies aim to enhance adoption of improved inputs, there is no evidence that these policies actually increased input use.

We use a sample of farmers from the Eastern Region of Ghana, who are all members of a cooperative, Fanteakwa Union. This cooperative has approximately 2200 members across 25 communities, with a management team which groups farmers, and coordinates certification and value-chain collaboration, including access to inputs. Apart from the fact that some of our social capital variables are measured in the context of the cooperative, all analyses relate to inputs adoption at the individual farm level. This paper is divided as follows. In Section 1 we describe the existing theory of social capital and form hypotheses based on this theory; Section 2 describes the context of the study; Section 2 discusses the model, methods and variables used; Section 3 summarizes the results, Section 4 presents conclusions and policy recommendations.

1.1. 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 "neo-capital theory" by Lin (2017). Neo-capital 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 and Christopher, 2001; Dercon and Christiaensen, 2011; Feder et al., 1985; Foster and Rosenzweig, 2010; and Magruder, 2018). Information allows agents to discover opportunities and choices that they would have otherwise not known about. Grootaert and Van 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, farmers' 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. Farmers 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 and Gross (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 and 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

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

et al., 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 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, this doesn't imply that social networks may not play a very important role in terms of promoting technology adoption. One of the impediments to seedlings' adoption is higher risk aversion (Chetty and Looney, 2006, Dercon and Christiaensen, 2011), which makes farmers less willing to undertake activities and investments even when they have high expected returns (Lipton 1968; Rosenzweig and Binswanger 1993). There might be some uncertainty about the yields of hybrid seedlings, which can be overcome if farmers interact more with their peers, and by doing so obtain more information about the profitability of using new technologies, either by observing behaviour of their peers, or by sharing knowledge with them. Given the riskiness of the investment and the opportunity costs associated with it, farmers might rely on their social networks for the most accurate information about the returns of the new technology 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 an increase in reliable information, either via observing behaviour of other farmers in the farmer group, or by knowledge sharing, 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 latter looks at the nature of the relationship. Social capital, defined as a mix of structural, relational and cognitive dimensions of relationships (Khayesi and George, 2011), is found to be a primary mechanism that enables individuals to mobilize resources (Adler and Kwon, 2002; Nahapiet and 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 et al., 2000). Putnam et al. (1994) 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 and 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 and 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 and Richardson (1986) defines social capital in the context of social relations that increase the ability of an actor to advance her/his interests. Ahuja (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 and 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 hypothesize (second hypothesis) that relational social capital measured in terms of social status within a community and the farmer cooperative increases individual farmers' adoption of input supplies (seeds and fertilizer) e.g. as relational social capital increases the ability of an actor to advance her/his interests (second hypothesis). Relational status may especially be important in terms of eluding existing regulations, and thus may help to come around government requirements for access. 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 from community social capital, arguing that "community 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 and Richardson (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 and Richardson, 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.

2. Methodology and empirical application

2.1. 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 and Vigneri, 2011; LaanLaurens, 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 have 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 and 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 farm services, such as farm mapping and pest control, and farming goods, such as access to 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[4]), 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 in2013[5]), Olam Ghana Limited, and Cargill Kokoo Sourcing Ltd. LBCs send Purchasing Clerks (PCs) directly to farm gates to purchase cocoa.[6] 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 and 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 et al., 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.

2.2. 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. Hybrid seedlings have consistently been provided for free. Yet, farmers 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 heavily subsidized, there were limited quantities of free fertilizer available, limiting farmers' access to it (Bymolt et al., 2018).

2.3. 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 2200 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

[4] http://mofa.gov.gh/site/?p=11406.

[5] https://www.ft.com/content/020b18d2-4ad8-11e3-8c4c-00144feabdc0.

[6] For a complete list of all 28 LBCs, refer to http://mofa.gov.gh/site/?p=11406.

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. Apart from ensuring that farmers comply with the certification requirements of Fairtrade, the management team has only limited influence on production decisions at the individual level.

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 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, 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.[9] 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, 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%).[10] 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. Moreover, 10% of the farmers that have access to seedlings have not cleared their land, and 14% of the farmers that have access to fertilizer have not cleared their land. Somehow, these farmers found ways to come around the government requirements for access. Perhaps social capital has played a role.

2.4. Survey design and data collection

Our survey sample consists of 1503 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.

2.5. 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:

$$Y = \alpha + \beta \mathrm{N} + \Upsilon \mathrm{S} + \delta C + \mathrm{I} + \varphi F + \varepsilon \tag{1}$$

for OLS and,

$$P = F(Z) = \frac{1}{1+e^{-z}} = \frac{1}{1+e^{-(\alpha+\beta N+\Upsilon S+\delta C+\zeta I+\varphi F+\varepsilon\ )}} \tag{2}$$

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 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).

2.6. Variables description

Seeddum and *Fertilizerdum* are dependent, binary variables defining whether farmers have access to seedlings and fertilizer respectively. They are defined as follows. The seedlings dummy equals one if the amount of seedlings that a farmer received for the cocoa farms exceeds zero. This dummy equals zero, if the farmer did not receive any seedlings for the cocoa farms. The dummy for fertilizers is constructed in the same way, e.g. the dummy equals one if the amount of bags and/or bottles of fertilizer received for all cocoa farms exceed zero; this dummy equals zero if the amount of bags and the amount of bottles of fertilizers obtained equals zero.[11]

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

[7] See the Appendix, survey Module 6 on Farmer services, question 611.
[8] See the Appendix, survey module 6, questions 603 and 604.
[9] See the Appendix, survey Module 6, question 611.
[10] 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%.
[11] Note that both dummies do neither correct for farmers who do not need access to seedlings and/or fertilizer nor for farmers who want to have more seedlings or fertilizer.

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.[12]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 leader* (leader 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.

2.7. 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 'none'). 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.[13] 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[14]

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,[15] 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.[16]

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. Note, however, that our sample of

[12] Note that our approach does not imply that we assume that meeting various types of agents should always work in the same direction as, in theory, meeting different types of people may have opposite effects. For instance, for some reasons, spiritual leaders may oppose new seedlings. The signs of the factor loadings determine whether different types of agents have a similar effect, or an opposite effect. In our case, al factor loadings of the first factor (the one that is used in the analysis) happened to be positive. So, rather than imposing ex-ante that meeting different types of agent's work in the same direction, the factor analysis suggests that meeting different types of agents indeed work in the same direction. However, note that in the appendix we also present regressions where the network variable is based on principal component analysis (PCA). Regarding the PCA, the analysis suggests that 2 components need to be taken into account. In the principal (first) component, in line with the factor analysis, the different variables again all have the same sign, and hence indicate that meeting different types of agent's work in the same direction. However, in the second component, which is almost entirely driven by a very high positive loading for the certification manager, interactions with the spiritual leader and the farmer group leader (with small loadings, though) have opposite signs vis-à-vis interactions with the chief and the certification manager. The results of the factor analysis and the principal component analysis can be obtained on request.

[13] Information provided by cooperative management.

[14] There are a total of 25 communities within the cooperative.

[15] The variable "number of farms" indicates at how many farms (in terms of different ownership) a farmer works. Sometimes a farmer "owns" the main farm, but "leases" another farm.

[16] 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 1
Descriptive statistics of farm and network, relationships and community social capital variables.

Independent variables	No seedlings (n = 1115)	Adopted seedlings[a] (n = 386)	No fertilizer (n = 746)	Adopted fertilizer[a] (n = 755)	Adopted none[a] (n = 1271)	Adopted both[a] (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[a]:						
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[a]	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[a] (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[a]	31%	41%***	25%	3%***	32%	47%***
Land not cleared	15%	10%***	13%	15%*	14%	13%

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Note that the tests for significance of the difference in means refer to column 2 vs column 1; column 4 vs column 3; and column 6 vs column 5.
[a] Binary variables.

immigrants refer to first and second generation of immigrants, and that the group of immigrants is almost 50% of our entire sample. Hence, without controlling for other characteristics (which we will do in the regression analysis below), one should be careful in interpreting this result.

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.[17] 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.

2.8. 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 and Cochran, 1989). This hypothesis is rejected (X2 = 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

[17] Note that labour costs and land-preparation costs are farm-specific.

Table 2
Access to fertilizer and hybrid seedlings.

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

[a] The 12 binary variables refer to: (1) Ordinary member; (2) Spiritual leader; (3) Village elder; (4) Women's leader; (5) Spiritual leader; (6) Savings group leader; (7) Purchasing clerk; (8) Fanteakwa executive member; (9) Assembly man; (10) Formal sector employee; (11) Community chief farmer and (12) other.

only took this factor.[18] 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 ($X2 = 911.663$, p-value $= 0.000$) confirm that the farm variables were suitable for factor analysis.

3. Results

The results of the OLS regression using factor analysis are summarized in Table 3 below.[19] 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.

3.1. 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, measured by "status" only being a cooperative leader is significant. Note that our sample includes only one cooperative and hence only one cooperative leader. The fact that of our "status" dummies only the cooperative leader is significant suggests that social capital in the form of status only works at the top of the hierarchy. May be the cooperative leader is able to bribe government official's/extension officers. 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 Fig. 2and Community means tests table in the Appendix which depict which communities have significantly higher and which significantly lower access to seedlings[20]. During data collection, we also observed very poor roads for the three communities marked red in the areas close to the cooperative headquarters.

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.

3.2. 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 the adoption of seedlings, network social capital is less relevant. We have argued before that fertilizer application is less risky to farmers than seedlings applications. This difference in risk may explain the difference in results regarding the impact of social capital. However, it should be noted that we are not able to test this channel with our data set. More research is needed to fully explain the differences in results. 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 heavily subsidized. 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).

[18] 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.

[19] 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.

[20] 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[a]	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[b]				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[c]							−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	1312	1312	1312	1297	1297	1297	1066	1066	1066
Adjusted R-squared[d]	0.09	0.03	0.04	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.
[a] The number of observations of social status variable in question.
[b] Binary variable for whether farmer owns a car, bike or other means of transportation on wheels.
[c] Factor variable comprised of cocoa farm size (+), number of cocoa farms (+), total income (+) and proportion of income from cocoa (+).
[d] 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 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).

4. Conclusions and policy recommendations

The aim of this paper was to evaluate the effect of social capital on farmers' adoption of subsidized 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. While our dataset doesn't enable us to explicitly test the main channels by which social capital affects adoption of seedlings and 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 and Looney, 2006, Dercon and Christiaensen, 2011), which makes farmers less willing to undertake activities and investments even when they have high expected returns (Lipton 1968; Rosenzweig and 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 reliable 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. Social networks may improve the reliability of information as farmers may observe their peer's behaviour and may share information between each other. 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, especially the cooperative leader. Network learning is a powerful way of enhancing seedlings adoption. Although we have not tested this explicitly, it is likely that 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 for adoption (Karlan et al., 2014; Perez-Viana, 2019), but such intervention calls for further research for cocoa farmers specifically.

Second, we see that social status, except for the cooperative leader, 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, as mentioned before, 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.

4.1. 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 heavily 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.

4.1.1. 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.

Author confirmation statement

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). He/she is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. We confirm that we have provided a current, correct email address which is accessible by the Corresponding Author and which has been configured to accept email from (Robert Lensink: b.w.lensink@rug.nl).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jrurstud.2022.10.027.

References

Adler, P.S., Kwon, S., 2002. Social capital: prospects for a new concept. Acad. Manag. Rev. 27 (1), 17–40.
Ahuja, V., 1998. Land degradation, agricultural productivity and common property: evidence from Cote d'Ivoire. Environ. Dev. Econ. 3 (1), 7–34.
Ameyaw, G.A., Dzahini-Obiatey, H.K., Domfeh, O., 2014. Perspectives on cocoa swollen shoot virus disease (CSSVD) management in Ghana. Crop Protect. 65, 64–70.
Anderson, J.R., 2003. Risk in rural development: challenges for managers and policy makers. Agric. Syst. 75 (2), 161–197.
Azhar, R.A., 1991. Education and technical efficiency during the green revolution in Pakistan. Econ. Dev. Cult. Change 39 (3), 651–665.
Baah, F., Anchirinah, V., Badger, E., Badu-Yeboah, A., 2012. Examining the cocoa farmer-purchasing clerk relationship in Ghana. Glob. J. Sci. Front. Res. (GJSFR) 12 (11).
Banerjee, A., Chandrasekhar, A.G., Duflo, E., Jackson, M.O., 2013. The diffusion of microfinance. Science 341 (6144), 1236498.
Banerjee, A.V., Duflo, E., 2007. The economic lives of the poor. J. Econ. Perspect. 21 (1), 141–168.
Beaman, L., Dillon, A., 2018. Diffusion of agricultural information within social networks: evidence on gender inequalities from Mali. J. Dev. Econ. 133, 147–161.
Bertolozzi-Caredio, D., Bardají, I., Garrido, A., Berry, R., Bijttebier, J., Gavrilescu, C., Harizanova, H., Jendrzejewski, B., Meuwissen, M.P.M., Ollendorf, F., Pinsard, C., Rommel, J., Severini, S., Soriano, B., 2021. Stakeholder perspectives to improve risk management in European farming systems. J. Rural Stud. 84, 147–161. https://doi.org/10.1016/j.jrurstud.2021.04.004.
Besley, T., Case, A., 1993. Modeling technology adoption in developing countries. Am. Econ. Rev. 83 (2), 396–402.
Birkhaeuser, D., Evenson, R.E., Feder, G., 1991. The economic impact of agricultural extension: a review. Econ. Dev. Cult. Change 39 (3), 607–650.
Bitzer, V., Glasbergen, P., Leroy, P., 2012. Partnerships of a feather flock together? An analysis of the emergence of networks of partnerships in the global cocoa sector. Global Network 12 (3), 355–374.
Boahene, K., Snijders, T.A., Folmer, H., 1999. An integrated socioeconomic analysis of innovation adoption: the case of hybrid cocoa in Ghana. J. Pol. Model. 21 (2), 167–184.
Bolino, M.C., Turnley, W.H., Bloodgood, J.M., 2002. Citizenship behavior and the creation of social capital in organizations. Acad. Manag. Rev. 27 (4), 505–522.
Bonjean, Isabelle, 2019. Heterogeneous incentives for innovation adoption: the price effect on segmented markets. Food Pol. 87, 101741.
Bourdieu, P., Richardson, J.G., 1986. Handbook of Theory and Research for the Sociology of Education. Greenwood Press, New York.
Brune, L., Giné, X., Goldberg, J., Yang, D., 2016. Facilitating savings for agriculture: field experimental evidence from Malawi. Econ. Dev. Cult. Change 64 (2), 187–220.
Bymolt, R., Laven, A., Tyszler, M., 2018. Demystifying the Cocoa Sector in Ghana and Côte d'Ivoire. The Royal Tropical Institute (KIT).
Caselli, F., Coleman, W.J., 2001. Cross-country technology diffusion: the case of computers. Am. Econ. Rev. 91 (2), 328, 328.
Centola, D., Macy, M., 2007. Complex contagions and the weakness of long ties. Am. J. Sociol. 113 (3), 702–734.
Chetty, R., Looney, A., 2006. Consumption smoothing and the welfare consequences of social insurance in developing economies. J. Publ. Econ. 90 (12), 2351–2356.
Cocobod, 2018. accessed in spring 2018). https://cocobod.gh/oursubsidiaries.php.
Coleman, James S., Katz, Elihu, Herbert, Menzel, 1966. Medical Innovation: A Diffusion Study. Bobbs-Merrill Company, Indianapolis.
Coleman, J.S., 1994. Foundations of Social Theory. Harvard University Press.
Comin, D., Hobijn, B., 2004. Cross-country technology adoption: making the theories face the facts. J. Monetary Econ. 51 (1), 39–83 (use of capital letters is not consistent).
Conley, T., Christopher, U., 2001. Social learning through networks: the adoption of new agricultural technologies in Ghana. Am. J. Agric. Econ. 83 (3), 668–673.
Deaton, A., 1997. The Analysis of Household Surveys: a Microeconometric Approach to Development Policy. The World Bank.
Dercon, S., Christiaensen, L., 2011. Consumption risk, technology adoption and poverty traps: evidence from Ethiopia. J. Dev. Econ. 96 (2), 159–173.
Dorward, A., 2009. Rethinking agricultural input subsidy programmes in a changing world. Paper prepared for the Trade and Markets Division, 1–54 (Food and Agricultural Organisation of the United Nations, Centre for Development, Environment and Policy, SOAS).
Emerick, K., de Janvry, A., Sadoulet, E., Dar, M.H., 2016. Technological innovations, downside risk, and the modernization of agriculture. Am. Econ. Rev. 106 (6), 1537–1561.
Feder, G., Just, R.E., Zilberman, D., 1985. Adoption of agricultural innovations in developing countries: a survey. Econ. Dev. Cult. Change 33 (2), 255–298.
Foster, A.D., Rosenzweig, M.R., 2010. Microeconomics of technology adoption. Am. Econ. Rev. 81 (3), 883–939.
Gockowski, J., Afari-Sefa, V., Sarpong, D.B., Osei-Asare, Y.B., Dziwornu, A.K., 2011. Increasing income of Ghanaian cocoa farmers: is introduction of fine flavour cocoa a viable alternative. Q. J. Int. Agric. 50, 175–200, 892–2016-65197.
Gollin, D., Morris, M., Byerlee, D., 2005. Technology adoption in intensive post-green revolution systems. Am. J. Agric. Econ. 87 (5), 1310–1316.
Gordon, J., 1976. Cocoa production in West Africa. In: Simmons, J. (Ed.), Cocoa Production. Economic and Botanical Perspectives. FAO.
Grootaert, C., Van Bastelaer, T., 2002. Conclusion: Measuring Impact and Drawing Policy Implications. The Role of Social Capital in Development, pp. 341–350.
Jackson, M.O., 2010. Social and economic networks. In: Social and Economic Networks. Princeton university press.
Just, R.E., Zilberman, D., 1983. Stochastic structure, farm size and technology adoption in developing agriculture. Oxf. Econ. Pap. 35 (2), 307–328.
Kaiser, H.F., 1960. The application of electronic computers to factor analysis. Educ. Psychol. Meas. 20, 141–151.
Karlan, D., Osei, R., Osei-Akoto, I., Udry, C., 2014. Agricultural decisions after relaxing risk and credit constraints. Q. J. Econ. 129, 597–652.
Khayesi, J.N., George, G., 2011. When does the socio-cultural context matter? Communal orientation and entrepreneurs' resource accumulation efforts in Africa. J. Occup. Organ. Psychol. 84 (3), 471–492.
Kolavalli, S., Vigneri, M., 2011. Cocoa in Ghana: shaping the success of an economy. Yes, Africa can: success stories from a dynamic continent 201, 258643–1271798012256.
Laan, van Der H. Laurens, 1987. Marketing West Africa's export crops: modern boards and colonial trading companies. J. Mod. Afr. Stud. 25 (1), 1–24.
Lin, J.Y., 1991. Education and innovation adoption in agriculture: evidence from hybrid rice in China. Am. J. Agric. Econ. 73 (3), 713–723.
Lin, N., 2017. Building a network theory of social capital. Social capital 3–28.
Lipton, M., 1968. The theory of optimizing peasant. J. Dev. Stud. 4, 327–351.
Magruder, J.R., 2018. An assessment of experimental evidence on agricultural technology adoption in developing countries. Ann. Rev. Resour. Econ. 10, 299–316.
Nahapiet, J., Ghoshal, S., 1998. Social capital, intellectual capital, and the organizational advantage. Acad. Manag. Rev. 23 (2), 242–266.
Nakano, Y., Tsusaka, T.W., Aida, T., Pede, V.O., 2018. Is Farmer-To-Farmer Extension Effective? the Impact of Training on Technology Adoption and Rice Farming Productivity in Tanzania, vol. 105. World Development, pp. 336–351.
N'Guessan, K.F., 2013. Major pests and diseases, situations and damage assessment, protocols in Côte d'Ivoire. In: Presentation at Regional Workshop on Integrated Management of Cocoa Pests and Pathogens in Africa, 15 to 18 April 2013, Accra.
Narayan, D., Pritchett, L., 1999. Cents and sociability: household income and social capital in rural Tanzania. Econ. Dev. Cult. Change 47 (4), 871–897.
Nkamleu, G.B., Keho, Y., Gockowski, J., David, S., 2007. Investing in agrochemicals in the cocoa sector of Côte d'Ivoire: hypotheses, evidence and policy implications. African J. Agric. Resour. Econ. 1 (No. 2), 145–166, 2007.
Nkamleu, G.B., Nyemeck, J., Gockowski, J., 2010. Technology gap and efficiency in cocoa production in West and Central Africa: implications for cocoa sector development. African Dev. Bank: Abidjan, Côte d'Ivoire 1–18.
Onumah, J.A., Al-Hassan, R.M., Onumah, E.E., 2013. Productivity and technical efficiency of cocoa production in Eastern Ghana. J. Econ. Sustain. Dev. 4 (4), 106–117.
Perez-Viana, B., 2019. Risk and Development: an Experimental Study of Insurance Demand and Risky Decision Making in Rural Uganda, PhD Thesis. University of East Anglia, UK.
Putnam, R.D., Leonardi, R., Nanetti, R.Y., 1994. Making Democracy Work: Civic Traditions in Modern Italy. Princeton University Press.
Quarmine, W., 2013. Incentives for smallholders to enhance the production of quality cocoa beans in Ghana: the role of institutions. Research.wur.nl 1–170.
Renzulli, L.A., Aldrich, H., Moody, J., 2000. Family matters: gender, networks, and entrepreneurial outcomes. Soc. Forces 79 (2), 523–546.
Reisinger, H., 1997. The impact of research designs on R2 in linear regression models: an exploratory meta-analysis. J. Empir. Gen. Mark. Sci. 2, 1–11.
Rosenzweig, M., Binswanger, H., 1993. Wealth, wealth risk and the composition and profitability of agricultural investments. Econ. J. 103–416, 56–78.
Ruf, F., 2009. Libéralisation, cycles politiques et cycles du cacao: le décalage historique Côte-d'Ivoire-Ghana. Cah. Agric. 18 (4), 343–349.
Ryan, B., Gross, N.C., 1943. The diffusion of hybrid seed corn in two Iowa communities. Rural Sociol. 8 (1), 15.
Shapiro, H.Y., Rosenquist, E.M., 2004. Public/private partnerships in agroforestry: the example of working together to improve cocoa sustainability. Agrofor. Syst. 61 (1–3), 453–462.
Simtowe, F., 2006. Can risk-aversion towards fertilizer explain part of the non-adoption puzzle for hybrid maize? Empirical evidence from Malawi. J. Appl. Sci. 6 (7), 1490–1498.

Snedecor, G.W., Cochran, W.G., 1989. Statistical Methods, eighth ed. Iowa State University Press.
Takahashi, Kazushi, Muraoka, Rie, Otsuka, Keijiro, 2020. Technology adoption, impact, and extension in developing countries' agriculture: a review of the recent literature. Agric. Econ. 51 (1), 31–45.
World Bank, 2008. World Development Report. Agriculture for Development, Washington, DC (World Bank).
Yesuf, M., Bluffstone, R.A., 2009. Poverty, risk aversion, and path dependence in low-income countries: experimental evidence from Ethiopia. Am. J. Agric. Econ. 91 (4), 1022–1037.
Young, H.P., 2009. Innovation diffusion in heterogeneous populations: contagion, social influence, and social learning. Am. Econ. Rev. 99 (5), 1899–1924.
Yu, B., Nin-Pratt, A., 2014. Fertilizer adoption in Ethiopia cereal production. J. Dev. Agric. Econ. 6 (7), 318–337.