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Index-based weather insurance for perennial crops: A case study on insurance supply and demand for cocoa farmers in Ghana

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ABSTRACT

Adaptation to climate change is crucial for many farming households around the world. Due to path dependencies, perennial crop farmers often face a confined set of adaptation options. This paper explores the potential for index-based weather insurance for cocoa as an example of a perennial crop. The paper presents empirical findings on determinants of interest in index insurance based on a sample of 313 cocoa farming households in Ghana. Further, results of key informant interviews with representatives relevant for the planning and implementation of index insurance are presented.

A key finding on the demand side is that more than 90% of the sampled cocoa farmers are interested in index insurance. The main determinants for interest were ownership of the cocoa farm, access to extension services, and age of the cocoa farm. For the supply side, main findings are that while stakeholders showed a general appreciation of the conceptual benefits of index insurance, a plethora of disadvantages and obstacles relating to insurance implementation were mentioned ranging from insufficient data and infrastructure, over low profitability, to wrong perceptions of insurance among farmers. The paper concludes that structural changes to the cocoa economy are necessary to address these impediments in the long run.

1. Introduction

Climate change with temperature increases, erratic rainfall and increased frequency of extreme events is negatively impacting food security in many parts of the world (FAO, 2017; IPCC, 2019). The tropics are particularly vulnerable to climate change due to agricultural yield decline paired with the prevailing high dependency on the primary sector for food, jobs and revenue (Rosenzweig, Elliott, Deryng, Ruane, Müller, Arneth, & Jones, 2014; Thiault et al., 2019). Adaptation strategies aiming at decreasing smallholders' vulnerability to climate change can be divided into two groups – short-term options for incremental change and more long-term strategic responses (Holzkämper, 2017).

In this paper, we focus on index-based weather insurance as one long-term response strategy. Index-based weather insurance (index insurance) is a financial adaptation option that pays out benefits based on a predetermined level of a weather variable e.g. rainfall level, temperature, floods or droughts (Ahmed, 2013). It uses triggers from these weather indices instead of actual loss assessments on a farm (Ellis, 2017). The triggers are set to a weather station to detect extreme events. Premiums are normally defined based on payout which is related to the expected income or cost of production (Ellis, 2017). Time-series weather data is a prerequisite for index insurance contract design (Leblois, Quirion, Alhassane, & Traoré, 2014). Insurance companies have used different approaches to set triggers in different countries: for instance, cumulative rainfall levels, droughts, yield-indices for an area, or vegetation cover levels (Carter, Janvry, Sadoulet, & Sarris, 2014; International Labor Office, 2011). Index insurance has a uniform structure and does not require trained experts to check or confirm losses, and thus has comparatively low administrative costs. This helps to avoid loss adjustment by both the insurer and the insured which lessens risks, enhances trust and avoids alterations (Carter et al., 2014; Greatrex, Hansen, Garvin, Diro, Blakeley, Le Guen, & Osgood, 2015; Shahadat, 2013). Index insurance can operate as a stand-alone contract or can be linked up to credit for buying farm inputs, which in turn can render insured farmers more credit-worthy than uninsured ones (Meze-Hausken, Patt, & Fritz, 2009).

Given that index insurance is a fairly new insurance solution in

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developing countries, there is need to assess the demand for the insurance product among farmers (Budhathoki, Lassa, Pun, & Zander, 2019). So far, many studies have been conducted on index insurance for annual crops (Budhathoki et al., 2019; Hill, Hoddinott, & Kumar, 2013; Senapati, 2020) but very little is known on insurance demand among perennial crop farmers, whose decision processes are likely to be different due to the crops' long-term perspective and resulting path dependency for the farmers (Gunathilaka, Smart, & Fleming, 2018; Zinnanti, Schimmenti, Borsellino, Paolini, & Severini, 2019). Moreover, effective implementation hinges not only on the demand for insurance but also on its supply. Few studies shed light on the needs, e.g. in terms of data availability, of the supply side (Kimengsi & Azibo, 2015).

In this paper we start to fill these gaps by presenting findings on the demand for index insurance among cocoa farmers in Ghana, as well as on the opportunities, needs and threats that are relevant to the supply side of index insurance. We expect that our empirical findings from Ghana will help advance a balanced understanding of the market potential but also the institutional challenges related to index insurance for cocoa, as an example of a perennial crop.

2. Literature review

2.1. Determinants of demand

Referring to indemnity insurance products, a risk averse agent is expected to fully insure provided there is an offer for an actuarially fair premium (Smith, 1968). However, this assumption derived from a utility maximization framework is often not reflected in empirical findings on index insurance uptake in developing countries. Clarke (2016) presents a model of rational demand for index insurance that points to the existence of basis risk as one conceptual explanation for low uptake among poor households.

Basis risk, is a mismatch between index measurement at a weather station and the actual incurred loss due to variation in local conditions and microclimates (Leblois & Quirion, 2013; Skees, 2008). If basis risk occurs, farmers do not receive payout for their loss (Fonta, Safiétou, Boubacar, & Boubacar, 2015; Greatrex et al., 2015; Leblois et al., 2014). Thus, basis risk can worsen a farmer's situation and make index insurance lose its appeal (Leblois & Quirion, 2013; Patt, Suarez, & Hess, 2010). In the same way, this mismatch can lead to farmers receiving payout without encountering yield loss (Ellis, 2017). Basis risk falls under two risk categories; spatial and model basis risk. Spatial basis risk arises from differences in slope, altitude, latitude, longitude and distance from farms to weather stations (Norton, Turvey, & Osgood, 2012). Most often, distance from weather stations to farms determines basis risk and hence, demand for index insurance (Mobarak & Rosenzweig, 2012). The average distance from a farm to a weather station is about 20 km to 30 km in most developing countries (Leblois & Quirion, 2013). Meanwhile, a difference of 10 km can have a significant influence on microclimate. Unpaid losses due to basis risk can make farmers more vulnerable than before.

Model basis risk occurs from risks which are not weather related e.g. pests or disease infestations. Addressing basis risk is expected to enhance demand for index insurance (Carter et al., 2014; Kapondamgaga & Fisher, 2011). A key question for our empirical investigation is thus whether the existence of basis risk negatively impacts farmers' interest in index insurance.

Apart from basis risk, the empirical literature on index insurance provides indications of various other factors that are also likely to impact farmers' interest in index insurance. For example, previous experience with extreme events has been found to increase willingness to pay for insurance (Budhathoki et al., 2019; Liu, Tang, Ge, & Miranda, 2019). Previous experience with credit and insurance products has also been found to positively impact farmers' interest in crop insurance in Ghana (BalmaIssaka, Wumbei, Buckner, & Nartey, 2016). By intuition, access to extension advice could likely increase farmers' interest in novel solutions. However, previous studies rather found that access to extension advice decreased farmers' willingness-to-pay (WTP) for index insurance, possibly as a consequence of their awareness of a large set of adaptation alternatives (Budhathoki et al., 2019).

While most empirical studies on index insurance focus on annual crops or livestock, few have addressed perennial crops. Afriyie-Kraft, Zabel, and Damnyag (2020) argue that due to the current economic superiority and perennial nature of cocoa trees which causes path dependencies, cocoa farmers' adaptation decisions differ from those of annual crop farmers. The implications of path dependency in terms of commitments for repaying investments and limited adaptation options are likely to be most stringent for younger cocoa plantations. We thus expect that interest in index insurance as financial adaptation strategy is higher among farmers with younger trees and lower among farmers with older trees. However, based on data from Côte d'Ivoire, Kouame and Komenan (2012) found that cocoa farmers' WTP for insurance increases with the age of the cocoa trees. They argue that as trees grow older, yield declines and farmers' incomes become more vulnerable, which creates an incentive to insure against additional weather induced risks.

Households that derive a large share of income from cocoa farming are expected to be more likely to be interested in index insurance than households that are less dependent on income from cocoa (Teshome & Bogale, 2015). Similarly, we argue that ownership of the cocoa plantation provides a long-term perspective. We expect that farmers who own their land are more likely to be interested in index insurance than non-owners. Previous studies report mixed results in terms of significance and sign on socio-demographic controls such as gender, age of household head, household size, and education (Jensen, Mude, & Barrett, 2018; Kwadzo, Kuwornu, & Amadu, 2013).

2.2. Preconditions for supply

Index insurance requires time series weather data to serve as a baseline for the insurance policy (Wang, Karuaihe, Young, & Zhang, 2013). Unfortunately, most developing countries lack adequate weather stations and reliable time-series weather and yield data. Further issues like structural breaks in the available time series data and limitations of remote sensing data can hamper up-scaling of insurance products to large regions (Ahmed, 2013; Fonta et al., 2015; Ndamani & Watanabe, 2016). Several studies have shown that weather data limitation weakens the reliability of index insurance contracts (Fonta et al., 2015; Leblois & Quirion, 2013; Noujeima, Belkacem, & Mimoun, 2013). Other limitations include the enabling environment, inadequate government subsidies and low capacity of extension agents to train farmers (Ndamani & Watanabe, 2016). Several measures can help to reduce basis risk. These include: i) higher resolution analysis tailored to the microclimate of farms; ii) ample rain gauge installation to capture triggers; iii) community-based data to set index thresholds; iv) careful index selection, well-planned contracts; v) quality and reliable yield and weather data to set thresholds (about 20–30 years) to mark the expected trend of losses; and vi) a satellite-derived crop specific vegetation index (Kost, Laderach, Fisher, Cook, & Gomez, 2012; Leblois & Quirion, 2013; Leblois et al., 2014; Noujeima et al., 2013).

Index insurance requires high start-up investments of human and financial capital to design a standard product. It takes substantial investments to train and build capacity among farmers to understand the basic principles of insurance policies (Collier, Skees, & Barnett, 2009; Nimoh, Baah, & Tham-Agyekum, 2011). However, local insurance companies often lack sufficient financial resources to start index contracting (Shahadat, 2013; Skees, 2008).

3. Case study

The cocoa sector of Ghana provides income to more than 800′000 farming families (Asamoah & Owusu-Ansah, 2017). Cocoa is produced in rain-fed plantation systems, mostly in the south and south-western parts of the country. Ample and evenly distributed rainfall throughout the year is required for the healthy growth of cocoa trees. According to ICCO (2013), an annual rainfall level of between 1500 mm and 2000 mm is required for optimum cocoa yield. However, too much rainfall above this upper limit can result in increased incidence of black pod disease in cocoa plantations (ICCO, 2013). For instance, annual rainfall amounts below 1250 mm makes cocoa trees lose more water due to evaporation, while annual rainfall above 2500 mm results in fungal infestation of cocoa trees (Wood & Lass, 1985). Extreme climatic events i.e. rainfall variation, temperature or the length of drought periods are expected to increase in the West African cocoa belt (Schroth, Läderach, Martinez-Valle, Bunn, & Jassogne, 2016).

As in other regions of the tropics, there is great need for adaptation strategies to improve households' resilience to the impacts of the shifting climatic patterns. While crop diversification is a common strategy for farmers of annual crops, this strategy is not available to farmers of perennial crops, where path dependencies confine the set of adaptation choices and any major changes to the production system typically entail substantial cost (Gunathilaka et al., 2018; Zinnanti et al., 2019).

In view of these challenges, insurance has been proposed as financial adaptation strategy (Mason, Asare, Cenamo, Soares, Carrero, Murphy, & Bandari, 2016). Formerly, in Ghana the extended family system served as security net during difficult times (Kpoor, 2015; Meze-Hausken et al., 2009). This type of traditional insurance can function well for idiosyncratic shocks, e.g. due to injury or death of a household member, but is likely to fail in case of covariate risks (Meze-Hausken et al., 2009). At present, no formal agricultural insurance policy exists for cocoa production in Ghana. The Ghana Agricultural Insurance Pool (GAIP) is currently the only agricultural insurance service provider in the country who gives insurance to annual crop farmers on a pilot basis (Ellis, 2017).

However, the design of the index insurance is similar to the multi-peril crop insurance scheme in Ghana. In Ghana, and particularly in the cocoa producing regions in and close to the savannah transition ecological zone, perils such as bushfires and drought are covariant in nature and occur over a large area in these regions. These perils exhibit a high frequency and high impact on crop output in general. As a result of these features, Kwadwo, Kuwornu, and Amadu (2013), recommend that weather index-insurance products are piloted for bushfires and drought. Kwadwo et al (2013) further recommend that the government provides subsidies for the provision of weather station equipment and to enable insurance companies to validate liability of claims by farmers.

3.1. Study area

The study was conducted in the Dormaa West district (DWD) of Brong Ahafo region and the Bia East district (BED) of Western region in Ghana. While the DWD is located in the transitional zone, the BED is located in the moist semi-deciduous forest zone, south of DWD (Fig. 1). DWD has an annual rainfall level ranging between 1250 mm and 1750 mm and temperature ranging from 26.1 °C to 30 °C (Ghana Statistical Service [GSS], 2014b). The district has an estimated total area of 381 km^2, known to be prone to dry spells which have negatively affected cocoa production and yield in the area. BED has an annual rainfall ranging between 1250 mm and 2000 mm and temperature from 25.5 °C to 30 °C (Ghana Statistical Service [GSS], 2014a). This district has an estimated total land area of about 783 km^2. BED has favorable climatic conditions, good soil and vegetation cover. DWD and BED are among the main cocoa producing areas in Ghana.

3.2. Data collection

Our research questions on index insurance demand and supply called for two data collection phases. We collected household-level

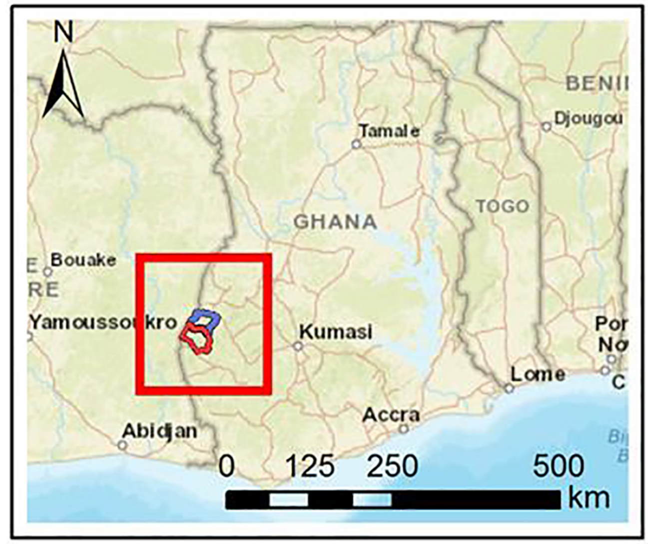

Fig. 1. Geographic representation of the study area: Dormaa West (blue) and Bia East district (red). Source: Own illustration from GPS data. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

survey data from 313 randomly selected households in 20 communities. The communities themselves were randomly selected, 10 each from the two districts Dormaa West and Bia East. To prepare the surveys, one focus group discussion was held in each district. The survey consisted of a semi-structured set of questions including respondents' socio-economic characteristics, experiences of risks in cocoa production, experiences of insurance, and their interest in index insurance. Open questions were used to let farmers explain why they were interested or not in index insurance. The data was collected during spring 2017.

For the supply side, we first conducted a stakeholder analysis to understand which organizations can affect cocoa index insurance policy design and implementation in Ghana. Key informant interviews were then conducted with representatives of the following organizations: the reinsurance companies SwissRe and MunichRe, the meteorological organizations-Swiss Meteodat and Ghana Meteorological Agency (GMA), the Ghana Agricultural Insurance Pool (GAIP), the finance division of the Ghana Cocoa Board (COCOBOD), and the Cocoa Research Institute of Ghana (CRIG). The objective was to explore which opportunities and threats these organization associate with weather index insurance and what their views are on requirements for index insurance policy design. Moreover, we collected their suggestions on how to address basis risk.

4. Results

4.1. Demand side – socioeconomic characteristics of respondents

Table 1 presents descriptive statistics of the variables used for the household-level analysis. The dummy variable 'Interest' indicates whether a respondent was generally interested in index insurance. We use the dummy 'Financial effects' as indicator for previous experience with weather events that caused financial effects for the respondent. The dummy variables 'Microfinance', 'Health insurance', and 'Extension' simply indicate whether the respondent has used these services. The variable 'Oldest' contains data on the age of the farmer's currently oldest cocoa plantation. The variable 'Cocoa-income-share' expresses which share of household income is derived from cocoa cultivation. The dummy variable 'Ownership' indicates whether the respondent owns the farm. 'Household size' and 'Gender' are simply control variables.

In our sample, the share of income derived from the cocoa sector, on average, is 69%. This value is similar to the findings of other studies in

Table 1
Respondents' socioeconomic characteristics and interest in insurance.

Variable	Specification	Mean	Std. Dev.	Min.	Max.	Freq.	Percent	N
Interest	0 = no, 1 = yes					291	93.27	312
Financial effects	0 = no, 1 = yes					305	97.44	313
Microfinance	0 = no, 1 = yes					124	39.62	313
Health insurance	0 = no, 1 = yes					232	74.12	313
Extension	0 = no, 1 = yes					278	88.82	313
Oldest	Age of oldest plantation	23.65	11.34	3	60			313
Cocoa-income-share		68.53	16.68	10	100			313
Ownership	0 = no, 1 = yes					264	84.35	313
Gender	0 = female, 1 = male					228	72.84	313
Household size		8.13	3.63	1	26			313

Ghana which report around 67% (Ghana Statistical Service, 2015; Vigneri & Kolavalli, 2018). Most households in our sample (84%) own their cocoa farms. This ownership structure corresponds to the findings by Asamoah and Owusu-Ansah (2017). However, the average household size in our sample is 8 persons, which is significantly larger than the national average of 5 persons in 2010. The differences remain when we compare our data to the census statistics of the two regions Brong Ahafo and Western region (Ghana Statistical Service, 2013). An explanation may be that our sample included only cocoa farmers while census data naturally represents the entire population. Based on these comparisons, we argue that our sample is representative for the cocoa growing sub-population.

4.2. Interest in taking index insurance cover

Table 2 presents two models. The first is the full model to test the hypotheses that we derived from the literature and it contains the two control variables household size and gender. The second model includes only the two variables that are significant in the full model and the variable 'oldest' which is our key variable to understanding the difference between previous studies on annual crops and this study on perennial cocoa trees. The pseudo R-squared values for the models are 0.35 and 0.32 respectively, indicating that they have moderate explanatory power. Apart from the constant, the coefficients' signs remain the same in the two models, which points to certain robustness of the results. Multicollinearity is not an issue in these models – the VIF values computed for the explanatory variables are all below 1.16.

Table 2
Logistic regression results.

	(1)	(2)
VARIABLES	interest	interest
financialeffects	1.273	
	(1.608)	
microfinance	0.632	
	(0.604)	
healthinsurance42	0.478	
	(0.598)	
extension	1.375**	1.409**
	(0.675)	(0.614)
oldest	−0.043	−0.048*
	(0.028)	(0.026)
cocoaincomeshare	−0.011	
	(0.018)	
ownership	3.703***	3.534***
	(0.670)	(0.631)
householdsize	−0.037	
	(0.074)	
gender	0.638	
	(0.680)	
Constant	−0.802	0.584
	(2.173)	(0.712)
Observations	312	312
Pseudo R-squared	0.351	0.327
Log likelihood	−49.946012	−51.818886
LR chi2	54.00	50.25
Prob > chi2	0.0000	0.0000

Standard errors in parentheses.
Significant at *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

In both models, the variables extension and ownership are significant and have a positive sign, revealing that cocoa farmers who have access to extension service as well as those who are owners of their land are more likely to show interest in index insurance. The variable 'oldest' has a negative sign in both models and is weakly significant in the second model. The negative sign implies that the likelihood that a cocoa farmer is interested in index insurance decreases with increasing age of the trees.

After asking farmers whether they are generally interested in index insurance, we asked open questions to let them explain their views. Those who were interested stated that they expected benefits in terms of protection, support and livelihood security. About two thirds of the respondents who were not interested explained that they have tenure issues and about one third responded either that they don't think insurance will work in Ghana or expressed a general distrust toward insurers.

For a further follow-up question, basis risk was explained to the respondents that had already expressed a general interest in the insurance. They were then asked the following question: If you did not receive payout although there was no or very little rainfall at your farm, would you still be willing to pay in the next season? About 60% answered yes. Frequent explanations were that one cannot always expect payout, basis risk could favor them in the next season, and that their decision will depend on the contract agreement.

4.3. Supply side – advantages and disadvantages

During the key informant interviews, respondents were asked to mention the advantages and disadvantages of index insurance for cocoa farmers (see Table 3 for a summary). One of the reinsurance companies and the Swiss meteorological organization highlighted advantages related to the general concept of index insurance, such as the lack of moral hazard. The respondents from Ghana rather focused on market opportunities and data availability. According to the respondent from GMA, there are about 100 weather stations distributed across the cocoa growing regions with 30 km intervals that are recording temperature and rainfall. Reliable gridded datasets dating back to the 1970s are available.

Various disadvantages were mentioned in all of the key informant interviews. The reinsurers anticipated problems of low adoption as against high administrative cost to design the product. In addition, issues of land title, land ownership and other legal systems, data and infrastructure availability could threaten implementation. It was further mentioned that cocoa farmers are poorly organized, which would make it difficult to reach out to them. GAIP specifically mentioned that index insurance business with farmers is unattractive and not profitable

Table 3
Key stakeholders' views on opportunities and threats.

	Opportunities	Threats
SwissRe	No loss adjustment, easy to payout, can insure micro loans by default	Model and spatial basis risks, Land ownership issues, Low adoption potential and profitability for insurers, Difficult to reach out to farmers: poor organizational structure, Huge upfront investment
MunichRe		Model basis risks, Poor infrastructure: limited weather stations, incomplete historical weather data, High administrative cost
Swiss Meteodat	No moral hazard or negative selection, less transaction cost	Inadequate weather stations, Unavailable quality data, Poor planning of index, Transparency, Access to information, Lack of farmers' understanding of index
GMA	About 100 weather stations, available and reliable weather data	Variation in weather data for different stations
GAIP	Large number of cocoa farmers, untapped market	Unattractive: the nature of farming practices, Not profitable due to high level of illiteracy and cost to educate farmers, Wrong perception of insurance among farmers, Unreliable meteorological report, Lack of risk management techniques
COCOBOD	Available yield data drawn from purchasing clerks	Incomplete socioeconomic data, Lack of baseline knowledge of index insurance
CRIG	Available yield and weather data, trained personnel	Complications in payment of premiums, Unknown quantity of cocoa produced by individual farmers, Lack of understanding of insurance among cocoa farmers

due to the following reasons: The nature of farming practices e.g. high dependence on rainfall, high illiteracy level of farmers and unreliable meteorological data. They further revealed that farmers have a wrong perception of insurance. Farmers were said to see insurance as free money and it would therefore involve high costs to educate farmers to change their perception of insurance. According to COCOBOD and CRIG, there is no baseline information about index insurance in Ghana to learn from. Respondents also anticipated that basis risks could threaten index insurance.

4.3.1. General requirements and suggestions to tackle basis risk

To be able to design and implement an insurance policy that is accessible to all, certain structures and procedures have to be laid out. Table 4 summarizes certain baseline requirements identified in the key informant interviews. Most of the respondents stated a need for a specific index designed purposely for cocoa and not one index for a number of different crops. In addition, the type of risk has to be clearly identified. Moreover, there have to be established local organizations or cooperatives to educate and possibly recommend index insurance to farmers. Extension officers have to be trained to teach farmers about climate smart ideas in general, and insurance in particular.

Various ideas on how to tackle basis risk were put forward. They referred to the design of the trigger, the inclusion of additional data sources and financial alleviation in terms of a decrease of the premium after several years without payout.

5. Discussion

The ambition of this paper was to shed light on the demand and supply side of index insurance tailored to perennial crops. Cocoa farming in Ghana served as case in point for our case study. Our household-level survey data revealed that more than 90% of the sampled cocoa farmers are generally interested in index insurance. This is a rather high value compared to findings from previous studies that ranged from 84% (Budhathoki et al., 2019), 77% (Zhang & Fan, 2016), 59% (BalmaIssaka et al., 2016) to 52% (Ali, 2013). The results of the logistic regression models revealed that farmers who have access to extension services are more likely to be interested in index insurance. This is intuitively plausible, given that farmers who regularly receive advice are likely to be more open to new adaptation options. Ownership of the farm was also found to increase the likelihood of being interested in index insurance. This finding was corroborated by responses to follow-up questions posed to those who were not interested in index insurance. The most frequently provided explanation for their lack of interest was land tenure issues. Moreover, we found weak support of our hypothesis that the likelihood of being interested in index insurance decreases with the age of the farm. This is contrary to the findings of Kouame and Komenan (2012) from Côte d'Ivoire. We argue that the negative relationship relates to path dependencies for perennial crop farmers which especially during the earlier years of their cocoa plantations need to secure income to support their livelihoods and to be able to repay any investment costs. Older or more mature plantations may have allowed farmers to establish savings and may give way to opportunities of opting out of the cocoa business if desired, making

Table 4
Key stakeholders' views on requirements and basis risk.

	Requirement of index insurance policy design	Adressing basis risk
SwissRe	Potential for insurance, Specific index for specific crop, Data availability, Education, Farmer cooperatives, Good number for start-up	Trigger based on key parameters and yield requirements of cocoa
MunichRe	Main risks, Relationship between historical weather and yield data, Reinsures: the volume insured by local insurers, cost and risks involved.	Very precise index that captures the production seasons, Complement weather data with satellite and NDVI data, Sell premium on community base
Swiss Meteodat	Type of risks, Clear understanding of premium-payout calculations, Historical and time-series data, Infrastructure, Specific crop index, Farmer cooperatives	Well-defined index thresholds
GMA	Availability of historical yield data, Good farm management practice, Mitigation measures for risks covered, Minimum of 100 farmers with farm size not less than 2 acres, Affordability of premium	Merge gauge and satellite data to provide stronger basis for evaluation of threshold
GAIP		25% refund of premium as farm inputs after three years of no strike, Control model basis risks e.g. pest and diseases, Strengthen the capacity of meteorological service and increase the density of weather stations, Combine weather and satellite data
COCOBOD	Biophysical data on farms -Farmer cooperatives, Farmers' income and ability to pay, Reliable time-series weather data, Clear implementation strategy, Capacity of insurance companies to design the policy	
CRIG	Cost-benefit of index insurance, Farmers' WTP	Use remote sensing technology, Build generic crop model for cocoa

insurance redundant.

Various key informant interviews were conducted with stakeholders that were deemed relevant for the planning and implementation of index insurance for cocoa producers in Ghana. While there appeared to be a general appreciation of the conceptual benefits of this type of insurance, a plethora of disadvantages and obstacles relating to insurance implementation were mentioned ranging from insufficient data and infrastructure, over low profitability, to wrong perceptions of insurance among farmers.

In both parts of the analysis we laid a special focus on basis risk. Among the cocoa farmers, 40% of the generally interested respondents indicated that they would not renew their insurance contract in case they are negatively affected by basis risk. This potential rate of withdrawals highlight the magnitude of the issue. Carefully designing the trigger and improving data quality and the diversity of data sources were the main recommendations put forward as remedies for basis risk in the key informant interviews.

A limitation of this study is that we did not delve into explaining details of the contract design. Our ambition was to investigate the general scope for index insurance for cocoa as a perennial crop. We argue that a more detailed study, e.g. of willingness to pay for a specific contract, will be needed as soon as the framework conditions in Ghana are such that insurance providers see favorable business prospects.

6. Conclusions

Concerning data availability and quality, there appears to be a certain discrepancy in the responses provided from stakeholders in Ghana and those in Europe. This points to a need for exchange and discussion to build a mutual understanding of what type and quality of data exists and what is required, e.g. by reinsurers.

The representatives of the insurance supply side expressed certain reluctance toward providing index insurance because they anticipate unprofitably low premiums. We suggest that cocoa producing companies and industries could subsidize a certain percentage of the insurance premium for the farmers. This way, farmers could obtain at least a minor level of insurance protection once they sell their cocoa to the company in question. Since COCOBOD operates under a monopolistic system, it could address this aspect together with international cocoa producers and industries. This could additionally serve as an incentive to sell cocoa in Ghana and a disincentive for cocoa smuggling to Cote d'Ivoire. Alternatively, there could be a declaration of free market operation by COCOBOD. This could enhance fair trade companies to come on board and possibly increase farmers' income and enhance their ability to pay for index insurance. At the same time, strong and well-functioning farmer cooperatives in different cocoa growing communities need to be established to ensure easy flow and dissemination of information.

The findings of this study point to several avenues for future research. A follow-up study could go beyond investigating general interest in index insurance to quantify cocoa farmers' willingness to pay for insurance premiums. Moreover, we argue that there is need for more case studies to shed light on adaptation strategies and demand for insurance among perennial crop farmers. Finally, the short list of studies presenting findings on farmers' interest in index insurance in the discussion section shows an increase in the reported percentage over time. This may point to a growing popularity of the concept or an increasing need to adapt to the changing weather. Such trends could be addressed in a meta-analysis of the empirical literature on index insurance.

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.

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