Three Essays on the Implications of a Double Trigger Mechanism for Area Yield-Based Index Insurance in Rural Communities: a Case Study from Burkina Faso

Dissertation

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By

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Declaration

I hereby declare that this work has not been submitted or accepted elsewhere other than for the fulfillment of the requirements of the Degree of Doctor of Philosophy (PhD) in International Development at the University of Ottawa. I am the sole author of this three-paper format thesis, which is the result of my own investigations. None of the three essays has been used in a previous thesis, nor has been published before the thesis proposal was approved. To the best of my knowledge, this three-paper format does not contain any material previously published or written by another author except where due reference is made in the text.

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Dedication

I dedicate this thesis to my entire family.

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Abstract

Rainfed agriculture is inherently risky, with climate change expected to intensify its variability. In the West African Sahel, where agriculture is crucial not only for subsistence but for national and household incomes through cotton production, the need to safeguard farmers' livelihoods against risk is essential. Formal crop insurance providers in such contexts cannot easily rely on traditional models, where indemnifications are based on realized losses, and have instead proposed a stream of index-based insurance products which indemnify clients based on a predefined, and yet objective parameter (the index). One promising product for Burkinabe cotton farmers is, the Double-Trigger Index-Based Insurance (2TIC), whose two-tier triggering mechanism has the potential of reducing moral hazard and minimizing basis risk. This dissertation uses three essays to consider a farmer-centric approach to assessing the implications of this double trigger mechanism for index-based insurance. The first essay explores cotton farmers' judgments of fairness vis-à-vis the 2TIC indemnification system by using Principal Component Analysis (PCA) and Logistic Regression Analyses, and examines if and how these judgments affect decisions to subscribe. The second essay assesses the impact of 2TIC on farmers' cotton-derived net income by employing Coarsened Exact Matching (CEM). The third essay compares the actuarially fair premium of the 2TIC with the commercial premium paid by cotton farmers, by using statistical approaches. The study provides important evidence-based insights into how 2TIC can be improved and promoted by incorporating farmers' needs and perspectives.

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List of Acronyms

AICB	Association Interprofessionelle du Coton du Burkina Faso
ATC	Agent Technicien Coton
ARBY	Area Yield Index Based Insurance
CMDT	Compagnie Malienne pour le Développement du Textile
FASO COTON	Cotonnière du Faso
FCFA	Francs de la Communauté Financière d'Afrique
GPC	Groupement de Producteurs de Coton
IBI	Index-Based Insurance
IBLI	Index-Based Livestock Insurance
SOCOMA	Société Cotonnière du Gourma
SOFITEX	Societé Burkinabé des Fibres et Textile
TCI	Traditional Crop Insurance
UNPCB	Union Nationale des Producteurs du Coton du Burkina
WIBI	Weather Index Based Insurance
2TIC	Double Trigger Index Based Insurance Contract

Definition of Terms

Term	Definition
Adverse Selection	A situation where highly risky famers purposely subscribe to the insurance contract as they anticipate larger gain by doing so
Basis risk	The imperfect correlation between losses incurred, and indemnity received
Covariate risk	Risk that is of a broader geographical coverage in terms of incident, such as drought, flood, earthquake
Credit Cooperatives	Groups where participating members make monetary contributions to a fund (held by an elder or a trustworthy person of the community) that is used as a capital that participants can borrow from.
Crop Diversification	The practice in which famers cultivate more than one staple crop
Dual-purpose cropping	The practice in which crop is used as a stock for grazing without reducing crop yield
False Negative	An incidence of under-compensation, where farmers who experienced a loss do not receive a payment
False Positive	An incidence of overcompensation, where farmers who did not experience a loss receive a payment
Half-moons	A land management technique consisting of a large hole in a semi-circle shape where the excavated material is deposited in the semi-circle to serve as a water retention mechanism and therefore contribute to maintain soil humidity.
Idiosyncratic risk	Inherent factors that are unique to every individual or household.
Indemnity	A compensation paid out to an insured client with the intent of bringing him/her back to the before loss financial situation.
Information Asymmetry	A situation of imbalanced access to information, whereby one party has more information than the other
Moral Hazard	As situation where parties engage in a specific behavior (they would have not, had they not been insured) to secure themselves a payout
Premium	Amount of money paid to have a risk transferred to an insurer

Resowing	The practice in which farmers sow a field multiple times in case previous sowing fail to sprout out, due to erratic rainfalls
Systemic risk	Risk affecting a broader geographical area.
Stone lines	The practice of depositing rocks along contour lines to slow the runoff of water from rainfall
Tontine	A rotating savings club where participating members make monetary contributions (on a regular basis) to a fund, which is then given to each participant on a rotating basis.
Trigger	A predetermined threshold or strike value used to set the index on which payment will be based on.
Underwriter	A professional who assesses risk exposure, in order to determine the pure price of the premium
Zaï	The practice consisting of "digging small holes in the field before the first rains, to retain runoff water

Chapter 1: Introduction

1.1 Background

1.1.1 Setting the Scene: An overview of Agricultural Risk Management Strategies

Agriculture is a prominent sector in most developing countries, especially those of the Sahel where it represents more than 40% of their GDP. Like many other entrepreneurial sectors, agriculture faces a myriad of risks that have been put under five categories: production risk (the category of interest for this Thesis), market risk, financial risk, institutional risk, and personal risk (Kahan, 2008; Komarek et al., 2020). Production risk is the possibility of obtaining a lower yield than expected, due to a weak or incomplete growth of the cultivated crop that can be attributed to adversities related to weather, climate, or pest invasion. As such, production risk is a concern that haunts the quietude of farmers, as it can decrease production output, which often turns out to be their major source of food and /or revenues. To address this concern, farmers in developing countries, including cotton farmers in Burkina Faso have been using a plethora of intervention mechanisms that can be categorized under: Production System Strategies, Livelihood Strategies, and Risk Sharing Strategies.

Regarding Production Systems Strategies, *resowing*, *dual-purpose cropping* and the use of *Drought tolerant/ resistant crops,* are farming techniques that farmers have employed to reduce their exposure to climate variability, and in this way be able to withstand shocks that would have negatively impacted yield and perhaps food availability (Adger, 2002; Kisha et al., 2014). Along with those farming techniques, *zaï (half-moons)* and *stone lines* are land management techniques that have been employed by farmers to augment water infiltration and retain the organic sediments that contribute to soil fertility, all in an attempt to improve crop yield.

With respect to Livelihood Strategies, *non-farm activities* are sources of asset accumulation that farmers have used to withstand the risks of climate hazards (De Janvry and Sadoulet, 2001; Whitehead and Kabeer, 2001; Devereux et al, 2005). *Seasonal migration* and *long-term migration* are additional means used by local farmers to escape from the misery of hazards such as droughts or to support the migrant's rural family members by accessing more distant employment options (Ezra & Gebre-Egziabher, 2001; Hunter, 2005; Assan 2008; Warner et al., 2010). Another coping mechanism used in response to the financial stress stemming from environmental hazards is *asset monetization*. In Sahelian countries, the severity of events such as drought has often obliged households to pawn their assets to end their desperate search for money. In Burkina Faso, it has been documented that farmers have often traded their livestock (such as poultry, cattle, donkeys) and agricultural equipment (such as hand hoes, ox plows, carts) for a quick monetary proceed (Sommerfeld et al., 2002).

As for Risk Sharing Strategies, traditional or informal methods based on social networks or kinship have been used by famers to cope with the financial fallout of endogenous or exogenous shocks. For instance, *tontines* (collective labor and savings groups), which are commonly used to cope with risks of unexpected expenses such as funerals, wedding, broken agricultural equipment, and livestock losses due to pest outbreak, were found to be an effective way of coping with the financial consequences of agricultural loss emanating from climate hazards in Nouna, a rural department located in Burkina Faso (Sommerfeld et al., 2002). Likewise, *credit cooperatives*, which enable participants members to usually borrow at a very low interest rate for expenses related to a fortunate/joyful event such as a wedding, also enable them to borrow at a zero interest rate for expenses related to unfortunate/sad events such as funeral, livestock losses due to pest outbreak, and harvest losses due to desert locust infestation, or flood (Sommerfeld et al., 2002). However, since those informal risk-sharing strategies are based on trust rather than contract (a legally binding agreement between two or more parties), they lack the legally enforceable agreement that would have rendered them attractive to lending institutions. This is an important consideration, since traditional land tenure arrangements in Burkina Faso, as in many developing countries, do not rely on land titles, which might otherwise serve as an acceptable collateral for lending institutions. As a result, in lieu of such forms of collateral, lending institutions accept formal risk-sharing strategies such as agricultural insurance, as a form of security (Mahul and Stutley, 2010). Hence for farmers, agricultural insurance serves not only a formal intervention mechanism to cope with risk, but also as a collateral that allows them to access credit.

1.1.2 Agricultural Insurance

Agricultural Insurance is a formal means of risk sharing, where the insured client (e.g., a farmer or a herder) pays a premium to the insurer with the expectation that in the event of any contractually agreed losses, they will receive a payout (indemnity) that will help cover the costs of these losses. For its ability to compensate for stochastic losses over time and across geographical space, insurance is perceived as an effective disaster risk reduction tool (Cutter, 1996). Hence, the Bali Action Plan supported climate-resilience development practices by promoting risk sharing and transferring mechanisms (UNFCCC/ CP/ 2007/6/Add.1, 2008, p.4). As a result, a wide diversity of insurance products has been introduced in the market, and they can be put under three categories: Catastrophe bonds (Cat-bonds), Traditional Crop Insurance (TCI), and Index Based Insurance (IBI). The current work will focus on the last two products.

Traditional Crop Insurance (TCIs)

TCIs also known as conventional insurance are indemnity-based formal risk sharing strategies, which protect crop producers against losses due to climactic hazards. TCIs are contracted before the occurrence of the hazard, and depending on the nature of the contract, they cover part, or all the actual losses realized by the insured client. This partial or entire coverage of farmers' losses enables insured farmers to maintain a certain level of income and to further pursue their agricultural activities, occupations that may have been stalled, had farmers not been able to recuperate from the full impact of the financial losses. Moreover, the opportunity for farmers to obtain an indemnity in an event of loss (meaning little risk of financial loss for lending institutions), encourage financial institutions to continue their lending venture, and in this way sustain farmers' access credit.

Farmers who are insured against loss will adjust their perceptions of the riskiness of agricultural ventures and, in the most favorable scenarios, will be incentivized to increase investment in a potentially profitable, income-generating crop (such as cotton) even under uncertain climatic or other conditions. However, given that the protection provided by insurance offers an opportunity to obtain an indemnity (in an event of loss), which can help insured clients maintain their level of income, insurance schemes like TCI have the ability of changing insured farmers' behaviors in other, less favorable ways. Indeed, knowing that an event of loss can lead to an indemnity payment, farmers could deliberately modify their behavior to engender an event of loss (e.g., diminish their investments in the insured crop or activity), in order to guarantee themselves a payout. This situation known as *moral hazard* is a

challenge in TCIs, as it can set a pattern where insured farmers behave differently from the way they would if they were fully exposed to risk, simply because there is a reward (the indemnity) in the end (Hill, 2010). For instance, holding a TCI that compensates for low yield could be a disincentive for farmers to exert greater efforts in order to obtain higher yield. As such, because of moral hazard, TCI can be counterproductive. A study by Roberts and co-authors that controlled for adverse selection shows that moral hazard was the main source of crop insurance inefficiency in the US, as it amounted to $53.7 million in indemnities, the equivalent of nearly 10% of indemnities paid between 1992 and 2001 (Roberts et al., 2014).
Another challenge encountered with TCIs is *adverse selection* (i.e., the decision to participate, or not, in a contract based on information that is known or hidden by one party). For instance, farmers with higher risk are more likely to contract crop insurance products, a decision, which will be at the expense of the insurance provider (Cole et al., 2012). Likewise, issuance providers are likely to avoid clients they believe are facing high risk. Makki and Somwaru found strong evidence of adverse selection in a crop insurance scheme that was provided to producers of corn and soybean in the state of Iowa, USA (Makki and Somwaru, 2001). Also, issues of adverse selection were observed in India's National Agricultural Insurance Scheme (NAIS), as farmers of the states of Punjab and Haryana who were deemed too high risk to receive loans were also left out of the insurance scheme (Ifft, 2009).

Systemic risk—risk that affects an entire geographical area—is another hurdle for TICs. Crop yield depends on factors such as geographical location, spatial coverage, weather conditions. While crop yield risks are highly correlated with these factors, the way TCIs are designed fails to capture these correlations. This results in systemic risks, which is very detrimental to the insurance provider as it may suffer major losses. An empirical analysis found that the portfolios of US crop insurers for the period 1985 to 1992 were 22 to 49 times riskier than if indemnities were independent, owing to systemic risks caused by weather effects (Miranda and Glauber 1997).

High administrative and operating costs are another drawback of TICs. Since TICs require the insurer to have detailed information about the client being insured, access to relevant and reliable information necessitate expenses that can be costly. With expenses related to (i) the underwriting process (which requires data collection), (ii) the claim filing process (which necessitates document completion and site assessment), TCIs amount to high administrative, operating and transaction costs in developing country contexts. A study by Hazell, which examined the ratio of paid indemnities to the non-subsidized premium shows that for every $1 USD in premium paid into a TIC, the indemnities paid out (plus average costs) are: $2.42 for Brazil, $2.80 for Costa Rica, $5.11 for India, $2.60 for Japan, $3.65 for Mexico, $2.42 for the USA, and $5.74 for the Philippines (Hazell, 1992). These ratios, which exceed one, underline the high administrative and operating costs of TCIs.

Moreover, TCIs insurance schemes are often criticized for their slow settlement procedure, due to the nature of their concept. Insured clients only receive their payments once the claims that they have filed are duly processed. Delays in the claims settlement process (resulting from the insurer's duties to first verify the accuracy of the damage reported by the insured client, then assess the cost of the damage, and finally issue the compensation amount) can delay the payments, especially if too many claims are filed at the same time, as would be the case in the instance of widespread drought or flood. For instance, referring to India's NAIS, it was found that delays in farmers' claim payments often exceeded one year, owing to difficulties in assessing damages and logistical issues associated with the payment process (Kalavakonda and Mahul, 2005).

In response to these challenges, the search for alternative formal risk sharing strategies led to the development of Index Based Insurance (IBI), an insurance product linked to an index (like rainfall) that is closely correlated with local yields. Using this index to predict when agricultural production losses will occur (instead of TCI's post facto claims process) offers a potentially more rapid protection for farmers against covariate shocks (Cole et al., 2012).

Index Based Insurance (IBI)

IBIs are formal risk sharing strategies anchored on a parametric indicator or index (Halcrow, 1948). As such, IBI covers the losses of the insured client only if a predefined parametric indicator (that is, the index) deviates from the historic average variable. Depending on the nature of the index, a variety of IBI products have been found in the index insurance market of developed and developing countries. Among them is the Weather Index Based Insurance (WIBI), which is based on weather related parameters such as precipitation. Other WIBI's products are based on evapotranspiration, an estimator of water evaporation and plant transpiration from a well-watered reference surface (Begueria et al. 2014). The evapotranspiration is an indication of water availability in plants, and therefore is a proxy for assessing their potential level of growth. There is Index-based Livestock Insurance (IBLI), whose index is linked to remotely sensed Normalized Differential Vegetation Index (NDVI), an indicator of vegetative cover and therefore a proxy for assessing potential forage availability (Chantarat et al., 2017). There is also Area-Based Yield Index Insurance (ARBY) whose index is based on historic average yield pertaining to a defined geographical area.

Unlike TCI, where compensations are given to clients based on their individual realizations of losses, IBI products (including WIBI, IBLI and ARBY) make payments to all clients if the predefined indicator variable (that is, the index) deviates in a prescribed, threshold manner from the historic average variable. In doing so, IBI has the potential of addressing the issue of systemic risk, therefore presenting an advantage once compared to TCI (Miranda and Gonzalez-Vega, 2015).

Another advantage of the index insurance is its potential to minimize moral hazard. Since IBI products in an ideal situation, use objective indicators that insured farmers have no ways of influencing, possible deliberate actions taken by insured famers to undermine their production would have no impact on the IBI's indemnification outcome. As a result, IBI has the capacity of reducing or fully eliminating risks of moral hazard. Also, the objective nature of indicators (such as temperature, rainfall, vegetation) used in IBI schemes that are accessible and verifiable to the public prevent the insurer from utilizing them to their advantage. As such, risks of adverse selection are minimized Thus, IBI has the potential of minimizing moral hazard and adverse selection, two concerns that are inherent with TCI (Hazell et al., 2010; Jensen et al., 2018). IBI has the additional advantage of not needing site assessment for claims filed, as is the case with TCIs. As a result, administrative and operating costs involving claim assessment should be lower, a feature that can both reduce program costs and speed up the indemnification process. With the cost saving aspect, IBI has the potential of being more affordable for low-income farmers and pastoralists, enabling them to allocate their additional revenues to other welfare-improving investments such as health and education.

While the aforementioned advantages make IBI a promising risk mitigation tool that can be useful in areas prone to weather shocks such erratic rainfall, drought, and floods, its design is rather a complex task. Like TCIs, IBI insurance products are not free from basis risk. With basis risk, an insured farmer can face a loss and not be compensated or be compensated without incurring a loss (Skees, 1999; Alderman & Haque, 2007; Barnett et al. 2008). For this imperfection, high basis risk is viewed as the main determinant of the low uptake of IBI products (Skees, 2008; Clarke, 2011; Mobarak and Rosenzweig, 2012; Jensen et al., 2018). To lower basis risk and continue to offer the advantages mentioned above, innovation in contract design has led to novel IBI products such as the Double Trigger Index Based Insurance (2TIC).

1.1.3 The Double Trigger Index Based Insurance (2TIC)

The Double-trigger Insurance Contract (2TIC) is an ARBY product with a dual trigger mechanism that protects the insured client against yields losses emanating from covariate shocks (such as erratic rainfall), which threaten agricultural production farmers' livelihoods and incomes (Carter 1997; Kazianga and Udry 2006, Dercon et al., 2012). The 2TIC was first introduced to cotton farmers in Mali with the purported goal of minimizing basis risk experienced under single trigger IBI schemes (Elabed and Carter, 2013). Building on the experience of the neighboring Mali —a country that is member of the Sahel region and shares the northern border of Burkina Faso—, a similar 2TIC product was proposed in 2013 to cotton producers in Burkina Faso, namely in the provinces of Balé, Mouhoun and Tuy. The cotton sector in Burkina Faso is coordinated geographically by local monopsonistic companies: SOFITEX covers the west, FASO COTON the center, and SOCOMA covers the east. In that monopsonistic organized environment, local companies provide cotton inputs on credit to farmers and later (at the end of the season) buy back the cotton output from the same farmers who are organized in Cotton Producer Groups (*Groupements de Producteurs de Coton*, or GPCs). This group-lending format anchored on a joint liability scheme was proposed in order to minimize moral hazard, as participating members will monitor the credit commitment of their peers, and in this way reduce risks of strategic default (Besley and Coates 1995; Ghatak and Guinnane, 1999). Taking advantage of the group lending format, the 2TIC was proposed in the form of a package "credit + insurance" under a contingent credit contract, meaning that the loan is linked with a credit contract that covers the value of the loan upon maturity (Farrin et al., 2015). This contingent risk credit format is attractive to farmers, who do not need to make an upfront payment to join the scheme and access inputs on credit. It is also attractive to lending institutions, since the deduction of the premium costs from farmers' payment for a successful cotton harvest means otherwise liquidity-constrained farmers are less likely to default on their loan repayment.

Three conditions are required for a farmer to be insured. First, the cotton farmer must be member of a GPC, which receives inputs for the group on credit. Second, the total cultivable land area of the GPC (which is the sum of all areas sown by cotton farmers, members of the GPC) must be located within the zone covered by the index insurance product. Third, the GPC's premium (i.e., the sum of individual premiums of the members of the GPC) must be collected by the financial institution (i.e., ECOBANK) prior to the beginning of the cotton farming season. With the contingent risk credit design of 2TIC, premium payments by the insured GPCs are authorized—before the start of cotton farming season— through the signing of a contract that legally binds the insured GPCs to the financial institution. However, the actual payment occurs after the harvest in a form of revenue deduction. In this way, revenue that insured farmers receive is the revenue from cotton output sold back to SOFITEX, net any unpaid joint liability credit that financed the 'cotton inputs and 2TIC premium'.

Indemnification Mechanism

With premium payments authorized before the start of the cotton-farming season, individual farmers of the insured GPC are entitled to the indemnities that their GPC will receive. Under the double trigger index insurance contract, a GPC receives an indemnity once two conditions (the triggers) are met concomitantly. The first condition or trigger, which is set at the GPC level, is met, once the current yield of the GPC (i.e., the yield of the GPC at the end of the cotton farming season) falls below a predetermined threshold (which in the case of Burkina Faso was calculated as the 12-year historical yield average threshold preceding the season). The second condition or trigger, which is set at neighboring GPCs level, is met once current yield of neighboring GPCs (i.e., the yield of the neighboring GPCs at the end of the season) falls below a similar historical average. According to the designers of the 2TIC, the motive for having a second trigger is to eliminate moral hazard, hence, instances when farmers of the same GPC might collude to obtain a lower yield that would guarantee them a payout. Another motive for having a second trigger is to reduce basis risk, which is the imperfect correlation between indemnity received and losses incurred. These imperfect correlations can be categorized into false positive—instances where farmers who did not experience a loss receive a payment— and false negative—cases where farmers who experienced a loss did not receive a payment— (Barré et al. 2016). In looking at the motives for having a second trigger, previous empirical studies have shown that the addition of the second, external trigger (based on performance of neighboring GPCs) is especially useful for minimizing false positives, e.g., payments to GPCs who had not actually incurred meaningful losses (Carter, 2007; Guirkinger, 2011, Elabed et al. 2013). A study that analyzed the quality of the 2TIC contract provided to cotton farmers of Mali and Burkina Faso revealed that setting the external threshold (i.e., the threshold of neighboring GPCs) to always exceed that of the insured GPC reduces false negatives, relative to the case where the external threshold is lower than that of the GPC (Bellemare et al., 2012).

Levels of Indemnification

Farmers are compensated according to terms of their signed contract, which offers indemnities based on the decrease (whether minor, moderate, or severe) in cotton yields. The contract whose premium in the study context amounts to 11, 200 FCFA/ha pays back 90,000 FCFA/ha for a severe loss, 34, 000 FCFA/ha for a moderate loss, and 11, 200 FCFA/ha for a minor loss (PlaNet Guarantee[1], 2014). The contract whose premium is 5, 600 FCA/ha reimburses 45,000 FCFA/ha for a severe loss, 17, 000 FCFA/ha for a moderate loss, 5, 600 FCFA/ha for minor loss (PlaNet Guarantee, 2017). The channeling of the indemnity—which is given in a form of a lump sum— goes from the insurance company (Allianz- Burkina[2]) to the lender (ECOBANK), and then, from the lender to the borrower (the insured farmer).

1 Founded in 2007 (headquartered in Paris, with field offices located in Burkina Faso, Cote d'Ivoire, Mali and Senegal) PlaNet Guarantee was renamed "Inclusive Guarantee" in March 2020. The name change is the result of a shift in the company's mission to focus on making insurance accessible to all.

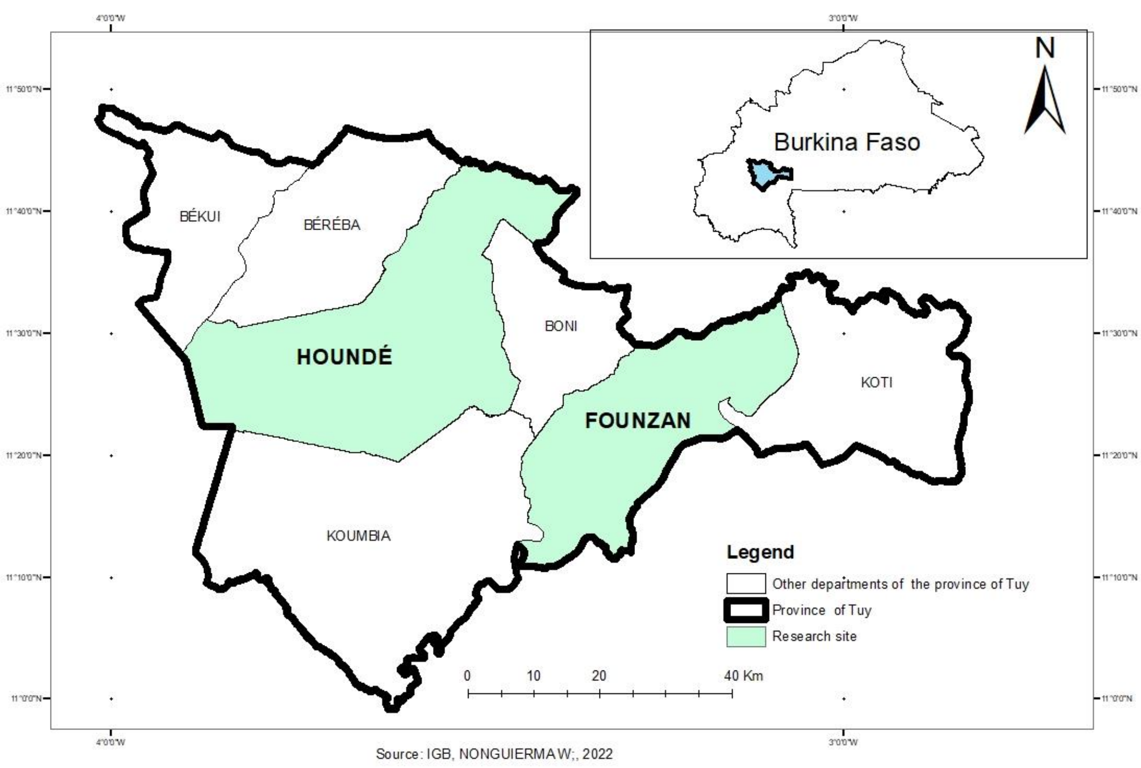
2 Allianz-Burkina, the subsidiary of the Allianz Group in Burkina Faso became officially "SUNU Assurances IARD Burkina Faso" in January 2020, after selling its shares to the SUNU Group in a financial transaction that occurred in April 2019.

After receiving the indemnity, the lender (ECOBANK) reimburses itself for the amount of premium lent to the farmer, before disbursing to farmers the remainder, supposed to cover the credit contracted for inputs purchasing. In other words, a farmer's cotton-derived revenue—obtained from the sale of his or her cotton production—is directly put in the account that he or she has with the financial institution. The financial institution, then deducts the borrowed credit—covering inputs and premium expenses—before issuing the indemnity to the farmer. This channeling system prevents farmers from defaulting on their credit.

1.1.4 An Overview of the Study Area

With its potential to reduce risk, improve investment in cotton, and stabilize incomes, the 2TIC was first introduced to cotton farmers based in the provincial capital of Houndé, which comprised of seven departments: Houndé, Békuy, Béréba, Boni, Koumbia Founzan, Koti. Altogether these departments form the province of Tuy, one of the 45 provinces making up the territorial composition of Burkina Faso.

Figure 1.1: Map of the Study Area



Source: Author's drawing

Cotton farming has historically been a prominent agricultural practice in the six rural communes, making Houndé one of the largest cotton production areas (60, 000 ha) in Burkina Faso. Due to its location in the Soudano-Sahelian agro-ecological zone (500-900 mm rainfall per year), Houndé is prone to climate variability and environmental stress, meaning interannual and spatial variations in cotton output are rampant. In addition to the climate variability and environmental stress, soil degradation, and fluctuations in the world price of cotton, have been threatening the African cotton sector at least since the 1990s (Koutou et al., 2015). In response to these challenges, cotton farmers of the Houndé region have already been employing a selection of (if not all) the risk management strategies mentioned in section 1.1.1. For instance, sesame farming is considered lucrative given its low cost of production in comparison to cotton-farming (Dossa et al., 2017; Stoeffler et al., 2020) serves as an income diversification strategy. Also, the rising number of foreign gold mining firms settling in Houndé triggered the interest of certain locals to engage in artisanal mining as a form of income diversification.

The use of these various risk mitigation strategies suggests a potential niche where 2TIC can thrive. Thus, through a partnership involving SOFITEX, UNPCB, ECOBANK, Allianz Burkina, and Swiss Re, PlaNet Guarantee-Burkina led the implementation of the 2TIC pilot project in Houndé (Figure 1). Hence, being the locality where the 2TIC project started is the first reason justifying my selection of Houndé as a study site. The second reason stems from the fact that insured farmers in Founzan (one of the six rural communes of Houndé) who suffered losses reported that they did not receive a payout despite their losses. The third reason is the already existing infrastructure that allows data collection in the six rural communes forming Houndé. A major center of cotton production, Houndé had previously benefited from several project such as the experimentation of Bt-Cotton (Lopez, 2017) whose spillovers could provide insights to our research questions.

1.2 State of Knowledge on Index Based Insurance

1.2.1 Index Based Insurance Around the World

Conceptualized theoretically by Halcrow (1948) in his work on the theory of crop insurance, IBI evolved to become a risk management tool that has been mainstreamed around the world. IBI schemes have been implemented in many countries around the world especially in developing countries where low-income farmers and pastoralists are vulnerable to covariate shock (Skees, 1999a, 1999b; Mahul, 2001; Tadesse et al., 2015). For instance, in the Americas, WIBI have been offered in Peru (Boucher and Mullaly, 2010), USA (Deng et al., 2007), and Canada (Turvey et al., 2006; Cyr and Kusy, 2007). In Asia, IBI schemes have been proposed in India (Giné and Yang, 2009; Rao, 2010; Clarke et al., 2012; Mahul 2012), Bangladesh (Al-Maruf et al., 2021), and China (Lin, 2015; Tang, 2019) to name a few. In Europe, IBI schemes were rolled out in France (Romiguié et al 2017), Germany (Doms, 2017); Spain (Kölle et al. 2021). In the Oceania, IBI have been present in Australia (Adeyinka et al. 2013). In Africa, IBI have been proposed in Morocco (McCarthy, 2003), Ethiopia (Skees et al., 2009; Hill and Visceiszia, 2011; Brans et al., 2012), Niger (Leblois et al., 2014), Mali, (Elabed et al., 2013), Senegal (Aguiton, 2019), Ghana (Adjabui et al., 2019), Malawi (Giné and Yang, 2009), Tanzania (Sarris et al., 2006), Burkina Faso (Elabed et al.,2013; Stoeffler et al., 2016; 2020; Tiemtoré, 2021; Koloma, 2015; 2022) and many other countries. In some African countries, like Kenya, Ethiopia, and South Africa where pastoralists are exposed to covariate shocks, index insurance for livestock have been proposed (Takahashi et al., 2016; Chantarat et al., 2009; Mude et al., 2013; Woodar et al., 2016; Shee et al., 2015; Oduniyi et al., 2020). Thus, the presence of the various IBI schemes in these countries paved the way to conduct studies on the impact and demand for index insurance schemes.

1.2.2 Studies on Index Based Insurance

The literature abounds with a considerable list of studies on IBI. With no intention on being exhaustive in citing them all, many will be mentioned in this thesis. In Burkina Faso, Berg et al. (2009) investigated the potential gains for farmers of a weather-index insurance scheme implemented in Burkina Faso and found that an increased uptake of this insurance was associated with an increase in crop yield, due to a presumed willingness to invest more resources in an otherwise risky endeavor, especially in the driest part of the country where exposure to drought was previously limiting. In Ethiopia, Hill and Viceiszia (2011) found that farmers who are offered insurance products experience an increase in their average return by 21.8%. Findings from a small-scale field experiment conducted in south-central Georgia (Deng et al. 2007), revealed that a weather-based insurance reduces dairy production losses caused by heat stress. Chantarat et al. (2009) examined livestock insurance in Kenya and found a significant positive correlation between income and the take-up of index insurance, a result suggesting that index-based insurance has an income smoothing potential.

Regarding demand for IBI, non-behavioral and behavioral factors affecting demand for IBI products have been documented in the literature. For non-behavioral factors, basis risk levels (Skees, 2003; Hill, 2010; Clarke, 2011; Clement et al., 2018) premium cost (Serfilippi et al. 2015; Barré et al., 2016; Abugri et al., 2017), triggers (Elabed et al., 2013, Castellani and Vigano, 2017); chosen index (Jensen et al. 2019); compensation amount, compensation frequency (Karlan et al. 2014; Norton et al., 2014); wealth and education level of the client (Patt et al., 2009; Hill et al., 2013; Bogale, 2015; Takahashi et al., 2016; Fonta et al., 2015; Amare et al., 2019; Vasilaky et al., 2019) have been found to have been found to affect demand of IBI products. For behavioral factors, trust (Cole et al. 2009; Hill and Robles, 2011) was found to be a significant determinant for take-up.

The various studies conducted lead to the understanding that although IBI is very sound in theory, in practice it has been challenging to implement due to discrete distastes constantly being expressed by the two major parties committing to the IBI contract (hence, the insurer, and the insured). In its coarsest terms, insurance companies are concerned with basis risk but also moral hazard amongst their clients, while farmers are likely to be most concerned with basis risk relating to their own production. Efforts to reconcile these expressed distastes led to continuing innovation of IBI schemes around the world.

1.2.3 Innovation in Index Insurance Schemes

In an attempt to find a balance that will make the insurance product attractive to both the insurer (to minimize moral hazard) and the insured (to minimize basis risks), underwriters, scientists, economists, and development practitioners in the field of agricultural insurance made novel suggestions to the design of index insurance products. Some made the suggestion of using long-run series of weather data in order to obtain good indices that could generate a better correlation between yields and rainfall indices (Osgood et al., 2007; Barnett et al., 2008; Cole et al., 2013). A such suggestion has the potential of addressing actuarial risk, a core risk that is present in both IBI and TCI. Others proposed a combination of remote sensing and satellite imagery, a feature that has the possibility of minimizing basis risk (Woodard et al., 2016). In an effort to better manage basis risk, some authors have suggested to use ARBY, as it has the capability of providing an enhanced correlation between indices and yields (Miranda, 2011). Building on the principle of ARBY, schemes with a double triggering system have been proposed to mitigate both moral hazard and basis risk. Thus, the ARBY with double trigger mechanism (2TIC) was an enhancement attempt to render IBI attractive to both the insurer and the insured (Elabed et al. 2013). As a result, 2TIC was implemented in developing countries, offering opportunities for empirical studies.

1.2.4 Existing Studies on 2TIC

Given its relatively recent origin, many studies on the 2TIC have addressed issues related to demand, product characteristics, and short-term impact. Regarding demand, the take-up rate for 2TIC was 46% in the early stage of its implementation in Burkina Faso (Stoeffler et al., 2020). This level of take-up in Burkina Faso was considered high compared to other developing countries where rates were relatively low (Giné and Yang, 2009; Hazell et al., 2010; Binswanger-Mkhize, 2012; Debock and Gelade, 2012; Cole et al., 2013; Goodrich et al., 2020; Stoeffler and Opuz, 2020). But in recent years the high rate that was initially observed in Burkina Faso started to decrease (PlaNet Guarantee, 2017). The decreasing rate signaling farmers' reluctance to subscribe to the 2TIC product prompted researchers to understand the motives for take up. At this time, investigations have focused on product's characteristics and impact.

For product characteristics, several studies looked into the particularities of the 2TIC. Because of its concept based on area-yield —which directly measures farmers' production output, rather than weather indices such as rainfall, which act more as a proxy— Elabed et al (2013) viewed the 2TIC as better insurance product in terms of accuracy for yield prediction. The study by Barré et al. (2016) considered 2TIC as a superior product for moral hazard prevention, because of its dual trigger mechanism and the joint liability contract that farmers commit to. While the area-yield concept, dual trigger mechanism, and joint liability contract format seem to present some advantages, the initial cost of the premium was high, jeopardizing the demand for the product (Barré et al. 2016). Field work experiments show that Burkinabe farmers were inclined to continue subscription if the premium was subsidized, underlining their aversion to a costly insurance product (Serfilippi et al. 2015; Stoeffler and Opuz, 2020).

Regarding impact, a study conducted in Mali found that cotton farmers' subscription to 2TIC lead to a 25% increase in their input use and a 40% increase in the cultivated area of cotton

(Elabed and Carter 2018). In Burkina Faso, those who subscribed to 2TIC saw an increase in non-cotton farming activities, underlining the spillover effect that 2TIC has when the risk of the primary activity (cotton farming) has been insured. For instance, subscription to 2TIC was associated with a 17.6% increase in sesame production, 1.6% increase in cattle stock, and 6.8% increase in poultry stock (Barré et al. 2016). Despite the range of studies on 2TIC, its uptake has remained relatively low (Barré et al. 2016), signaling a reluctance to subscribe that is worth probing.

1.3 Research Gaps in the Index Based Insurance Literature

An overview of the literature on 2TIC summarized in the previous section exposes gaps that are worth addressing.

While behavioral factors (such as trust) have been mentioned as affecting take-up for various agricultural IBI schemes, attention to other behavioral factors (such as perceptions of fairness) have minimally been discussed. Studies conducted previously on 2TIC as a prelude to this thesis' fieldwork, which hinted at farmers' perceptions of the (un)reliability, (un)predictability, and (in)appropriateness of the 2TIC product, its mechanisms, and the institutions delivering it, demonstrated a much wider range of potential concerns. Moreover, given the expressed uncertainty regarding indemnity payments in times of loss that was recorded during our focus groups, "perceived fairness aspect of 2TIC" appears as a gap not yet addressed under the lens of justice theory in the literature.

Regarding Impacts, discussed in the previous section, where positive correlations were shown between 2TIC take-up and the non-cotton farming activities forming the cotton farmers' income portfolio, little is known empirically about the effects of 2TIC on cotton-derived income. As such, "impact of 2TIC on cotton-derived income" appears as gap, not yet explored in the literature.

Regarding product characteristics, referred in the previous section, where it was mentioned that high premium cost was jeopardizing the demand for the 2TIC product, only one study to date (Barré et al 2016), looked into how the actuarially fair premium compares to that of the commercial premium that was in effect. Thus, "Assessing premium levels" to see how the actuarially fair premium compares to the commercial premium is a topic that not yet been adequately covered in the literature on 2TIC.

1.3.1 Gap 1: The Fairness Aspect of 2TIC

The novelty of the 2TIC is the addition of the second trigger, which is intended to control for moral hazard. The dual trigger system of 2TIC as it was designed can also help minimize basis risk (specifically, false positive) and minimize basis risk. However, as with most forms of insurance, residual basis risk will still exist, generating possibilities that farmers will not be compensated even when losses occur (false negative), or be compensated when a loss has not occurred (false positive). The fact that farmers who did not experience loss may receive a payout, and/or that famers who did experience losses may not receive a payout can be perceived as unfair. This is especially true in the case of the 2TIC, where the second trigger is critical in determining whether or not a payout will occur. The possibility of perceived unfairness is therefore enhanced in as much as the second trigger has the potential of cancelling payouts that would have otherwise occurred without the second trigger intervening. The added complexity, or opaqueness even, of the 2TIC model definitely hinders the ability of lay-people easily assessing the 'fairness' of an indemnification decision or its refusal (Bellemare et al., 2012). Thus, if farmers have the impression that the indemnification's dual triggering system does not meet their expectations of how likely a payout will occur, they could perceive the indemnification system of 2TIC as unfair. From the large number of studies on the determinant of index insurance take-up, none to my knowledge has looked at the fairness dimension of index insurance products. As such, farmers' perceived fairness of the 2TIC's indemnification system is a topic that is worth exploring, as it can provide evidence-based information to the relatively new index-insurance sector.

1.3.2 Gap 2: Impact Assessment of 2TIC on cotton-derived income

Previous studies of 2TIC have assessed its performance vis-à-vis other index insurance products and its impact on income portfolios. Regarding performance, empirical results have shown that 2TIC has the potential to outperform single trigger index-based insurance and other weather index-based insurance products in term of its ability to reduce basis risk (Debock et al., 2010; Barré et al., 2016). As for the impact assessment, previous studies found that sesame farming for 2TIC subscribers increases by 17.3% suggesting that 2TIC has a positive, spillover effects on non-cotton crop farming (Stoeffler et al., 2020). Hence, it is reasonable to think that income from sesame is likely to increase as a result of subscribing to 2TIC. In the same vein, the same authors found that 2TIC subscribers farmers saw a 1.6% increase in cattle stock, as well as a 6.8% increase in chicken stock, showing that 2TIC has a positive effect in livestock owning. Despite the wide range of impact studies of 2TIC on non-cotton-farming sources of income making up the total income portfolio of cotton farmers, little is known empirically about the effects of 2TIC on cotton-derived income. Providing insight into the relationship between 2TIC subscription and farmers cotton-derived income is worth investigating, as it will generate new evidentiary knowledge about the 2TIC.

1.3.3 Gap 3: Premium Levels Assessment

A large body of literature on Insurance (including TCI and IBI) acknowledges that high premiums charged to clients are a disincentive to insurance purchase. The premium charged to clients commonly known as commercial premium, consists of the actuarially fair premium (that is, the pure premium without the loading) and the loading (a commercial mark-up, added to the actuarially fair premium). In developing countries where liquidity is a constraint, a given commercial premium is not always affordable to all, if priced at a high level. Highly priced commercial premium can prevent liquidity-constrained farmers from repaying their loans. Indeed, a previous study found that the default rate increases if borrowers are offered index insurance products whose premium are above actuarially fair levels, therefore suggesting that insurance premium creates a disincentive for repaying agricultural loans (Miranda and Gonzales-Vega, 2011). Another stream of literature maintains that it is nearly impossible to offer insurance at an actuarially fair premium due to inevitable expenses such as administrative costs, and profit margin for the underwriter (Chantarat et al., 2017; Maisashvili et al., 2019). These views from the literature suggest that premium pricing is critical to the viability of the insurance product. In that sense, assessing the cost of the 2TIC using a methodological approach employed in previous studies offers complementary insights on the pricing of 2TIC.

1.4 Research Objectives, Questions and Methods

Based on the research gaps described above, the main objectives of the study are three-fold: (i) explore cotton farmers' judgments of fairness vis-à-vis the 2TIC indemnification system and see if/how these judgments affect decision to subscribe, (ii), assess the impact of 2TIC on farmers' cotton-derived net income, and (iii) compare the actuarially fair premium of the 2TIC with the commercial premium paid by cotton farmers. These three objectives are separate and will be pursued through analyses made in three distinct essays.

1.4.1 Objective #1: Explore the Relationship Between Perceived Fairness of the 2TIC's Indemnification System and Subscription Decision.

For this research objective, which makes the bulk of Essay 1, the intent is to understand possible relationships between perceived fairness of the 2TIC indemnification system and subscription decisions by examining farmers' view of fairness regarding the 2TIC indemnification system and how that translates into their decision-making vis-à-vis the insurance take up. For these, the following research questions were of relevance and significance to consider:

- How is fairness perceived by cotton farmers when it comes to the 2TIC indemnification system?
- Are there factors explaining how fairness is perceived by cotton farmers?
- Are there factors apart from perceived fairness, which influence cotton farmers' decisions to subscribe?
- Does perceived fairness of the 2TIC indemnification systems influence cotton farmers' decisions to subscribe?

1.4.2 Objective #2: Assess The Impact of 2TIC on Farmers' Net income

For this research objective, which constitutes the essence of Essay 2, the aim is to examine causal relationship (if any) between 2TIC, and farmers' net income obtained exclusively from the cotton production. Examining the impact (if any) with data disaggregated by income group levels was sought out as it can inform us about potential differential impact. For these objectives the following research questions were of pertinence to consider:

- What is the effect of 2TIC (if any) on farmers' mean net income derived from cotton-farming?
- Does the effect (if any) of 2TIC on cotton farmers' net income differ by income group (quintile)? If so, are there equity implications?

1.4.3 Objective #3: Compare Actuarially Fair with Commercial Premium

For this research objective, which is addressed in Essay 3, the goal is to estimate the cost of the actuarially fair premium and compare it with the commercial premium being charged to cotton farmers. While a high premium is seen as a disincentive for insurance subscription, selling insurance at its actuarially fair rate is less likely to occur in practice, as it will fall short in capturing the administrative costs and profits margins of those who design the product. Nevertheless, estimating the cost of the actuarially fair premium can be revealing, as it can generate evidence-based information on the costliness of the 2TIC. Regarding that objective, the following research questions were of pertinence to consider:

- What is the cost of the 2TIC's actuarially fair premium?
- How does the actuarially fair premium of the 2TIC compare to the commercial premium? If there is a deviation what might be the implications?
- How do actuarially fair premiums at sub-group levels (based on GPCs' yield performance) compare to the commercial premium? If there are deviation what might be the implications?

1.4.4 Methods for field work and Data Collection

To pursue the research objectives, data collection and a rigorous methodological approach were useful. Being an outsider of the research team, which has been involved with work related to 2TIC in Burkina Faso, a way to obtain relevant data and insights was through outreach. As the people of interest were hesitant to share relevant information, the viable option left was to proceed with data collection in the field. Therefore, following a pre-terrain completed in 2017, that was subsequently followed by field scope that was conducted in the research study area in 2018, information gained from the field scoping enable me to develop a survey questionnaire and administer it to cotton farmers in the following year more precisely (January 2019 to February 2019). The empirical strategies which will be discussed later in one of the study objectives necessitate the development of a counterfactual. To that end, Randomized Control Trials viewed as the golden standards in impact study is desirable. However, given my limited capacity to conduct a study of that nature, alternative but robust analyses were employed.

1.5 Significance of the Study

The study, which is in three parts, was conducted to understand the implications (for clients) of setting a 2-tier trigger system in an ARBY. Index Based Insurance in the agricultural sector is an area where a growing number of innovative products are constantly being introduced. Hence, further understanding the features of each product, as well as their impacts on certain matters of interest can be valuable. Overall, the significance of the study stems from the fact that it draws on three factors —(i) perceived fairness, (ii) income effect, (iii) premium pricing— that have either not yet been covered or been only minimally covered in the literature pertaining to 2TIC schemes. Relating to each of the three factors mentioned above, distinct significances of the study, of relevance to mention follows:

1.5.1 Significance #1: expending on behavioral factors, with perceived fairness

With IBI becoming a topic of interest to researchers, policymakers, and development practitioners, in these times of a changing climate, studies have looked at how to render IBI products more attractive to clients. With this objective in mind, more studies focused on the product itself, than the client. Product characteristics such as: the number of triggers (Elabed et la 2013), the type of contract—whether individual or group— (Gallestein, 2019), threshold levels (Castellani and Vigano, 2017), frequency of payout (Castellani and Vigano, 2017), or size of basis risk (Elabed et al., 2013) have been documented in the literature. However, the way clients feel about IBI products has received little systematic coverage, beyond a general assessment of farmers' trust in IBI products (Matul et al., 2013; Cole et al., 2009). Their judgment of the timing of indemnity payout has also received coverage (Barré et al., 2016). However, their judgment of fairness has not yet been explored in the literature. Focus group discussions during my field scoping in Houndé revealed a sense of how the 2TIC product is perceived. Fairness was mentioned frequently by cotton farmers:

"The 2TIC insurance is not fair. Our GPC incurred a loss, but they did not indemnify us" (3, FG1).

Indeed, from a client's perspective, an instance of false positive-basis risk (i.e., a scenario where a farmer who did not experience a loss, receives a payout), can affect his /her judgment of fairness vis-à-vis the 2TIC's indemnification system. Likewise, an instance of false negative-basis risk (i.e., a scenario where a farmer who experienced a loss, does not receive a payout) can taint farmers' judgment of fairness vis-à-vis the 2TIC's indemnification system. In addition to those scenarios, knowing that the second trigger has the potential to cancel payouts (that would have occurred had the second trigger not existed) can also affect farmers' judgment of fairness vis-à-vis the 2TIC's indemnification system. In light of those possibilities, examining farmers' perception of fairness vis-à-vis indemnification, and how that translates into insurance uptake, is an area of study that can contribute to the literature in two ways. First, a study on farmers' perceived fairness would add to the literature on behavioral factors affecting the demand for index-based insurance. Second, obtaining cotton farmers' opinion on perceived fairness of the 2TIC indemnification system and how that translate into their decision to subscribe give a sense of their view the 2TIC product, an information that can be useful to insurance underwriters in terms of how to make farmers view IBI products as more "fair-minded" and how to make IBI products more attractive.

Thus, the work will apply the concept of fairness developed by Folger and Cropanzano, (2001) to address equity in organizations and programs' intervention. For the two authors, fairness embodies equity and unbiasedness in four dimensions: distribution, procedure, information, interaction (Folger and Cropanzano, 2001). Based on this thinking, my approach explores how cotton farmers' judgment of distributive fairness, procedural fairness, interpersonal fairness, and informational fairness pertaining to the indemnification of 2TIC influence its take-up. Considering that fairness is a state of mind that can affect judgments, and therefore decision making, this study on index-based insurance through the lens of the four dimensions of fairness could shed some light on the equity aspects affecting demand. As such, the application of Folger and Cropanzano's four-dimensional approach of fairness to IBI provide a context that can facilitate the understanding of insurance uptake. In this way, the study not only contributes to expanding the breadth of studies on the determinants of demand for IBI, but also contributes to the depth by now directing the focus on equity of processes and outcomes. In this fashion, integrating the four dimensions of fairness to understand cotton farmers' perception of the 2TIC indemnification system could help towards the design of IBI products that are as fair as possible to the eye of farmers. The significance of the study vis-à-vis the big debates on IBI resides in its ability to: offer insights on how cotton farmers perceive fairness when it comes to IBI products and generate empirical research into how the understanding of perceived fairness can impact decision making related to insurance take-up.

1.5.2 Significance #2: tapping into the effects of a new topic: cotton-derived net income

With IBI being relatively new in developing countries, limited long-time series on subscriptions constrains the research on impact analyses to hinge upon experimental and quasi –experimental design. In Mali where a 2TIC has also been proposed to cotton farmers, a study found that subscription to the insurance causes an extensification of cotton production (Elabed et al., 2013), signaling the potential to generate more revenues once cotton output is sold back to the CMDT (a cotton company similar to SOFITEX in Burkina Faso). In Burkina Faso, studies show that 2TIC has a stabilizing effect on farmers' agricultural income (Barré et al., 2016). However, it is worth noting that this study, while theoretically sound, (employing the expected utility function under risk uncertainty), relies on simulation techniques, which could not account for the possible impacts of different farm-gate prices set by SOFITEX, which are based on the quality of cotton produced. To account for the difference in farm-gate price my study looks at the impact of insurance subscription on cotton-derived income, where cotton-derived income is obtained by subtracting revenue from sales (using farm-gate price) from production costs. This approach addresses the variation in farm-gate price that can affect farmers' revenues. Hence the study uses a theoretical analysis, as well as an empirical illustration to show the impact of 2TIC subscription on farmers' net income deriving from the cotton production. This angle of analysis offers complementary insights to the findings of Barré et al. (2017). It also adds to the previous findings presenting the income stabilization potential of IBI products that were demonstrated in other studies (Janzen and Carter, 2013; Jensen et al., 2014).

Despite the significance mentioned above, the current study presents some limitations that are worth mentioning. First, due to time and financial constraints, the sample and data collection occurred in a limited geographical area: Houndé. Thus, the interpretation of results and the generalizability of the research findings should be done with extreme caution. Second, the study's usage of data collected from farmers (through survey questionnaires) assumes their honesty and sincerity once answering the questions. While those attributes cannot be guaranteed, confirmatory data were collected to minimize inaccuracies in responses. Third, the study's focus on 2TIC and Burkina Faso narrows the scope of the analysis to a specific IBI product and country. Hence external validity though limited at this stage can further be increased with a replication of the same study in the Mali where 2TIC is provided.

1.5.3 Significance #3: adding to the literature on affordability, with an investigation on pricing

Research on insurance take-up has shown the importance of premium rates. Priced high, premium can be a disincentive for contracting insurance products. Priced low, premium can fail to account for transaction costs borne by stakeholders within the insurance supply chain, therefore threatening the commercial viability of the insurance product. Hence, a price that is convenient to both parties from the supply and demand would be judicious. While the right pricing of 2TIC is not the focus of this study, examining how the actuarially fair premium of the 2TIC compares to the commercial premium can be revealing. Considering actuarially fair premium as a premium free from any commercial mark-up, and commercial premium as a premium containing a mark-up, it will be insightful to see how the two compare. Historical data on GPCs in Burkina Faso obtained by Barré and colleagues enabled an analysis of that kind. Based on their data and methodological approach of analysis, Barré et al. (2016) found that the price of the 2TIC commercial premium valued at CFA 11, 200 was about three times that of the actuarially fair premium. To date, only Barré et al. (2016) looked into the comparison of actuarially fair and commercial premium of the 2TIC. Apart from that study, there has been little evidence of empirical research on the pricing of 2TIC regarding how actuarially fair premium weighs against commercial premium.

My thesis through Essay 3 offers additional insights on the topic in two ways: (i) using a gamma probability function (found to be the best fit for the collected data) to estimate the long term expected yield, and (ii) employing both time- and GPCs-specific effects to determine actuarially fair premiums to see how they fare with the commercial premium that was in force. By using these distinct methods of determining the actuarially fair premium and then comparing it to the commercial premium charged to cotton farmers, Essay 3 sheds light on the affordability of the 2TIC product in Burkina Faso, a topic that has been scantily discussed in the literature. With results showing that the commercially premium charged to cotton farmers is much higher than the actuarially fair premiums, a key takeaway from Essay 3 of the thesis is that premium differentiation can be beneficial to both the insured (who will most likely contract the insurance product as he / she will find it attractive) and the insurer (who will most likely sell more of the insurance product, because of the increased demand).

Despite the significance or contributions mentioned above, Essay 3 of the thesis presents some limitations that are worth mentioning. First, collected data were relatively short in terms of time horizon, due to SOFITEX inability to provide credible data past a certain number of years. Second, the data collection occurred in a limited geographical area (the provinces of Houndé) therefore limiting the generalizability of the research findings. Third, the premium estimate was solely about the 2TIC product being implemented in Burkina Faso, therefore narrowing the scope and context of the study. Hence external validity of the study can further be increased with future research exploring other insurance schemes and geographical areas.

1.6 Organization of the Thesis

Analyses of the three research gaps identified in the literature—that is, (i) the role of perceived fairness with respect to subscription decisions pertaining to the 2TIC, (ii) the impact of 2TIC on farmers' net income, (iii) the comparison between actuarially fair premium and commercial premium of the 2TIC — constitute the core of the dissertation. The core of the dissertation is preceded by an introductory chapter and followed by a concluding chapter. In recap, the dissertation is organized in five chapters as follow: Chapter1: Introduction; Chapter 2: Essay 1 titled *Perceived Fairness of Indemnities and the Double Trigger-Index Based Insurance Product: Evidence from Cotton Farmers in Burkina Faso*, Chapter 3: Essay 2 titled *The Effects of Index-Based Insurance on Farmers' Income: Evidence from Cotton Farmers in Burkina Faso*; Chapter 4: Essay 3 titled *Actuarially Fair Premium and Commercial Premium: The Case of the 2TIC in Burkina Faso*; Chapter 5: Conclusion.

Chapter 1, which is the general introductory chapter, presents a contextual background of the 2TIC product in Burkina Faso, namely a contextual background, the product characteristics, indemnification mechanism and level of indemnification. Then, it presents the state of knowledge on IBI by showing the breadth of IBI projects in a selection of countries around the world, innovation made with IBI schemes, and an overview of previous studies on 2TIC. After that it identifies the research gaps and objectives that helped steer the narrative of the thesis. Subsequently it elaborates on the significance of the study and its limitations. Chapter 1 concludes by presenting the structure of the thesis.

Chapter 2, which is Essay 1—titled *Perceived Fairness of Indemnities and the Double Trigger-Index Based Insurance Product: Evidence from Cotton Farmers in Burkina Faso*—provides a detailed discussion of the research rationale, methodology, and statistical analyses used to identify factors of Perceived Fairness that are relevant for shaping farmers' decision to subscribe to the 2TIC.

Chapter 3, which is Essay 2—titled *The Effects of Index-Based Insurance on Farmers' Income: Evidence from Cotton Farmers in Burkina Faso*—provides a detailed discussion of the research rationale, methodology, and statistical analyses employed to assess the impact of 2TIC on farmers' net income deriving from the cotton production.

Chapter 4, which is Essay 3--titled Actuarially Fair Premium and Commercial Premium: The Case of the 2TIC in Burkina Faso—provides a detailed discussion of the research rationale, methodology, and statistical analyses employed to estimate the monetary value in FCFA of the 2TIC's actuarially fair premium and compare it to the FCFA value of the commercial premium offered by PlaNet Guarantee.

Chapter 5, which is the general concluding chapter, provides a summary of the major findings resulting from each of the three essays. It mentions the limitations of each study, opens up on areas for future research, proposes some policy recommendations and finally concludes the dissertation.

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Chapter 2—Essay 1: Perceived Fairness of Indemnities and the Double Trigger-Index Based Insurance Product: Evidence from Cotton Farmers in Burkina Faso

Wilfried D. J. Nonguierma

Abstract

The Double Trigger-Index based Insurance Contract (2TIC) was introduced in 2013 to cotton farmers of Burkina Faso to help them cope with climate- related risks. While many studies have looked into both behavioral and non-behavioral factors affecting the demand for index insurance schemes, one overlooked behavioral factor (perceived 'fairness') was identified as a matter of interest in focus group discussions. This essay draws on cotton farmers' perceptions of the 2TIC indemnification system to see if their perceptions of fairness affect their decision to subscribe. To do so, the essay uses survey data collected in the field, and employs Principal Component Analysis to compute indicators related to farmers' perceptions of fairness regarding the 2TIC. Then, a logistic regression is used to identify factors that are relevant for shaping farmers' decision to subscribe to the 2TIC. Results show that four of the five fairness related indicators had a significant impact on the subscription decision. Farmers were more likely to subscribe when they held a higher perception that the insurance payout would align with incurred losses. Results also show that farmers' insurance literacy positively affects their decision to subscribe to the insurance product. Taking perceived fairness of insurance product into consideration opens new avenues for improving insurance schemes to the liking of the clients.

2.1 Introduction

Rainfed agriculture faces risks of variable weather conditions that threaten productivity, and therefore income related to farming activities. In countries of the Sahel where those risks are projected to increase due to the effects of climate change (Monerie et al. 2016; 2020; Biasutti 2013, 2019), the threats are unequivocal. To respond to those threats farmers have already been implementing (i) informal risk mitigation strategies (such as livelihood diversification, crop diversification, community solidarity clubs like tontines, and outmigration) and (ii) formal risk mitigation strategies, such as Traditional Crop Insurance (TCIs), which indemnify insured farmers based on their realized losses. From farmers' perspective, the latter (i.e., TCIs), on the one hand, are quite advantageous, as they can serve as a means to access credit, which otherwise would be impossible to obtain without a collateral. On the other hand, high transaction costs, and slow settlement procedures related to verifying realized losses are challenges undermining the appeal of TCIs for farmers. From the insurers' perspective, moral hazard (farmers taking on new risks if they believe insurance will cover them) is a concern for which they have a low level of tolerance. In an effort to reconcile the challenges expressed by both parties (the insured and the insurer), index-based insurance (IBI) has been put forward as an alternative, formal and yet objective risk mitigation strategy. Rather than paying indemnities against realized losses, insured farmers receive payments when an objectively chosen index is triggered. The index is objectively chosen based on weather events (Giné et al., 2007), on the region's average livestock mortality rate (Bertram-Huemmer and Kraehnert, 2018), average crop yields (Elabed et al., 2013), or on satellite-based prediction of forage scarcity (Chantarat et al., 2009) or crop losses (Flatnes et al., 2018).

A variant of this type of insurance, the Double-Trigger Index-based Insurance Contract (2TIC), was introduced in Burkina Faso in 2013 by the insurance company PlaNet Guarantee in collaboration with one of the country's three cotton growing organizations (SOFITEX) (Elabed and Carter, 2013). Unlike standard, individual-subscriber based IBIs, 2TIC is an area-based yield (ARBY) index insurance, which pays farmers (organized in groups, known as "Groupements de Producteurs de Coton", or "GPC") when two trigger conditions are met. The first is that the group's yields fall below a specific level, which in this case is the 12-year historical yield average. The second trigger is that the yield of neighboring GPCs also falls below a similar historical average. The motive for a second trigger is to eliminate moral hazard (e.g., instances where farmers of the same GPC can collude to obtain a lower yield that will guarantee them a payout). The insurance contract is sold as part of the cotton credit package by SOFITEX, eliminating the need for farmers to individually finance the premium payment up-front. Hence a farmer is insured without disbursing any funds at the beginning of the cotton production season and is then entitled to receiving an indemnity if the two triggers' index thresholds are met. This contingent risk credit format is attractive to lending institutions as liquidity constrained farmers are less likely to default on their loan repayment. By including the performance of neighboring GPCs (to capture the effects of covariate shocks) as a second condition for payout, the intent of the second trigger is to reduce moral hazard (Elabed and Carter 2013, 2015; Barré et al. 2016). Indeed, with GPCs often organized following a lineage system structure (Phliponeau and Guibert, 2011) farmers within GPCs are often members of the same family, and therefore live in the same village where they share similar ethnic and/or religious affiliation. Under these circumstances it is not unlikely that a form of coordination aimed at deliberately affecting the production outcome of the GPC could occur. In such circumstances, on the one hand, setting a condition at the neighboring GPC's level could prevent the fruition of a deliberate coordination on their part. On the other hand, considering performance at the neighboring GPCs' level as a condition for payout could also be a source of basis risk, if in the end payouts are not correlated with individual farmers losses (Elabed et al., 2013; Stoeffler et al., 2016). Thus, cotton farmers who contract 2TIC are confronted to basis risk, which can engender a scenario where farmers might receive an indemnity even if they did not experience a loss (case of false positive), or a scenario where farmers might not receive an indemnity even when losses occur (case of false negative).

My field scoping study in early 2017 asked cotton farmers specifically for their opinions about the possibilities of either of these scenarios. On false negatives, many responded with a clear expectation that subscription is like a contract: "We expect to be indemnified in the event of a loss, if we will be deducted funds for an insurance". Similarly, respondents took a dim view of possible false positives, "We do not expect someone who did not face a loss to receive an indemnity". With these perspectives in mind, discussions frequently returned to how both scenarios (false positive and negative) are *"Yi cou"* in Bouamou, the local language spoken in the area which means 'unfair'. Once asked about their opinion on the double trigger system, a group of farmers claimed, "The two-tier triggering systems is unfair because trigger 2 prevents farmers who see the realization of trigger 1 from receiving an indemnity." Asked about their view on the indemnity amount being paid based on the level of losses incurred the majority of participants agreed that "The indemnities promised are not really fair, because we have the impression that they are not truly representative of the efforts we put, which unfortunately will turn into a loss." These focus group discussions make it clear that farmers' perceived fairness of the 2TIC's indemnification system is a topic worth exploring, as it can provide evidence-based information to the relatively new index-insurance sector.

This paper (Essay 1) therefore builds on fairness theory (Adams, 1965;), and more specifically the four dimensions of fairness[3] proposed by Folger and Cropanzano (2001) to explore factors that are relevant in explaining farmers' decision to subscribe to the 2TIC insurance. Specifically, Essay 1 answers the following questions:

- How is fairness perceived by cotton farmers when it comes to the 2TIC indemnification system?
- Are there factors explaining how fairness is perceived by cotton farmers from the studied sample?
- Does perceived fairness of the 2TIC indemnification systems influence cotton farmers' decisions to subscribe?

To answer those questions, Essay 1 uses survey data that I collected during the period of January to February 2019 in Burkina Faso. The survey consists of using the simple random sampling approach to reach the cotton farmers in the cotton regions of Houndé and Founzan. Specifically, the survey selected 13 farmer groups in each region and the final sample size consists of 437 farmers (out of 500 interviews). The survey has four parts: the first collects sociodemographic information about farmers; the second is about farmers' opinion on cotton farming. The third asks farmers' opinion on the 2TIC product; the fourth part asks farmers' opinions about the fairness of the indemnification system (distributive fairness, procedural fairness, interpersonal fairness, and informational fairness).

For the empirical analyses, Essay 1 uses Principal Component Analysis (PCA) to identify fairness variables that are relevant for shaping the subscription to the 2TIC. Then, a logistic

[3] These are: distributive fairness, procedural fairness, interpersonal fairness, and informational fairness.

regression is performed to investigate the interplay between farmers' observable characteristics and their decision to subscribe to the 2TIC.

Essay 1 finds that four of the five fairness indicators have a significant relationship with the decision to subscribe to the 2TIC. Most notably, farmers were more likely to subscribe when they held a higher perception that the insurance payout would align with incurred losses. This finding is in line with Fuchs and Wolff (2011) and Hill et al. (2013) who find that farmers will have a higher consideration for a range of insurance products where the indemnities are more closely aligned with their actual losses. Moreover, my results also show that farmers' insurance literacy positively affects their decision to subscribe to 2TIC, results that are aligned with previous findings (Cole et al. 2013; Hill et al. 2016; Vasilaky et al., 2020). In other words, a greater financial awareness would allow farmers to make a more reasoned choice, and adopt a product that is suitable, but might also make it clearer to them that the likely indemnities are not aligned with their real possibility of loss.

With these findings, Essay 1 contributes to the on-going debate about the demand for insurance products in developing countries. It adds to the literature on take-up determinants of index-based insurance. By eliciting the role of perceived fairness in subscribing to 2TIC, there is evidence that perceived fairness is a variable not yet reported in the literature (until this study) but a key determinant for index-insurance take-up. From a development practice point of view, with index-insurance being a relatively new, but yet evolving sector in developing countries, findings of this nature can contribute to improving the design of index-insurance contracts and the communication of their possible benefits.

Essay 1 proceeds as follows. The next section presents the related literature. Section 3 present some definitions of perceived fairness, and Section 4 describes the data. Section 5 presents the methodology. Results of the analyses are presented in section 6 and the conclusion in section 7.

2.2 Related Literature

Several studies investigated factors influencing the decision-making process leading to the take-up of index-based insurance products. These studies on the determinants of take-up can be put in two main categories: (i) the non-behavioral factors and (ii) the behavioral factors.

Among the non-behavioral factors, a stream of studies identified basis risk as an obstacle for the take up of index insurance products (Bryan, 2010; Hazell et al., 2010; Jensen et al., 2015, 2018) Thus, the more an insurance product is designed to ensure that farmers' compensations are aligned with their incurred losses, the greater the preference for such insurance product. For example, Castellani et al. (2014) use a discrete choice experiment to estimate the demand for rainfall index-based insurance in Ethiopia. They find a negative relationship between basis risk and farmers' Willingness to Pay (WTP) for the insurance product. Volpi (2005) shows that Ethiopian farmers' perception of basis risk was strongly informed by both an awareness that rainfall variability was only one potential risk of many, and an awareness that rainfalls recorded at weather stations correlated poorly with those that occurred on their own farms.

Another non-behavioral factor that poses a serious threat to subscriptions of index-based insurance products is high commercial premium. The less affordable the insurance scheme, the lower the subscription rate. In the case of 2TIC implemented in Burkina Faso, Barré et al. (2016) found the commercial premium was 3 times higher than the actuarially fair price (due to a loading factor applied by insurance and reinsurance companies). That tripling of the actuarially fair price could be a disincentive for cotton farmers to subscribe to 2TIC, and actuarially fair premium will be discussed in much more detail in Essay 3.

With respect to behavioral factors, financial literacy (namely the knowledge and awareness of the mechanics and value involved with index insurance products) has proven to influence insurance take-up. Studies have shown that educational programs to build financial literacy on index insurance products increase their take-up. In Ethiopia, more precisely in Silte Woreda, Hill and Robles (2011) conducted a series of experimental games and found that take-up rate for index insurance was 20% higher for farmers who were trained in insurance concepts. Still in Ethiopia but now in the localities of Adiha, Awetbikalsi, Genetie, Hadealga, Hadushadi where cross sectional household data were used to investigate the effect of financial literacy on demand for index insurance, it was found that financial literacy has a positive impact on purchasing index insurance (Awel and Azomahou, 2015). In the same line of reasoning, Giné et al. (2007) found that for a low-priced, rainfall index-based insurance product in Andhra Pradesh, southern India, risk averse farmers were still unlikely to subscribe but willingness to take up the insurance increased both with greater understanding of insurance contracts or familiarity with the insurance vendor .

Another behavioral factor found to be a key determinant for index insurance uptake is trust (Matul et al., 2013). Indeed, heterogeneity (in the socio-economic characteristics) existing within farmers' groups, and their lack of a clear knowledge of the insurance contract being proposed to them, make them rely on trust. For instance, Patt et al. (2009) who examine the role of field games in establishing trust in the insurance product, the participating organizations, and farmers' own ability to make good decisions, show that trust in the insurance product and in organizations involved in the management and selling of insurance products affect farmers' decision to subscribe to insurance contracts. Similar findings are documented in studies by Suarez et al. (2007) in Malawi, Giné et al. (2007) and Cole et al. (2013) in India, and by Chantarat et al. (2009) in Kenya.

Another behavioral factor that has proven to influence farmers' decisions to participate in index insurance programs is social links (Hill et al., 2013). Their study, which examined willingness to pay for weather index insurance among 1400 households located in Ethiopia, found that social links positively influence insurance take-up. In India, Giné et al. (2007) also found networks to be positively associated with insurance take-up, and important for building trust in a product especially when many of the participants did not fully understand it.

While the majority of studies on behavioral factors affecting the demand for index insurance products focused on social characteristics (such as literacy, knowledge, trust, or social links), the perceived fairness aspect, which seems to matter to Burkinabe cotton farmers based on results of the focus group has not yet been explored in the literature. Paying attention to what matters to farmers can help to better understand their decision-making motives in relation to 2TIC. Just as challenges expressed by the insured (such as high transaction costs, slow settlement procedures), and those expressed by the insurer (such as moral hazard) were taken into consideration in the design of 2TIC, farmers' view of fairness, which is currently not inherent in the design for 2TIC can be given a consideration. By focusing on perceived fairness, insights can be gained on what farmers consider as fair (or unfair) about the 2TIC product, a viewpoint that can offer complementary information to developers and marketers of IBI schemes. Focusing on fairness can help understand the aspects of famers' perceived fairness that influence their decision to subscribe to 2TIC or not. To understand farmers views on fairness, definitions on perceived fairness are worth mentioning.

2.3 Perceived Fairness

2.3.1 Definition and Dimensions of Fairness

Fairness derives from the equity theory (Adams, 1965), and its concept has evolved through time. In the early 1960s, Fairness was viewed as the application of justice in social and organizational interactions. Hence Fairness was viewed as including three dimensions: *(i) distributive fairness* defined as the degree to which a reward is allocated in an equitable manner (Folger and Konovsky, 1989; Niehoff and Moorman, 1993); *(ii) procedural fairness* defined as the degree to which those affected in the allocation processes of the reward perceive them, as being carried out according to fair methods and guidelines (Folger and Konovsky, 1989; Greenberg, 1987); *(iii) interactional fairness* defined as the quality of interpersonal treatment people receive during the enactment of organizational procedures (Bies and Moag, 1986). In the mid 1980s, the third dimension (i.e., interactional fairness) was broken down into two sub-dimensions: *(iii-a) interpersonal fairness*, which refers to the dignity and respect with which people are treated and *(iii-b) informational fairness*, which is the availability and adequacy of information provided to people (Bies and Moag, 1986). Following that decomposition, the concept of fairness has since been viewed as encompassing four dimensions: *(i) distributive fairness, (ii) procedural fairness, (iii) interpersonal fairness and (iv) informational fairness.*

2.3.2 Application of Fairness to the 2TIC

By applying these definitions to the indemnification system of 2TIC the following rationales were made. Since *distributive fairness* refers to peoples' views on the fairness of allocation of outcome, distributive fairness of indemnities would refer to farmers' beliefs about fairness of allocation of indemnities. With the literature on index insurance acknowledging that indemnity payments are often not aligned with losses (due to basis risk), distributive fairness of indemnity under the double trigger insurance contract can be equated with farmers' judgements of basis risk.

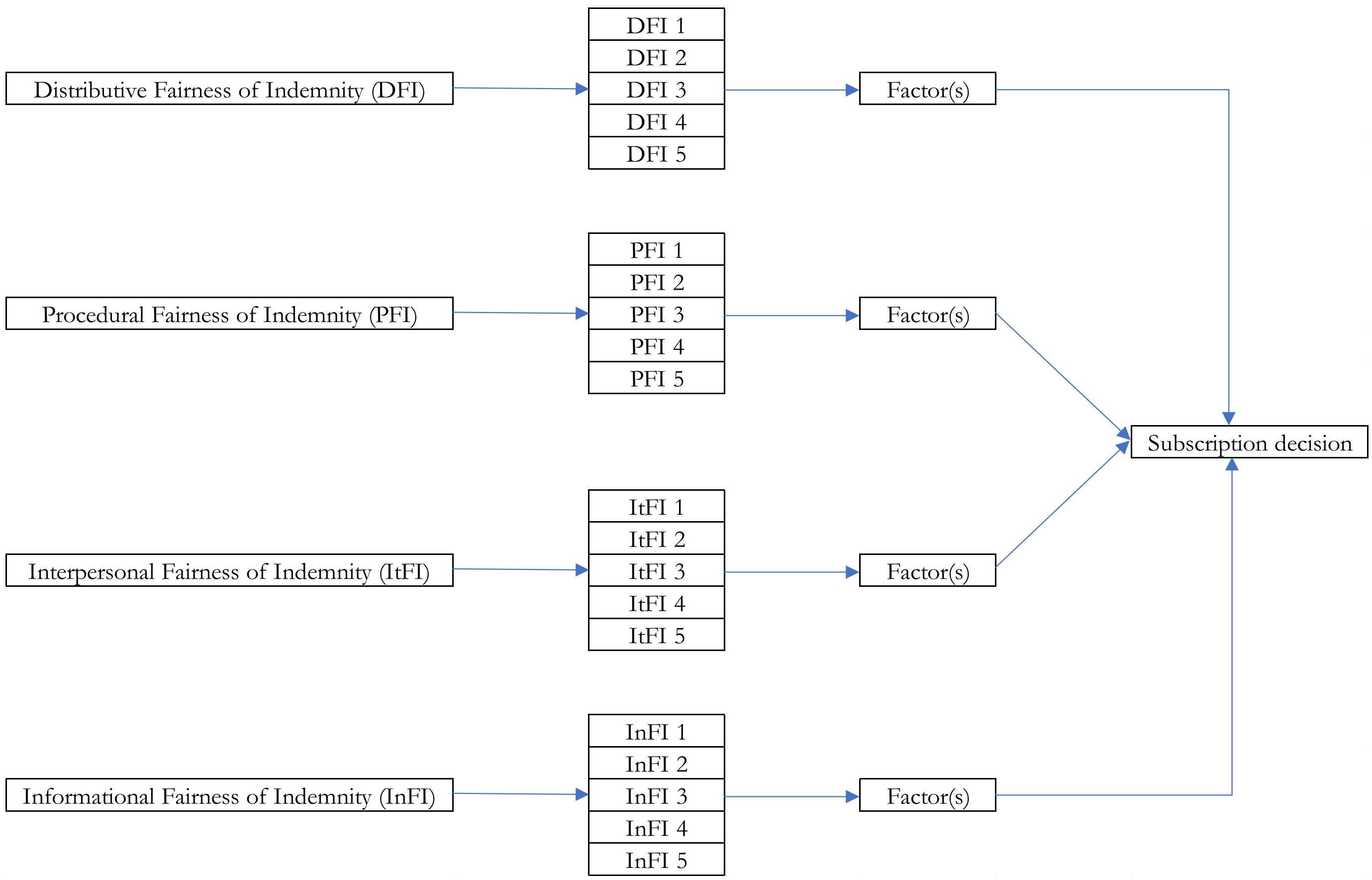
As *procedural fairness* refers to the perceptions of fairness of methods and guidelines used to carry out the allocation of outcomes, procedural fairness of indemnities would refer to farmers' perceptions of the fairness in procedures used to carry out the allocation of indemnities. In the case of 2TIC, where the issuance of indemnity requires the simultaneous occurrence of both first and second triggers, procedural fairness would be regarded as farmers' judgement of fairness regarding the procedures and protocols used for the indemnification. In other words, procedural fairness of indemnification can be viewed as farmers' perceived fairness of the two-tiered mechanism of indemnification process.

Regarding *interpersonal fairness*, which refers to the dignity and respect with which people are treated, the fact that cotton farmers during the focus group labeled the 2TIC indemnity as unfair for not being representative of their agricultural efforts, interpersonal fairness of indemnities would refer to farmers' opinion on the monetary value of the indemnity being offered. Indeed, studies in the field of sociology found that farmers feel they are being treated unfairly once their efforts and work are not recognized to their just value (Liebig et al., 2009, Hellberg-Bahr et al., 2012).

As to *informational fairness*, which is the availability and adequacy of information provided to people, informational fairness of indemnity will refer to the cotton farmers' judgment of the extent and amount of information they may have received about 2TIC. Previous studies have found that in emerging crop insurance markets like those of African countries, farmers receive limited education on the mechanisms of index insurance contracts (Mahul and Stutley,2010; Leipnik, 2014). In the case of the 2TIC in Burkina Faso, informational fairness will consist of obtaining farmers' view on how much they know about certain characteristics of the 2TIC such as the selection process of the neighboring GPC, and the determination of the first and second triggers.

With the four dimensions of fairness being applied to the context of 2TIC it could be of value to the literature to learn what cotton farmers think of those four dimensions of fairness. To do so, a survey questionnaire was developed with a section aimed at obtaining and quantifying relevant information on farmers' view of the four dimensions of fairness (See section V of the Survey Questionnaire in Appendix 1). Five questions (scored using a Likert scale from 1-5) pertaining to each dimension of fairness were posed, leading to five possible variables per dimension of fairness. For instance, for distributive fairness, answers to the first question generated the variable DFI1. Likewise, the second, third, fourth and fifth questions pertaining to distributive fairness led to DFI2, DFI3, DFI4, and DFI5. A similar approach was used for the five questions pertaining to the remaining dimensions of fairness. In total 20 variables were considered. Those variables are useful for the examination of fairness and whether farmers' perception of fairness affects their insurance subscription decisions. More precisely, Figure 2.1 and Table 2.1 summarizes the mechanisms behind my hypothetical approach.

Figure 2.1: Diagram summarizing the hypothesized relations between fairness and subscription to 2TIC insurance



Source: Author's drawing

Table 2.1: The twenty variables derived from the questions relating to the four fairness dimensions

Var.	Variable's definition	Var.	Variable's definition
DFI1	The judgment of merit a respondent makes of a situation where an insured farmer does not receive an insurance payout even if he suffers a loss	ItFI1	The respondent's level of faith in the insurer's desire to indemnify them when they realize a loss

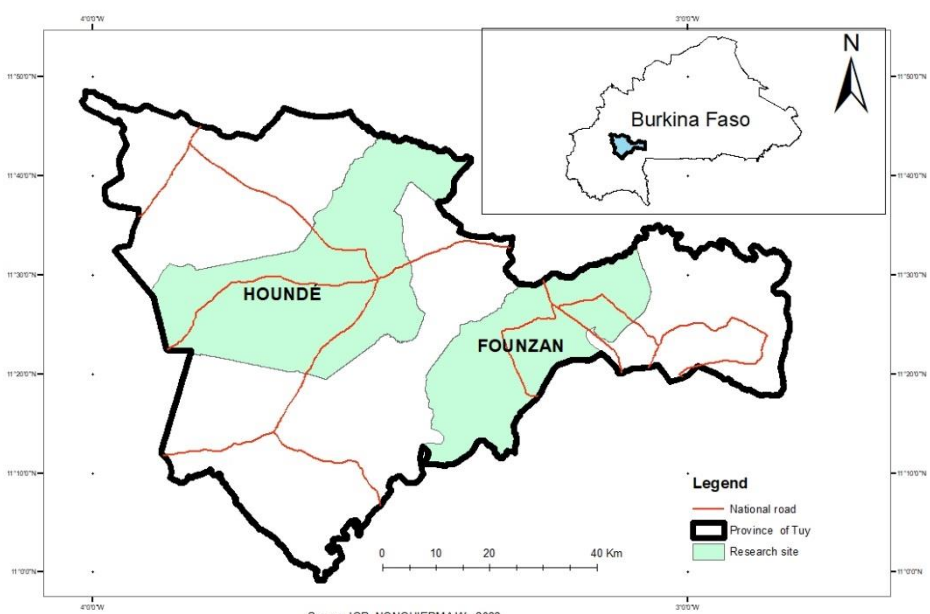
DFI2	The judgment of merit a respondent makes of a situation where an insured farmer receives an insurance payout without suffering a loss.	ItFI2	The respondent's degree of satisfaction about the support from financial institutions (i.e., banks) in the context of index insurance
DFI3	The respondent's opinion of the monetary value of the insurance payout issued in times of compensation	ItFI3	The respondent's degree of satisfaction about the support from SOFITEX in the context of index insurance
DFI4	The respondent's opinion on equity of the indemnification system	ItFI4	The respondent's degree of satisfaction about the support from PlaNet Guarantee in the context of index insurance
DFI5	The respondent's view on the ability of the insurer to indemnify those who passed the first trigger but did not meet the second trigger	ItFI5	The respondent's degree of satisfaction of the support provided by the UNPCB within the framework of index insurance
PFI1	The respondent's judgment of the fact that performances of neighboring GPCs are used as a condition for indemnity payments	InFI1	The respondent's level of awareness of the 2TIC indemnification stream for the lower premium priced at FCFA 5,600.
PFI2	The respondent's judgment of the fact that performances of the GPCs are used as a condition for indemnity payments	InFI2	The respondent's appraisal of how much information on the initial 2TIC indemnification (FCFA 11,200) may have been provided to them.
PFI3	The respondent's level of acceptability vis-à-vis thresholds set at GPC level, then used as criteria for indemnity payment	InFI3	The respondent's appraisal of how much information may have been provided to them, when it regards threshold determination at the GPCs level.
PFI4	The respondent's level of acceptability vis-à-vis the thresholds set at neighboring GPC level, then used as criteria for indemnity payment	InFI4	The respondent's appraisal of how much information may have been provided to them, when it regards threshold determination at the neighboring GPCs level
PFI5	The respondent's level of satisfaction with regards to the group-insurance format of 2TIC	InFI5	The respondent's appraisal of how much information may have been provided to them, when it comes to the selection of neighboring GPC

Source: Author's drawing

2.4 Data

I used data from a survey that I conducted with individual cotton farmers based in Burkina Faso. To learn more about the cotton farming context (that is, realities faced by producers on the farm fields, and concerns expressed by stakeholders involved in the chain of production), I did a pre-terrain in 2017, followed by a scoping field study in 2018. Then, survey questionnaires were administered from January to February 2019, a period coinciding with the post-harvest season. The surveys took place in Houndé and Founzan, two departments located in the province of Tuy. Houndé and Founzan are part of the SOFITEX-denominated cotton production area of Houndé, one of the most productive areas of the country, where cotton farming for decades has been viewed as a success story (World Bank, 2004). Houndé and Founzan represent 20% of the country's cotton production as of the end of the 2018/2019 cotton production season (UNPCB, 2019), and are characterized by a Sudano-Sahelian vegetation, with a similar low relief topography averaging 315 m above sea level. National road networks (considered a safer way to travel in rural Burkina Faso due to recurrent terrorist attacks), which are better in the departments of Houndé and Founzan —as shown in the orange line of Figure 2.2 (below)— played an important role in allowing convenient access to the study area and choosing the data collection sites.

Figure 2.2: Map of the Research Sites



Source: Author's drawing.

The data frame of cotton farmers and their basic details were obtained from the UNPCB's regional office of Houndé, which records production inputs and outputs information on individual farmers and their GPCs for every cotton production season. The UNPCB's office in Houndé provided me with a list of cotton farmers from which survey participants were drawn to analyze farmers' perception of fairness. The questionnaire, which contains inquiries on farmers perception of distributive fairness, procedural fairness, interpersonal fairness and informational fairness had a total of 20 variables describing perceived fairness. Following the general rule of thumb, which suggests having at least five times as many observations as there are variables in studies involving factor analysis (Hair et al 1998) a sample size of 100 observations would have been the minimum sample size required for the analyses. To account for possible attrition the survey questionnaire was sent out to 500 cotton farmers that were randomly selected from the list provided by UNPCB. I selected a sample of 500 farmers that is representative in terms of farmers' experience regarding the 2TIC insurance and invited them to participate in the survey. Respondents with incomplete answers or missing information were dropped from the analysis. The final sample thus consists of 437 farmers, a sample size deemed adequate to proceed with the factor analysis.

Since the main purpose of the survey was to investigate cotton farmers' feelings of fairness regarding the indemnity of the 2TIC, each farmer has been asked about their opinion on the four dimensions of fairness (distributive fairness of indemnification, procedural fairness of indemnification, interpersonal fairness, and informational fairness). The variables of interest and the survey questions needed for gathering information about them were informed by the findings of two focus group discussions (encompassing 8 participants in each group) that were conducted in March 2017 during my field scoping activities. Appendix 1 provides a full description of the questions asked to the farmers to assess each of these dimensions. Equally important, farmers who participated in the survey were also asked to provide information on their perceptions of insurance and risk premium, demographic characteristics (age, family size, origin, education level, as well as the characteristics of their cultivated land.

Table 2.2 presents the summary characteristics of the sample. The average age of farmers is 40 years and 75% have no formal education. Around 85% of farmers in the sample own a tractor, meaning that modern mechanized ploughing is a common practice for cotton farming in the departments of Houndé and Founzan. In addition, an overwhelming majority of the farmers (93%) from the collected sample own their cultivated land, which speaks to the security of land tenure in the cotton-farming sector. While roughly three quarters (76.9%) of respondents from the sample were subscribed to 2TIC at the time of the interview, slightly more (83.5%) of them reported having subscribed to 2TIC at least once since its rollout in 2013. This demonstrates the high willingness of farmers from the sample to experience the purported risk mitigation benefits of 2TIC such as: (i) reduction in the urge to invest in lower risk lower return project(s), an ex-ante risk mitigation strategy that farmers without insurance would adopt, for fear that higher risk- higher return project(s) will be susceptible to greater losses (Rosenzweig and Binswanger 1993; Dercon 1996; Stoeffler 2016) as well as (ii) avoidance in consumption smoothing and asset smoothing behaviors that farmers would have adopted as ex post risk mitigations strategies in the absence of insurance (Towsend 1994; Hoddinot 2006; Kazianga and Udry, 2006). In addition to the idea that 2TIC can protect farmers' consumption, assets, and investments when shocks occur, it was documented in Mali that 2TIC subscribers increased their cultivated area, and input purchases by approximatively 25-40% Elabed and Carter (2014) . In the next section, we investigate factors that are relevant for shaping farmers' decision to subscribe to 2TIC.

Table 2.2: Summary Statistics

Variables	Mean	Std	Min	Max
Index insurance subscription				
2TIC subscription (yes/no)	76.89		0	1
2TIC subscription at least once since 2013	83.52		0	1
Farmers' Sociodemographic characteristics				
Age	40.02	9.43	23	70
Education	1.31	0.58	1	3
Family Size (adults and dependent children)	12.08	7.75	1	76
Production output during 2017-2018				
Cultivated area (in ha)	6.69	6.14	1	55
Production (in kg)	6185.67	10615.23	405	185000
Yield (in kg/ha)	870.81	407.54	200	7400
Observation		437		

Note: "ha" denotes hectare; "kg" stands for kilogram.
Source: Author's computations from the database used in this essay.

2.5 Methodology

This section presents the two methods used in sequence in this essay: (i) the Principal Component Analysis (PCA) aimed at identifying relevant fairness variables, and (ii) empirical strategy employing a logistic regression that is intended to explore the influence of relevant variables on the decision to subscribe.

2.5.1 Principal Component Analysis

To gain insight into the relationships among the fairness variables presented in Figure 2.1, and Table 2.1, I followed Kolenikov and Angeles (2004), and Krishnan (2010) to conduct a PCA on the responses to questions posed to farmers about their perceived fairness of the 2TIC indemnification system. Folger and Cropanzano's (2001) four dimension of fairness (distributive fairness, procedural fairness, interactional fairness, informational fairness) was applied to the 2TIC's indemnification system. Five questions were posed on each dimension of fairness in order to obtain a farmer's view (see Appendix1). Simply put, each of the latent variables (to refer to each dimension of fairness) was measured by five observed variables, resulting in a total of 20 variables. Descriptive statistics of the variables are presented in Table 2.3.

Table 2.3: Respondents view on the four dimensions of fairness

Variables	Opinion	Mean	Standard Deviation	Mean (insured)	Mean (uninsured)
DFI1	Rights to indemnity in false negative	1.96	1.46	2.22	1.11
DFI2	Rights to indemnity in false positive	3.18	1.40	3.24	3.00
DFI3	Worth of the indemnity by size of loss	3.17	1.19	3.29	2.76
DFI4	Equity in indemnification	2.25	1.55	2.51	1.40
DFI5	Possibility of Paying at 1st Trigger	3.52	1.58	3.46	3.72
PFI1	Neighbor GPC's	1.87	1.42	2.06	1.24

	Performance				
PFI2	Own GPC's Performance	3.83	0.77	3.85	3.79
PFI3	Own GPC as threshold	3.85	0.78	3.91	3.65
PFI4	Neighbor GPC's as threshold	4.16	0.66	4.27	3.79
PFI5	Use of a Group-Insurance format	2.12	1.59	2.43	1.10
ItFI1	Insurer willing to payout	2.96	1.42	3.32	1.77
ItFI2	Faith in bank	3.80	0.98	3.94	3.33
ItFI3	Faith in SOFITEX	4.03	0.86	4.10	3.81
ItFI4	Faith in PlaNet Guarantee	3.76	0.98	3.89	3.32
ItFI5	Faith in UNPCB	2.82	1.33	3.04	2.04
InFI1	Info on indemnification New 2TIC	2.8	1.32	3.10	1.85
InFI2	Info on indemnification Old 2TIC	2.79	1.34	3.10	1.76
InFI3	Info on GPC threshold	2.86	1.30	3.13	1.93
InFI4	Info on neighbor GPC threshold	3.53	0.99	3.74	2.81
InFI5	Info on choice of neighbor GPC	3.54	0.98	3.75	2.82

Source: Author's computations from the data used in this essay

With the four dimensions of fairness being represented by a sequence of 20 variables, dimensionality of the dataset was a looming concern that is worth addressing. Thus came the idea of conducting a PCA. A feature of PCA is its ability to reduce dimensionality on a sequence of correlated variables by turning them into a smaller set of uncorrelated variables that explain most of the variations observed on the initial sequence of variables. Prior to proceeding with the PCA, the dataset was checked for multivariate outliers, missing values and multivariate normality. Then a PCA was conducted separately on each of the fairness dimensions. For instance, when the PCA was conducted on the latent variable distributive fairness—which is the comparison farmers make of the indemnity they think they deserve to losses they may have incurred— it includes the following observed variables: DFI1, DFI2, DFI3, DFI4, DFI5. A similar approach was used for procedural fairness measured by the observed variables PFI1, PFI2, PFI3, PFI4, PFI5, Interpersonal Fairness measured by the observed ItFI1, ItFI2, ItFI3, ItFI4, ItFI5, and Informational fairness measured by the observed variables InFI1, InFI2, InFI3, InFI4, InFI5. By doing so, one can easily check which of these five observed variables are correlated and can thus gauge each of the latent variables. For simplicity, I assume that a set of variables will contribute to the group formation if they are well represented in the chosen factor from the PCA.

Determination of the Number of Components

After performing the PCA, I relied on the Kaiser (1960) and Cattell (1966) criteria to determine the number of components that will be retained for the analysis. In fact, the Kaiser criterion requires that any component that displays an eigenvalue greater than 1 be accounted for, as such a value indicates the component contributes significantly to the total variance. Moreover, Stevens (2012) reviews studies that have investigated the accuracy of the eigenvalue criterion, and recommends its use when fewer than 30 variables are being analyzed, or when the analysis is based on over 250 observations. These criteria fit with the characteristics of my sample. Thus, eigenvalues of the 20 variables were determined as shown in Table 2.4.

Table 2.4: Eigenvalues of the Correlation Matrix

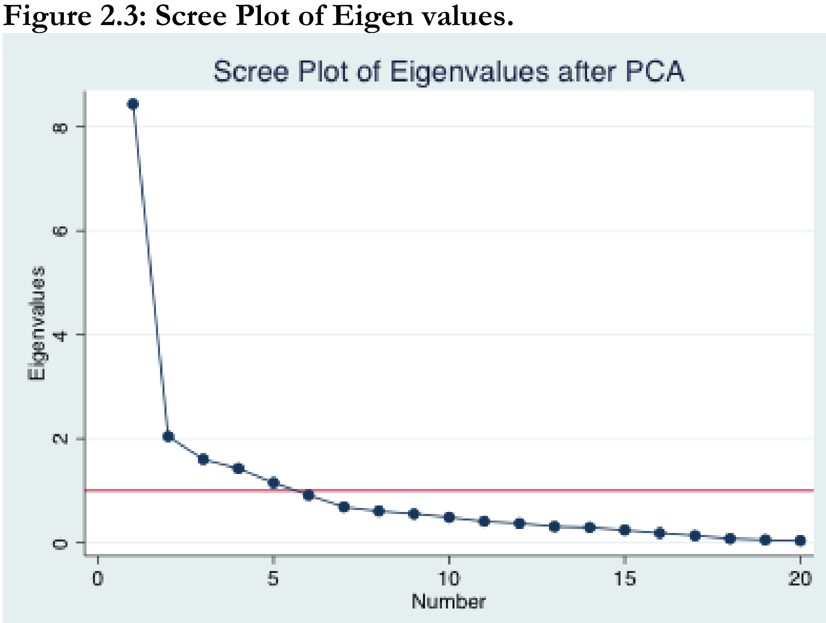
Principal Component	Eigenvalue	Difference	Variation	
			Proportion	Cumulative
1	8.43597	6.39455	0.4218	0.4218
2	2.04141	0.441628	0.1021	0.5239
3	1.59979	0.176126	0.0800	0.6039
4	1.42366	0.274392	0.0712	0.6750
5	1.14927	0.233904	0.0575	0.7325
6	0.915364	0.229635	0.0458	0.7783

7	0.685729	0.0796174	0.0343	0.8126
8	0.606112	0.0520898	0.0303	0.8429
9	0.554022	0.0671774	0.0277	0.8706
10	0.486865	0.0786576	0.0243	0.8949
11	0.408187	0.0378285	0.0204	0.9153
12	0.370359	0.0608169	0.0185	0.9338
13	0.309542	0.0177375	0.0155	0.9493
14	0.291804	0.519521	0.0146	0.9639
15	0.239852	0.0558032	0.0120	0.9759
16	0.184049	0.0493943	0.0092	0.9851
17	0.134655	0.0590103	0.0067	0.9918
18	0.0756444	0.0243445	0.0038	0.9956
19	0.0512998	0.0148586	0.0026	0.9982
20	0.0364412	-	0.0018	1.0000

Source: Author's computations from the data used in this essay

Table 2.4 indicates that the eigenvalues for the first five components are greater than one, an indication that the first five components are accounting for a meaningful amount of the total variance (73.25%). Therefore, they should be retained as components of practical significance. Still referring to the 'eigen value greater than one' criteria used to retain meaningful factors (Kaiser, 1961), I conducted a scree plot of eigenvalues on the overall list of 20 variables. Results of the scree plot suggest that five factors/components had to be retained (See, Figure 2.3).

Figure 2.3: Scree Plot of Eigen values.

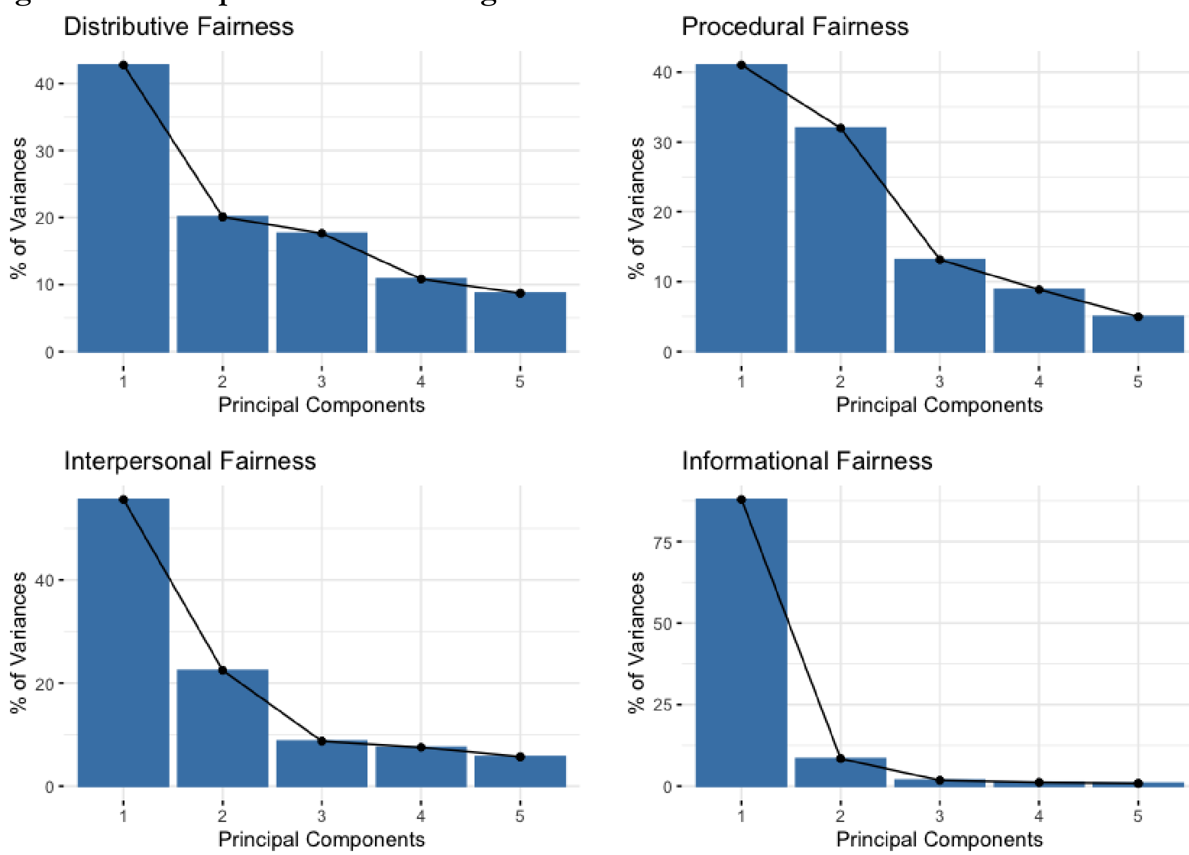


Source: Author's computations from the data used in this essay

Since Kaiser's approach is not the sole method used to determine the number of principal components that have practical significance, I also used a graphical method, known as Cattell (1966)'s "scree" test to verify the number of principal components that will be extracted from the PCA, if I were considering the percentage of variance explained.. This approach presented in Figure 2.4 shows plots for each of the eigenvalues of the factors. One can inspect each plot to find the place where the smooth decrease of eigenvalues appears to level off. Just like on a rocky slope, only loose ("scree") material collects on the lower part beyond that point. After examining the scree-plot, Figure 2.4 reveals that five components should be retained:

- One factor is extracted for the analysis of the distributive fairness (DFI)
- Two factors are extracted for the analysis of the procedural fairness (PFI)
- One factor is extracted for the analysis of the interpersonal fairness (ItFI)
- One factor is extracted for the analysis of the informational fairness (InFI)

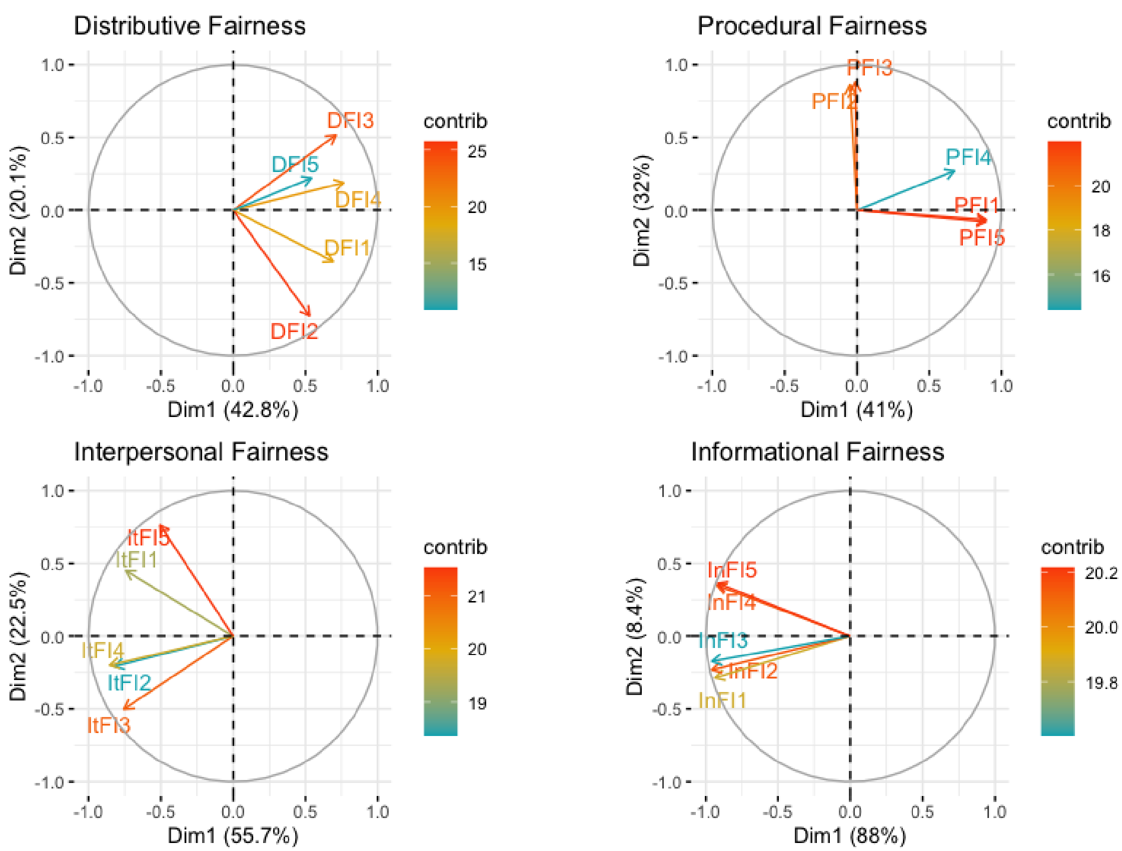
Figure 2.4: Scree plot from PCA of eigenvalues of factors



Source: Author's computations from the data used in this essay

Once the number of extracted principal components were identified, I proceeded to the identification of variables that meaningfully reflect those components. To do so, I examined their factor loadings. The literature on Factor Analysis considered 0.3 as the minimal the value of a loading that variables should have vis-à-vis the component they are attempting to define (Kim 1975; Kim et al. 1978; Kerlinger 1986; Hair et al. 1998). Loadings of 0.40 are considered more important, and those exceeding 0.5 are viewed as practically significant (Hair et al. 1998). In this essay, variables with loadings lees than 0.3 were not retained. Following these criteria, the variables DFI1, DFI3, DFI4, whose loading factors were respectively 0.47, 0.48, 0.52 were retained. A similar line or reasoning was used to keep relevant variables for Procedural Fairness, Interpersonal Fairness, and Informational Fairness.

Figure 2.5: Variables Contribution for Each of the Fairness Dimension



Source: Author's computations from the data used in this essay

Figure 2.5 known as the circle of correlation plots shows the relationship between variables pertaining to the each of the fairness dimension. It reveals that:

(i) DFI1, DFI3, and DFI4, are correlated and well representative of Distributive Fairness

(ii) PFI1, PFI4, PFI5 are grouped together, while PFI2 and PFI3 together form another group, therefore suggesting that two groups of variables are well representative of Procedural Fairness

(iii) ItFI1, ItFI2, ItFI3, and ItFI4 are representative of Interpersonal Fairness

(iv) InFI2, InFI3, InFI4, and InFI5 are representative of the informational fairness

These new groups were renamed into single variables, based on what the component highly loads on. As such:

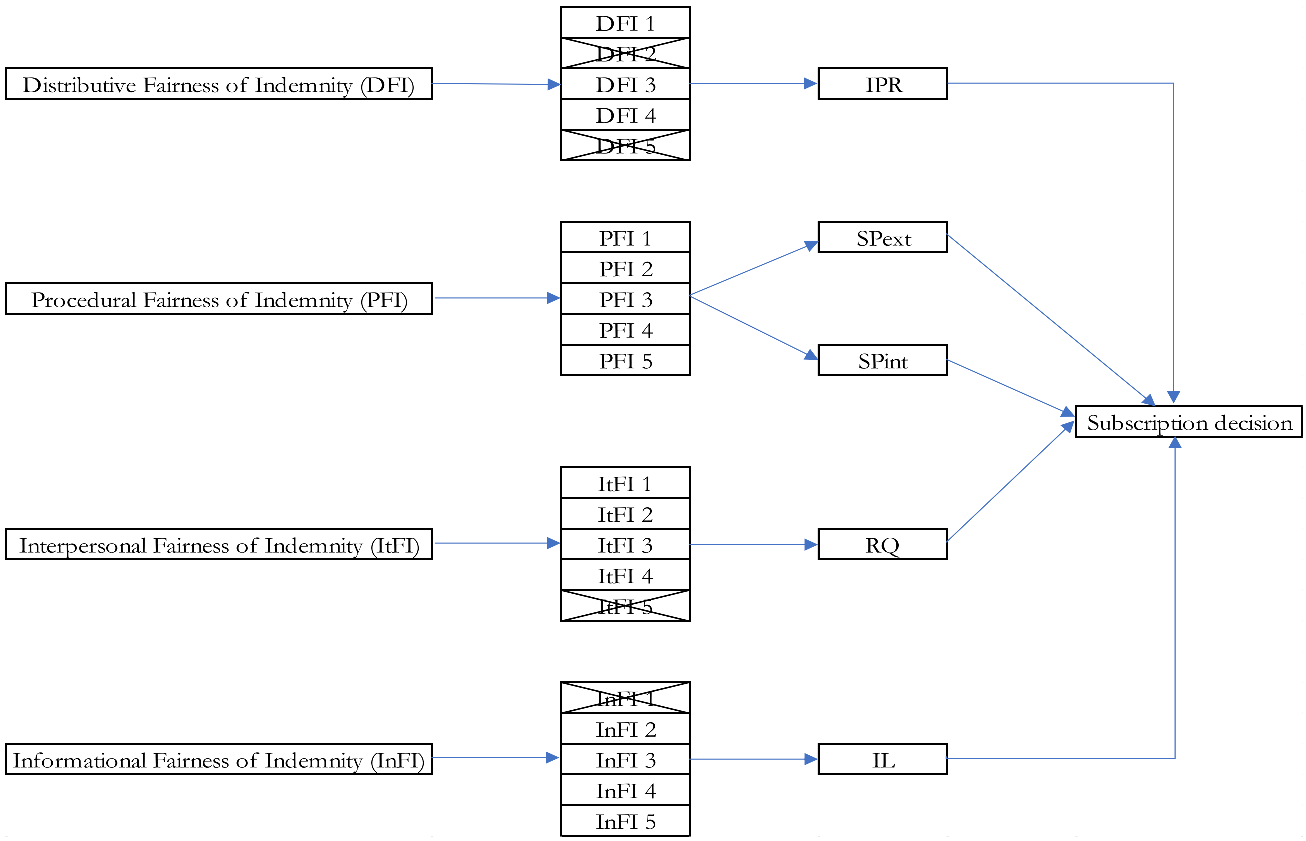
(i) the three variables DFI1, DFI3, and DFI4 measure "**Insurance Product Reliability**" (IPR) and describe farmers' judgment of the scale to which the indemnity is in line with the amount or value of the incurred loss.

(ii) for the two different groups of variables that appear to characterize the procedural fairness of the 2TIC's indemnification, the first group comprised of PFI1, PFI4, FI5 measures the "**Strike Point External**" (SPext). This indicator measures farmers' judgment of the suitability of the second (that is, the external) trigger criteria leading to the indemnification (e.g., the production of the neighboring, reference GPC vis-à-vis the established threshold). The second group consisting of PFI2and PFI3 measures the "**Strike Point Internal**" (SPint), which describes farmers' judgment of the suitability of the first (that is, the internal) trigger criteria leading to the indemnification (i.e., their own production vis-à-vis the threshold).

(iii) the group of variables that includes ItFI1, ItFI2, ItFI3, and ItFI4 measures the "**Relationship Quality**" (RQ), which is the quality of relationship, hence the level of faith and confidence that cotton farmers have vis-à-vis stakeholders from the insurance supply chain. More precisely, it describes the level of credence that cotton farmers have towards the various stakeholders from the insurance supply chain, when it comes to the 2TIC.

(iv) the group of variables encompassing InFI2, InFI3, InFI4, and InFI5 was named "**Insurance Literacy**" (IL). It measures farmers' judgment of the quantity of information about the insurance contract that was given to cotton farmers. With this information summarized on Table 2.6 , the boxes labeled "factors" in Figure 2.1 can be substituted by their relevant name as shown in Figure 2.6.

Figure 2.6: Diagram of the links between fairness elements and subscription decision



Source: Author's drawing

Once the number of extracted components and variables within those components were identified, I relied on statistical tests to check for the internal validity of the analyses.

Testing the Appropriateness and Consistency of the PCA

Researchers who use Factor Analysis check for the appropriateness of the process at the beginning (i.e., with the initial sequence of variables), and at the end (i.e., with the set of extracted variables) of the analyses to see if the variables show multicollinearity. A statistic test often used to detect the strength of correlation between variables, and therefore see if those strengths are good enough for a factor analysis to be pursued is the Kaiser-Meyer-Olkin (KMO). The maximum value of KMO can be 1. A value of 0.9 to 1 is considered as "marvelous", 0.80 to 0.89 "meritorious", 0.70 to 0.79 "middling", 0.60 to 0.69 "mediocre", 0.50 to 0.59 "terrible", and less than 0.49 "unacceptable" (Kaiser 1960, 1974; Antony and Rao, 2007). In this essay I used KMO to assess the strength of correlation, and only considered factors whose KMO were above 0.49. Results from Table 2.3 reveal that the KMO measures on each of the fairness dimensions are all above the 0.49 threshold of "unacceptable" that would prevent a factor analysis from proceeding. It was therefore justified to conduct a factor analysis, as shown by the significant statistical results of the Bartlett's test of Sphericity (Table 2.6). Moreover, I used the Cronbach's Alpha measure to investigate the internal consistency of the variables under consideration related to the concerned questions (Cronbach, 1951). Indeed, if Cronbach's Alpha is near one, then the variable under consideration has a good consistency. Nunnally (1994) and Rungtusanatham et al. (1998) argue that an alpha of 0.7 should be the minimally accepted value for multivariate analyses. However, other scholars attest that an alpha ranging from 0.60 to 0.70, though moderate is considered acceptable, especially when it comes to newly developed instruments (Griethuijsen et al. 2014). Cronbach's Alpha in Table 2.3 were at least equal to 0.6, suggesting that the variables have relatively high internal consistency.

Table 2.5: KMO measure of sampling adequacy, Bartlett's test of sphericity and Cronbach's Alpha (List of Initial Variables)

Variables	KMO Measure of Sampling Adequacy	Bartlett's Test of Sphericity			Cronbach's Alpha
		Chi-square	Df	Sig	
DFI1, DFI2, DFI3, DFI4, DFI5	0.631	350.9	10	0.000	0.652
PFI1, PFI2, PFI3, PFI4, FI5	0.578	622.9	10	0.000	0.609
ItFI1, ItFI2, ItFI3, ItFI4, ItFI5	0.736	837.7	10	0.000	0.772
InFI1, InFI2, InFI3, InFI4, InFI5	0.827	3445.1	10	0.000	0.962

Source: Author's computations from the database used in this essay. "Df" denotes the degrees of freedom and Sig. stands for significance.

Following the extraction of variables, similar tests were conducted with results summarized in Table 2.7. Those results) show an improvement in Cronbach's Alpha and a modest improvement in the KMO, therefore suggesting that the set of extracted variables is a set of characteristics that explain most of the variation present in the initial list of characteristics.

Table 2.6: KMO measure of sampling adequacy, Bartlett's test of sphericity and Cronbach's Alpha (List of Extracted Variables)

Variables	KMO Measure of Sampling Adequacy	Bartlett's Test of Sphericity			Cronbach's Alpha
		Chi-square	Df	Sig	
DFI1, DFI3, DFI4,	0.639	203.1	3	0.000	0.664
PFI1, PFI4, PFI5	0.618	440.2	3	0.000	0.747
PFI2, PFI3	0.500	157.3	1	0.000	0.711
ItFI1, ItFI2, ItFI3, ItFI4,	0.740	678.7	6	0.000	0.791
InFI2, InFI3, InFI4, InFI5	0.741	2452.4	6	0.000	0.951

Source: Author's computations from the database

Interpretation of results from PCA

As mentioned in Section 5.1, I began by running the PCA separately on the distributive fairness variables (DFI1, DFI2, DFI3, DFI4, DFI5) procedural fairness (PFI1, PFI2, PFI3, PFI4, PFI5), interpersonal fairness (ItFI1, ItFI2, ItFI3, ItFI4, ItFI5) and on the informational fairness variables (InFI1, InFI2, InFI3, InFI4, InFI5). Based on the 'eigenvalue greater than one' criteria, I later extracted five components that were used to run another PCA. Loadings of those extracted principal components indicate that with five components, 24.28% of the variation is still unexplained, meaning that the rest (75.72%) is explained. As explained above, since the first component loads highly on variables (DFI1, DFI3, DFI4) which can be interpreted as Insurance Product Reliability, the first component was labelled as such. A similar rationale (i.e., the fact that components loading highly on certain variables) was used to name the second component as Strike Point External, the third as Strike point internal, the fourth as Relationship Quality and the fifth as Insurance Literacy.

Computation of the Fairness Indicators

Following the extraction of the five principal components, I estimated their scores, so that the scores will serve as fairness indicators for the remainder of the analysis. I refer to the variables that are well representative on the selected components to compute the fairness indicators. Table 4 presents the selected variables and the names of associated indicators. I follow a similar approach adopted in Sekhar et al. (1991), Kobiane (2004), and Antony and Rao (2007) in studies involving PCA to compute the fairness indicators. Indeed, consider the PCA on the distributive fairness variables where only one factor is retained. Let $W_{1,i}$ be the farmer i's factor coordinates on this first component. I compute the "Insurance Product Reliability" indicator IPR_i for farmer i using the following two steps:

Step 1: Compute the values of quartile $Q_1, \dots, Q_4$ from all the respondent farmers' coordinates on the selected factor.

Step 2: Compute the "Insurance Product Reliability" indicator as follows:

$$IPR_i = \begin{cases} 1 & if \ W_{1,i} < Q_1 \\ 2 & if \ Q_1 \leq W_{1,i} < Q_2 \\ 3 & if \ Q_2 \leq W_{1,i} < Q_3 \\ 4 & if \ W_{1,i} > Q_3 \end{cases} \qquad (1)$$

A similar approach is used to compute the other indicators.

Table 2.7: Selected variables and Indicators' name

Variables	Indicators' name	Notation
DFI1, DFI3, DFI4	Insurance Product Reliability	IPR
PFI1, PFI4, FI5	Strike Point External	SPext
PFI2, PFI3	Strike Point Internal	SPint
ItFI1, ItFI2, ItFI3, ItFI4	Relationship Quality	RQ
InFI2, InFI3, InFI4, InFI5	Insurance literacy	IL

2.5.2 Empirical Strategy

Model

Consider a population of N farmers indexed by $i = 1, \dots, N$. Each farmer i must decide whether or not to subscribe ($Y_i \in \{0,1\}$) to the 2TIC in order to protect their production against natural shocks. Each farmer makes the choice Y_i in order to maximize their pay-off function $V: Y \longrightarrow \mathbb{R} \cup \{-\infty\}$. In other words, one can think of V as the sentiment of protection/ security that farmers could have when subscribing to the 2TIC. This sentiment can motivate farmers to fully spend their efforts for production since there are convinced that they will be able to cope with potential shocks. By exerting their maximum, farmers can therefore reach their potential production and then maximize their expected satisfaction.

I follow Soetevent and Kooreman (2007) and specify farmers' pay-off function as follows:

$$V(Y_i, S_i) = \psi Y_i S_i + (X_i\theta + \eta_i)Y_i - \frac{1}{2}Y_i^2 - \phi S_i \qquad (2)$$

where $S_i \in \{0,1\}$ captures the farmer's probability of experiencing a weather shock (reflected by their past experience) with S_i equaling 1 if farmer i experienced a weather shock in the past, and 0 otherwise; $\phi > 0$ is the farmer i's average damage from the weather shock; $\frac{1}{2}Y_i^2$ is the cost of the subscription to the 2TIC and ψ is the intrinsic benefit from subscribing to the 2TIC. I assume that for any farmer i, $\phi > \psi$. The vector X_i captures farmers' observable characteristics. The parameters θ and η_i stand respectively for the effect of individual's observed and fairness characteristics and may therefore capture the farmer's idiosyncratic risk preferences. This is consistent with the literature which finds differences across individuals (Croson and Gneezy, 2009). Thus, the term $X_i\theta + \eta_i + \psi S_i$ appears to positively influence farmers' subscription to the 2TIC.

The first order condition that derives from solving equation (2) is given by:

$$Y_i = \eta_i + X_i\theta + \psi S_i \qquad (3)$$

However, since the probability of a shock is generally an unobservable variable, I assume that S_i is unobserved to the econometrician. This leads equation (3) to:

$$Y_i = \eta_i + X_i\theta + \epsilon_i \qquad (4)$$

where ϵ_i is an error term that captures farmers' unobserved heterogeneity. Following Nicklin and Williams (2009) and Nicklin (2013), I assume that farmers' fairness characteristics η_i is a function of insurance product reliability (IPR), strike point external (SPext), strike point internal (SPint), relationship quality (RQ), and insurance literacy (IL). Finally, I estimate the model in the next section.

Model Estimation

Assuming that perception is something that can be influenced by things experienced in the past, the fact that 83.5 % of the sample reported having subscribed to 2TIC at least once since its rollout in 2013/2014, is a sign that subscription to 2TIC, per se, could possibly take the value of 0, 1, 2, 3 ,4, 5 over the period spanning from the 2013/2014 agricultural season to the 2018/2019 season. For that reason, I tried to capture the experience effect (See question 3.A.3) in the survey questionnaire in the hope of obtaining data, for which an ordered or conditional logit would have been more appropriate, given the nature of the explained variable. However, the response rate for that question failed to generate a set of data for which an ordered or conditional logit would have been feasible. With an ordered or conditional logit being infeasible given the final current dataset obtained, I proceeded with a simple logit model.

To examine the determinants of cotton farmers' decisions to subscribe to 2TIC, I estimated the following model:

$$Y_i = \beta_0 + \beta_1 IPR_i + \beta_2 \text{SPext}_i + \beta_3 \text{SPint}_i + \beta_4 \text{RQ}_i + \beta_5 IL_i + X_i'\theta + \epsilon_i \quad (5)$$

Where and $IPR_i, SPext_i, SPint_i, QR_i$ and IL_i are the selected fairness indicators described in the section 5.1.4. The vector of variables X includes farmer's observable characteristics such as: level of education, age, household size, etc. The error term ϵ captures unobservable factors that may explain farmers' subscription decision, which are not included in the equation (3). I assume that ϵ follows a logistic distribution. The next section presents the estimation results.

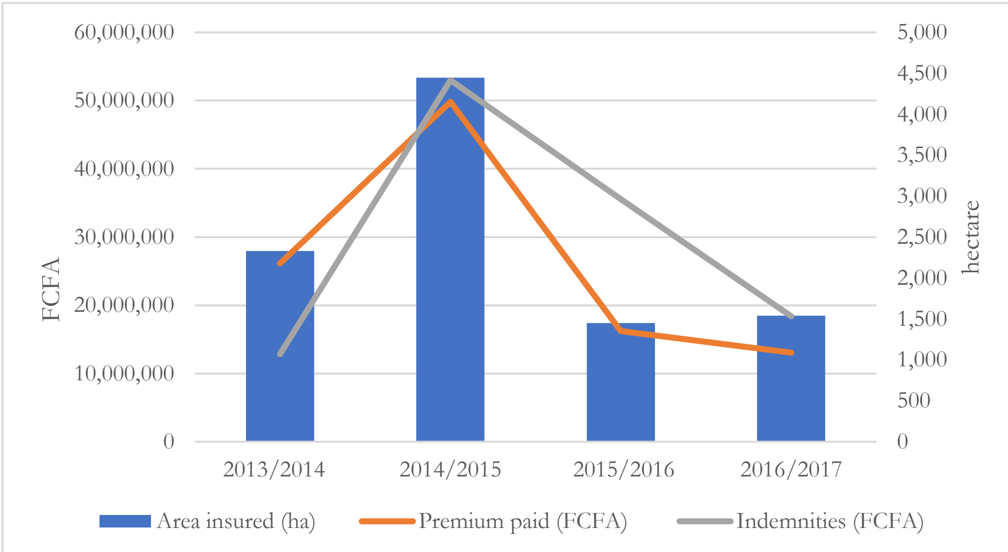
2.6 Empirical Results

Table 5 presents the estimation results. Column 1 provides a summary of the results on the fairness related indicators, our variables of interest in this study. It reveals that Insurance Product Reliability (i.e., the judgment farmers make about the indemnity they think they deserve against losses they may have incurred), with a coefficient of 2.606, is positively and significantly correlated with farmers' decision to subscribe to the 2TIC. In other words, the more farmers perceived an insurance payout as probable and aligned with their incurred losses, the more likely they are to subscribe to the 2TIC. This finding is in line with Casaburi and Willis (2018), Jensen et al. (2018), and Stoeffler et al. (2020) who find that insurance payouts and their right timing are likely to affect farmers' well-being and the desirability of the insurance product. Likewise, Fuchs and Wolff (2011) and Hill et al. (2013) find that the more an insurance product is designed so that farmers' indemnities are aligned with their actual losses, the higher their consideration for the insurance product. For instance, Stoeffler et al. (2020) show that in Burkina Faso, people who did not receive a payout were less inclined to renew their contract. In other words, receiving an indemnity in a given year is a strong predictor for a willingness to subscribe in the following year.

The next largest coefficient (0.849) is for Insurance Literacy (i.e., the quantity of information given to cotton farmers about the product and its thresholds), which is also positively and significantly related to the likelihood to subscribe to the 2TIC. This implies that the more farmers consider they have received (and understood) sufficient information about the 2TIC's indemnification system, the more likely their decision to subscribe. Several authors such as Giné et al. (2007), Akter et al. (2009), and Dercon et al. (2014) reached similar findings in their research.

Surprisingly, results show that Relationship Quality – the level of credence that cotton farmers have towards the various stakeholders from the insurance supply chain – has a negative and significant correlation with the probability to subscribe to the 2TIC. One potential reason that could explain the negative correlation is dissonance in views regarding 2TIC that farmers may have been receiving from the various stakeholders involved. Indeed, since the SOFITEX agent (i.e., "Agent Technique Coton" known as ATC) is not the same as the insurance agent (the broker PlaNet Guarantee), it could be that trusted ATCs, due to their longstanding work-related interactions with cotton producers are providing them with cues that perhaps 2TIC is not the best thing to purchase. While the decrease in number of subscriptions noted by PlaNet Guarantee-Burkina Faso between the 2014/2015 agricultural season and that of 2018/2019 speaks to that effect (See figure 2.7), more research is necessary to corroborate this intuition.

Figure 2.7: Trends in Area Insured, Premium and Indemnities paid for 2TIC over 2013-2017



Source: Author's drawing based on data obtained from PlaNet Guarantee

The analyses also finds both strike points (internal and external) to be negatively correlated with farmers' decision to subscribe, meaning that the less that farmers take issue with the applicable strike points the higher their probability of subscribing to 2TIC. While Strike Point External (i.e., judgment of the external, second trigger process that leads to decision related to the issuance of the indemnity) is not significant, Strike Point Internal (i.e., judgment of the internal, first trigger process that leads to decision related to the issuance of the indemnity) is statistically significant. In other words, the less that cotton farmers find the strike point set internally (SPint) to be problematic, the greater their likelihood to subscribe to the 2TIC. This finding is consistent with the earlier observation that a perception of high product reliability is associated with higher subscription likelihood, and is congruent with Patt et al. (2009) who showed that people are sensitive to trust indices used in the insurance contract as well as the structure of the insurance product itself.

Farmers' socio-demographic characteristics were added in column 2 to see how they affect the coefficients of the fairness related indicators, and their level of significance in the model. Three variables (Age, Education, Family Size) pertaining to framers' characteristics were retained. Comparing the sign and level of significance noted in column 1 for the perceived fairness-derived variables with those in column 2 shows consistent results (i.e., the magnitude and relative ranking of the coefficients is unchanged, and their significance levels are unaffected by the inclusion of farmer characteristics). From the three variables that were added, education had the greatest coefficient (1.120), was positively related to subscription decisions, and was statistically significant at the 5% level. This finding is in line with the earlier observations about the importance of insurance literacy and suggests farmers with more formal education (no respondents had higher than secondary schooling) were better able to understand and assess the 2TIC. The only other significant household characteristic variable (Family size) had a very modest coefficient (0.071) and was only significant at the 10% level. This suggests that an additional member to the family (a potential proxy for labor force) is associated with a 7 % higher chance of subscribing to 2TIC.

Finally, the full version of equation 5, which includes the 2TIC product characteristics (farmers' view on premium affordability and basis risk), is presented in column 3. Of the two inherent characteristics of the insurance product that were added, only farmers' opinion on basis risk proved significant, a finding which is supported by previous studies (Skees 2008; Carter et al, 2007; Clarke 2011; Mobarak and Rosenzweig, 2012; Jensen et al., 2018). The coefficient of farmers' opinion on premium affordability, although positive was not statistically significant. Column 3 also reveals that even when considering the inherent product characteristics in addition to farmers' characteristics, the coefficients for the fairness indicators, their relative magnitude, ranking, and significance levels still hold, suggesting they are robust.

Table 2.8: Estimation results from the logistic regression

Variables	(1)	(2)	(3)
Perceived Fairness-derived Factors			
Insurance Product Reliability (IPR)	2.606***	2.704***	2.456***
	(0.385)	(0.438)	(0.428)
Strike Point External (SPext)	-0.261	-0.089	-0.206
	(0.352)	(0.375)	(0.408)
Strike Point Internal (SPint)	-1.966***	-2.039***	-1.777***
	(0.416)	(0.442)	(0.444)
Relationship Quality (RQ)	-1.887***	-1.978***	-2.090***
	(0.370)	(0.389)	(0.412)
Insurance Literacy (IL)	0.849***	0.909***	0.906***
	(0.304)	(0.345)	(0.351)
Farmers' Sociodemographic Characteristics			
Age		-0.002	-0.001
		(0.023)	(0.023)
Education		1.120**	1.048**
		(0.494)	(0.497)
Family Size		0.071*	0.075*
		(0.038)	(0.040)
2TIC Characteristics			
Premium Affordability			0.268
			(0.201)
Basis Risk			1.489***
			(0.375)
Constant	9.179***	6.957***	4.717**
	1.797	2.021	2.258
Observations	437	437	437
R-squared	0.3121	0.3488	0.3964

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations from the data used in this essay

To assess how well the simple logistic regression model fits the data, a goodness of fit test was considered. Given our sample size of 437, the Hosmer-Lemeshow goodness-of-fit test, which determines compliance of logistic regression model for continuous and discontinuous predictors of sample size in the range of 400 (Hosmer and Lemeshow, 2000) was performed.

A p value less than 0.05 in the Hosmer-Lemeshow test (indicating that it is significant), means that the model is a poor fit to the data. The test result of the Hosmer-Lemeshow (presented in Table 2.6) showing a p value that is greater than 0.05 (a sign that it is significant) means that there is not sufficient evidence to suggest a poor model-data fit, therefore indicating that the simple logistic regression model is adequate.

Table 2.9: Hosmer-Lemeshow Test Results

Step	Chi-square	df	Significance
1	13.04	8	0.210

Source: Author's computations from the data used in this essay

2.7 Conclusion

This essay investigates the determinants of farmers' decision to subscribe to 2TIC in two departments of Burkina Faso: Houndé and Founzan. To do so, I collected data on 437 cotton farmers during the period of January to February 2019. I used PCA to compute five indicators related to farmers' perceived fairness of 2TIC. These indicators include insurance reliability product, strike point external, strike point internal, quality of the relationship between farmers and their insurer, and the insurance literacy. I then performed logistic regression to identify factors that are relevant for shaping farmers' decision to subscribe to the 2TIC. I find that farmers' perceptions of fairness clearly matter, and four out of the five fairness indicators had a significant relationship with subscription decisions even when adding socio-demographic and insurance product characteristics into consideration. Of these, the subscription decision became more likely when farmers held a higher perception that the insurance payout would align with losses. My results also show that farmers' insurance literacy positively affects their decision to subscribe to the insurance product.

A key takeaway from these results is that perceived fairness — derived from farmers' views on insurance product reliability, strike points, quality of relationship, and insurance literacy — is an important determinant of demand for 2TIC. This finding has important policy implications for the design of index insurance products as well as the implementation of index insurance program. Given the strong desire by the government of Burkina Faso to scale up

2TIC nationwide, it will be opportune to consult cotton farmers, and whenever possible include their views in the design and implementation phase of the program so that the program will meet farmers' expectations. An insurance program whose objectives are aligned with cotton farmers' expectations is likely to generate more subscriptions, an outcome that most likely will also benefit insurers and other parties involved in the transaction.

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Chapter 3 — Essay 2: The Effects of Double Trigger Index-Based Insurance on Farmers' Income: Evidence from Cotton Farmers in Burkina Faso

Wilfried D.J. Nonguierma

Abstract

This essay assesses the impact of the Double Trigger-Index based Insurance Contract (2TIC) on farmers' net income using data from cotton farmers that were collected during the period of January to February 2019 in Burkina Faso. Since cotton farmers are not randomly assigned in the sample, the Coarsened Exact Matching (CEM) approach developed by Blackwell et al. (2009) was used to estimate the effect of 2TIC subscription on farmers' net income from cotton production. Results show that 2TIC subscription was associated with a significant increase (+ 35%) in farmers' net income, compared to those who did not subscribe. Quantile regressions shows that 2TIC subscription was associated with higher mean net incomes for subscribers compared to uninsured farmers at all income levels. The differences in mean net incomes were greatest for cotton farmers in the bottom and top quintiles. These findings offer important insights, as they suggest that 2TIC for the collected sample was associated with important welfare gains across all income levels but has potentially important pro-poor benefits in labor saving and income security for the most vulnerable farmers (the bottom cotton income quintile).

3.1 Introduction

Over the past decade, the growth of agricultural index-based insurance (IBI) has been remarkable in developing countries(Hazell et al. 2010; Hazell and Hess, 2017). This is primarily due to the important roles played by academics, government agencies, and multilateral international NGOs in promoting index insurance as a way to safeguard smallholder agricultural livelihoods and to establish sustainable private agricultural insurance markets (Hess et al., 2005; Leblois et al., 2014; Miranda, 1991). In comparison with Traditional Crop Insurance (TCI) products which require an assessment of loss (when it occurs) that can be costly to farmers when costs are transferred from the insurer to the insured, IBI schemes which are designed to protect farmers' production against risks of losses caused by covariate shocks, can be economical to famers since the loss assessment component is non-existent. Hence, the economical aspect of IBI makes it an auspicious tool for addressing risks of losses that threaten farmers' agricultural investments. This is the case, because when loss occurs it tends to reduce farmers' expected profits (Morduch, 1995) and discourage them from pursuing other productive investment strategies. Under such circumstance, the provision of an insurance indemnity has the potential to offset the ruinous effect of losses that farmers are facing, and to a certain extent, allow them to embark on other productive investments strategies. In this way, not only could an insurance indemnity allow farmers to withstand the detrimental effect of losses, but it could also serve as a steppingstone boost to carry out other productive activities. With that rationale, a pilot project of the Double Trigger Index-based insurance Contract (thereafter, 2TIC) was initiated in Burkina Faso during the 2013-2014 agricultural season. Following its introduction, 2TIC has benefited from recurrent take-up by some farmers, prompting researchers and development practitioners to evaluate its impact.

Empirically the relationship between insurance and income has mainly been examined at an aggregate level. In the USA, Leatham et al. (1997) who employed an input-output model to investigate the effect of crop insurance in North Dakota, found that insured farmers saw their average annual personal income increase by $94 million over the 1987-1995 period, as compared to uninsured farmers. In Japan (more specifically in the prefecture of Aomori) where excessive low temperature during a summer led to severe losses of paddy rice, Yamauchi (1986, p. 234) showed that insured farmers were indemnified 64 % of their expected gross income, an indemnity that was sufficient to cover their operating costs of paddy farming, and also partially contribute to their profit. In China, Liang et al. (2008) who use a granger causality test to examine the temporal relationship between crop insurance and farmers' income found a positive link between insurance decisions and income outcomes. In the same vein, Sun and Chen (2011) also used a granger causality test to investigate the effect of insurance on income and found that insurance causes income to increase. Delving further into the causal relationship between crop insurance and farmers' income, Zhao et al. (2016) used three different approaches—Difference -in Difference (DID), Propensity Score Matching (PSM), Propensity Score Matching with Difference-in-Difference (PSM and DID)— in an analysis of a dataset obtained from farmers in Mongolia. Results in this context, however, show that crop insurance does not significantly affect farmers' income. With this ambivalent relationship (between insurance and income) demonstrated in previous studies, researchers, and development practitioners have used impact evaluation approaches to explore the relationship between insurance and income in the case of the 2TIC approach.

In cotton-growing regions of West Africa, 2TIC approaches have been in place since 2010 (in Mali) and 2013 (Burkina Faso). Using experimental and quasi –experimental methods in southern Mali, Elabed et al. (2013) found that subscription to 2TIC causes an extensification of cotton area (between +15 and +60%), suggesting that insurance could play an important role in encouraging farmers to undertake profitable but risky activities like cotton farming. In Burkina Faso, Barré et al. (2016) show that 2TIC has a stabilizing effect on farmers' agricultural income. However, it is worth noting that this study, while theoretically sound (employing the expected utility function under risk uncertainty), relies on simulation techniques, which could not account for the possible impacts of **different farm-gate prices** set by SOFITEX, which are based on the quality of cotton produced. Stoeffler et al (2020) who parsed the income portfolio of cotton farmers in Houndé, Burkina Faso, into income 'from cotton farming activity' and 'from non-cotton farming activities' show no impact of insurance on 'cotton-farming activity', but a significant and positive spillover impact on 'non-cotton farming activities'. The positive impact on 'non-cotton farming activities' suggest that farmers whose cotton production was insured were able to diversify their investments into other potentially profitable activities. For instance, insured farmers increased their sesame farming by 17%, and increased their livestock holdings on average by one unit, or +35% compared to the baseline

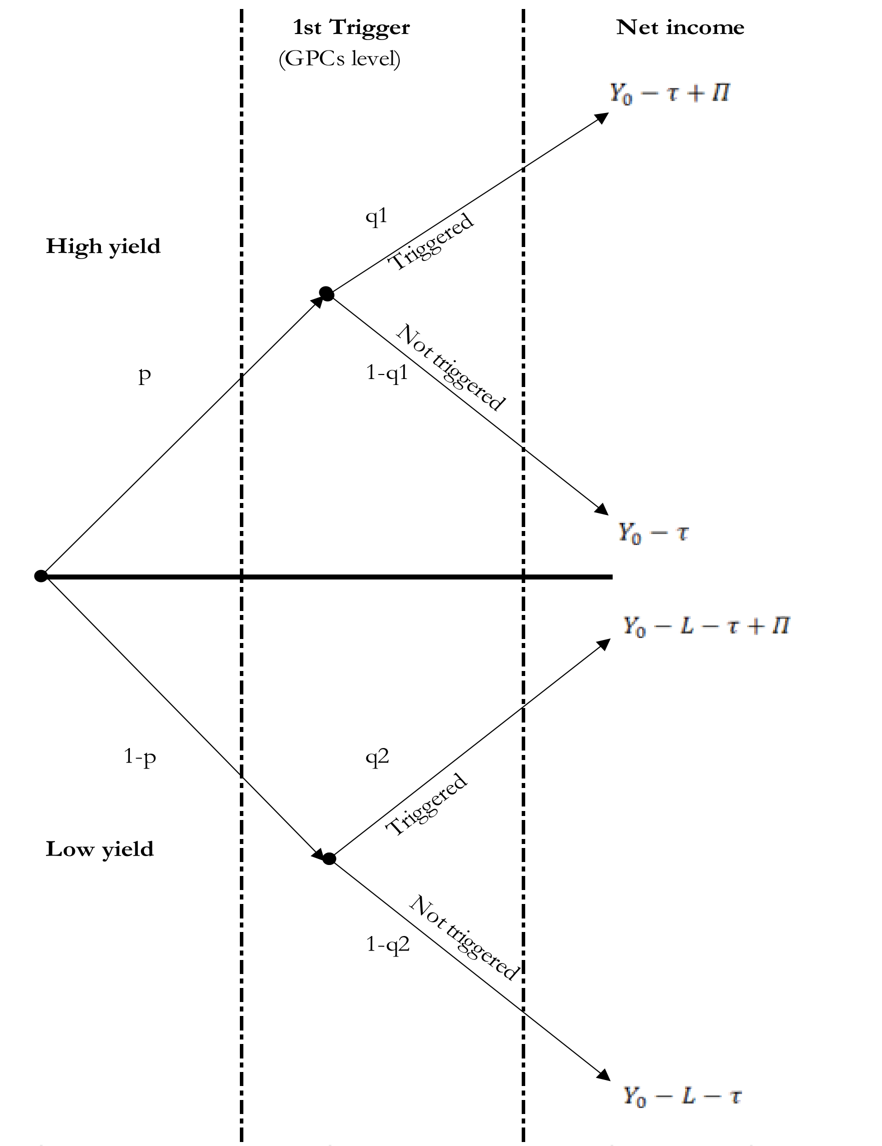
(Stoeffler et al. 2016; 2020). The studies by Stoeffler et al. (2016; 2020) are useful for demonstrating a significant and positive spillover impact on non-cotton farming activity, but explain the non-significant impact on cotton farming by **implementation challenges** with 2TIC. Their study was conducted in only the second year of the 2TIC (2014-2015 agricultural campaign). Besides farmers' relative unfamiliarity with the product, there were multiple challenges, including the comparatively late sale of the 2TIC to farmers, which would have undermined many cotton-related investment decisions at the time of planting. The present paper sought to revisit the insurance-income relationship in Burkina Faso to take account of both (i) the possible differences in farm-gate price and (ii) implementation challenges (such as late sales of the 2TIC) faced in the product's early years. This essay offers an analysis under new lenses: (i) assessing the impact of insurance subscription on cotton-derived income, where cotton-derived income is obtained by subtracting revenue from sales (using farm-gate price) from production costs, and (ii) undertaking such an assessment once the 2TIC program was well-established (five years after its launch), in a season where the product's sale was completed on time. In doing so, this essay fills the gaps mentioned in previous studies. By addressing the variance in farm-gate price that affect farmers' revenues and taking into consideration the good timing of 2TIC sales, the essay offers new insights that adds to the literature on the relationship between crop insurance and farmers income.

The essay presents a theoretical analysis, as well as an empirical illustration, of the interplay between 2TIC subscription and farmers' net income deriving exclusively from cotton production. To my knowledge, this essay is the first in the Burkina Faso cotton sector to use survey data and employ a matching technique to assess the effect of an area-based yield (ARBY) insurance product on farmers' income that derives from the crop for which they were insured. The theoretical framework used in the essay builds on Elabed et al (2013) with the important difference that it specifically models the first and second triggers. Similar to Elabed et al (2013), the model predicts that investing in the 2TIC reduces farmers' exposure to risk. This risk rationing strategy has the potential to impact farmers' cotton production, and subsequently their income. As such, an a-priory hypothesis tested in this essay is that subscribing to 2TIC is associated with higher net income deriving from cotton production. The essay tests that hypothesis by empirically estimating the impact of the 2TIC insurance on net income stemming from farmers' cotton production. Results shows a substantial increase in farmers' net income by about 35% for the 2TIC subscribers compared with those who did not subscribe. Robustness checks using Propensity Score Matching (PSM), Mahalanobis Distance Matching (MDM) and Kernel Matching (KM) show that results remain statistically significant, therefore suggesting consistently that subscribing to 2TIC is associated with higher net income. The essay also estimates quantile regression to see if the impact of 2TIC subscription on farmers' net income changes depending on the cotton farmer's level of net income. Findings show that while the effect of 2TIC on net income is positive across all quintiles, the effect is greater for farmers belonging to the bottom and top quintile than those belonging to the second and third quintile. The rest of the essay is organized as follows. In the next section I present a theoretical analysis of the 2TIC contract. In section 3, I describe the data and summarize the treatment and control group used in the study. Section 4 presents the empirical strategy used for the causal inference. I discuss the results in Section 5 and investigate the effect of the 2TIC on inputs use in section 6. I conclude the essay in section 7.

3.2 Theoretical Frameworks

Previous studies built on existing theories of decision-making under risk to investigate the interplay between crop insurance and welfare improvement (see for instance, Elabed et al., 2013; Flatnes and Carter, 2016; Jensen et al., 2014). In this essay, the analysis builds on the stylized representation of an agricultural insurance with a single trigger system, under two states of the world (good meaning high yield, and bad meaning low yield) that was presented by Elabed et al. (2013) (See Figure 3.1).

Figure 3.1: An Agricultural Insurance's Indemnification Framework



Source: From Elabed and Carter (2013)

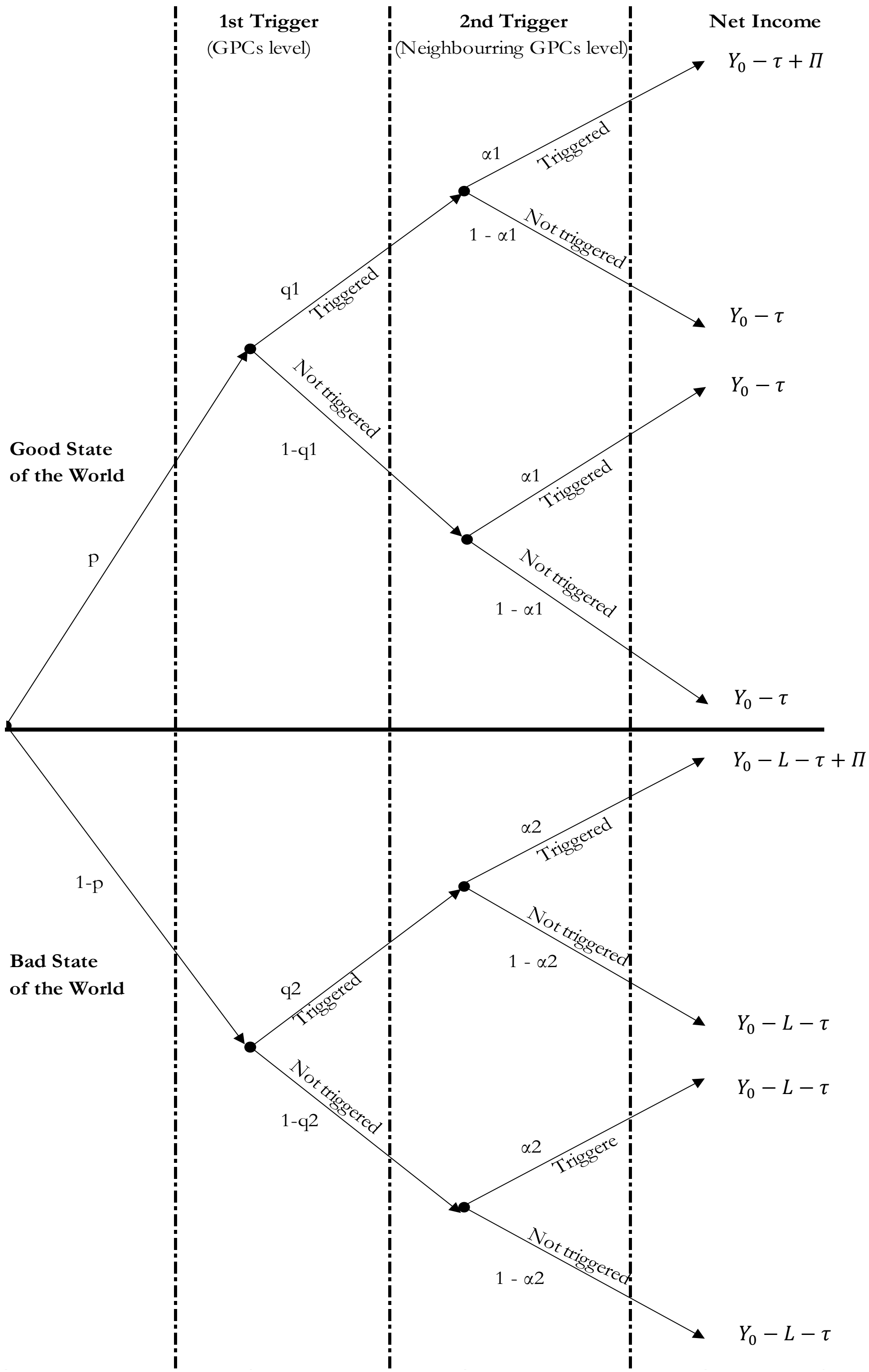
Given that the 2TIC requires the concomitant realization of the first and second trigger, this essay elaborates further on (Figure 3.1) by parsing out the triggering system into its two components. In this way, a first and a second trigger are presented to reflect the payout structure of the dual triggering system considered in the case of Burkina Faso (Figure 3.2). For such representation, I assume that farmers are expected utility maximizers and that they face some uncertainty in the amount of cotton they will harvest every season. Yields are assumed to be taking the value Y in the good state of the world and the value $Y - L$ in the bad state of the world, where L represents the yield loss incurred.

- **With the 2TIC**

In a good state of the world, yields are high (meaning no loss) with a probability p. If yields are high, there is a probability q_1 that the 2TIC's index threshold at the GPC level (i.e., first trigger) will be triggered, and a probability $1 - q_1$ it will not be triggered. If the first index is triggered, there is a probability α_1 that the 2TIC's index threshold at the neighboring GPC level (i.e., the second trigger) will be triggered, and a probability $1 - \alpha_1$ it will not be triggered. If the first and second trigger are met concomitantly, the 2TIC's triggering system is satisfied resulting in a probability $(q_1\alpha_1)$ that income is equal to the net income (Y_0) less the insurance premium (τ) plus the value of the insurance indemnity payment (Π). In other words, a farmer's final income is: $Y_0 - \tau + \Pi$. Since this payout occurs in a scenario where the insured farmer did not incur a loss, it represents a false positive, a case that should not have occurred had the 2TIC been perfectly indemnifying its insured clients. If the first and second trigger are not met concomitantly, the 2TIC's triggering system is not satisfied, resulting in no payout. If payout is not issued (i.e., Π = 0), because of a non-concomitant realization of the first and second triggers), there is a probability $[q_1\,(1 - \alpha_1)] + [(1 - q_1)\,\alpha_1] + [(1 - q_1)\,(1 - \alpha_1)]$ that farmers receive a final income equal to $Y_0 - \tau$.

In a bad state of the world where a loss occurs, farmers face a yield loss with a probability $1 - p$. Under this circumstance, there is a probability q_2 that the first trigger is met, and a probability $1 - q_2$ that it is not met. If the first trigger is met, there is a probability α_2 that the second trigger is met, and a probability $1 - \alpha_2$ that the second trigger is not met . Provided that the two triggers are met concomitantly, the 2TIC's triggering system is satisfied with an overall probability ($q_2\,\alpha_2$) that farmers receive an income of $Y_0 - L - \tau + \Pi$. If the first and second trigger are not met concomitantly, the 2TIC's triggering system is not satisfied, resulting in no payout. As a result, there is a probability $[q_2\,(1 - \alpha_2)] + [(1 - q_2)\,\alpha_2] + [(1 - q_2)\,(1 - \alpha_2)]$ that farmers therefore receive a payoff equal to $Y_0 - \tau - L$. This probability represents a false positive, a case that should not have occurred had the 2TIC been perfectly indemnifying its insured clients. Figure 3.2 below summarizes this set up.

Figure 3.2: A Double Trigger Agricultural Insurance's Indemnification Framework



Source: Adapted From Elabed and Carter (2013)

The expected utility (*EU*) associated with the 2TIC insurance contract presented in Figure 3.2 can be written as follows:

$$EU_{2TIC} = pq_1\alpha_1 U(Y_0 - \tau + \Pi) + [(1-\alpha_1)pq_1 + (1-q_1)p]U(Y_0 - \tau) + (1-p)q_2\alpha_2 U(Y_0 - L - \tau + \Pi) + [(1-p)(1-\alpha_2)q_2 + (1-p)(1-q_2)U(Y_0 - L - \tau) \qquad (1)$$

Where $U(.)$ stands for farmer's preferences, assumed to be a concave function.

- **Without the 2TIC**

In the absence of insurance, farmer's expected utility is given by:

$$EU_{no\ insurance} = pU(Y_0) + (1-p)U(Y_0 - L) \qquad (2)$$

A farmer may therefore decide to subscribe to the 2TIC if the satisfaction that they derive from consuming the insurance is greater than their satisfaction in the absence of 2TIC. Since equations (1) and (2) show that a farmer's utility depends on their net income, the essay assesses the effect of 2TIC subscription on net income by comparing two groups: farmers who subscribed to 2TIC during the 2018-2019 cotton production, and farmers who did not subscribe to 2TIC during the same cotton production season.

3.3 Data

Data comes from the survey that I conducted with cotton farmers in Burkina Faso (January to February 2019). This survey was described in chapter 2 (section 4) of this thesis. In addition to cotton farmers' sociodemographic background and production characteristics, the dataset contains information enabling the computation of their net income. To reduce farmers' reluctance about revealing their exact revenue, I computed their net income, using their net returns from the cotton production, and their net returns from the insurance take-up for the 2018-2019 agricultural season. The 2018/2019 agricultural season was selected as it occurred five years after the implementation of the 2TIC insurance program, a timeframe which can allow the observation of potential impact. I computed the net income as follows:

$$Net\ Income = \underbrace{Net\ returns\ from\ cotton\ production}_{(P_{it}\ x\ Q_{it}) - C_{it}} + \underbrace{Net\ returns\ from\ insurance\ Takeup}_{I_{it} - \rho_{it}}$$

Where P is the per-kilogram retailing prices (i.e., 1st choice or 2nd choice depending on the cleanness of cotton) established by AICB; Q represents the quantity of cotton outputs obtained by farmers after harvest; C represents the cotton production cost, which includes inputs costs (i.e., cotton seeds, fertilizers, pesticides, herbicides, urea, NPK, rental fees of the machine dispenser), and labor costs (both family and community); I represents the insurance indemnity received; ρ represents the insurance premium paid; i represents the individual farmer; t is the year (i.e., the 2018/2019 cotton production season). As mentioned in the end of the previous section describing the theoretical framework, comparing the net income of farmers who subscribed to those who did not subscribe is the aim of this essay. Thus, a summary statistic of the sample data comparing cotton farmers who subscribed (to 2TIC during the 2018-2019 agricultural season) to those who did not subscribe (during the same agricultural season), is displayed in Table 3.1.

Table 3.1: Summary Statistics of Treatment and Comparison Groups

				Control Group (Uninsured Farmers)		Treatment Group (Insured Famers)		
Variables	**Unit**	**Min**	**Max**	**Mean**	**Std Err**	**Mean**	**Std. Err**	**Diff (p-value)**
Age	Numerical	23	70	40.19	9.66	39.97	8.679	0.8389
Education	Categorical	1	3	1.17	0.04	1.35	0.03	0.0045
Experience	Numerical	5	47	17.69	0.64	17.9	0.38	0.7826
Family Size	Numerical	1	76	14.41	7.94	11.38	6.56	0.0005
Farm Size	Numerical	1	55	7.4	6.27	6.47	5.64	0.1823
Origin	Binary	0	1	0.99	0.01	0.93	0.01	0.0283
Off-farm Income	Binary	0	1	0.23	0.04	0.46	0.03	0.0000
Motorized Traction	Binary	0	1	0.11	0.02	0.17	0.03	0.1585
Family Labor Force	Numerical	1	35	10.12	4.94	7.91	4.41	0.0000
Cost of Cotton Inputs	FCFA	85230	5864650	789167.6	59831.92	689379.6	36506.36	0.1796
Cost of Family Labor Force	FCFA	0	350000	55594.06	5271.07	52623.51	2679.25	0.6010
Cost of Community Labor Force	FCFA	0	150000	18871.29	1737.27	17004.03	999.81	0.3642
Premium Paid	FCFA	0	616000	0	0	72483.33	70221.76	0.0000
Production	kg	405	64220	5447.86	535.06	5911.92	356.87	0.5161
Yield	kg/h	200	2000	714.25	21.4	898.04	13.16	0.0000
Cotton Retail Price	FCFA	220	245	244.01	0.49	244.48	0.2	0.2921
Revenue from Cotton	FCFA	99225	20700000	1332842	131209.4	1600626	1983016	0.2032
Indemnity Received	FCFA	0	4950000	0	0	153348.2	28619.08	0.0035
Observations	**437**			**101**		**336**		

Table 3.1 compares variables (i.e., observables characteristics) between the treated and control groups by examining the p-values of their means' difference at the 5% significance level. In other words, variables with a p-value greater than 0.05 have no statistically significant difference between the treatment and control., Such variables are left in white (no shading), e.g. *Age, Experience, Farm Size, Motorized Traction, Cost of cotton inputs, Cost of family labor force, Cost of community Labor force, Production, Cotton Retail Price, Revenues from cotton*. On the other hand, variables with a p-value lower than 0.05, do have an observable and significant difference between the means of the treatment and control groups. These variables are shaded in grey, and include *Education, Family Size, Origin, Off-farm income, Family Labor Force, Premium Paid, Yield, Indemnity Received.*

Many of these differences will be discussed below but it is worth noting at the outset that insurance is associated with a significantly higher likelihood that a farmer will have off-farm income (46% vs. 23%). This is consistent with previous findings by Stoeffler et al. (2016; 2020) who have shown that insuring the cotton crop facilitated a positive spillover effect, i.e., allowing farmers to diversify into other potentially profitable ventures. Off-farm income being a relevant variable to consider, our survey respondents were asked whether (or not) they have off-farm revenues. However, unlike cotton derived income where I was able to verify the accuracy of information provided by farmers (with organizations such as UNPCB and SOFITEX who record such information), it was challenging (if not impossible) for me to validate accuracy on data provided by farmers vis-à-vis their off-farm income activities. Thus, concern over data accuracy made me rely principally on cotton-derived income. If a farmer put less effort for on-farm activities, he might not be eligible for any reimbursements depending of the productivity of other participant farmers. Otherwise, the hours worked for on-farm activities is likely to be similar among the participant farmers. If the insurance positively affects off-farm income for the participants, this might mitigate overstate the effect of the insurance on participant farmers' income. Insurance was also associated with higher mean values for formal education level (this variable was scored at three levels, with 3 being secondary school, 2 only primary educations, and 1 no formal education). Interestingly, the significant differences in means between treatment and control groups for family size and family labor force show modestly lower values for insured farmers. This suggests that insurance may play an important offsetting role, so as to make up for income shortfall linked to the lack of household labor. It is nonetheless possible that insured farmers could have higher off-farm income that presumably would affect the hours of family labor force available for on-farm activities. Accounting for these observable differences between the treatment and control groups is the focus for the following empirical strategy.

3.4 Empirical Strategy

The primary objective of this paper is to assess the effect of the 2TIC insurance on farmers' net income derived from cotton production, an objective that requires the exploring of possible net income differences between farmers who subscribed (the treatment group) and those who did not (the control group). For that objective I am interested in the average treatment effect of the treated. To do so, I started the empirical analysis with an estimation of the following model:

$$\log (Y_i) = \beta_0 + \beta_1 2TIC_i + \boldsymbol{X_i \beta_2} + \varepsilon_i \qquad (1)$$

where Y_i stands for the farmer i's net income per hectare, $2TIC_i$ is a binary variable taking the value of 1 if farmer i has subscribed to the 2TIC insurance and 0 otherwise; $\boldsymbol{X_i}$ is a vector of observable variables presented in the Table 3.1. The dependent variable is estimated in logs to contain the variation in income within a reasonable threshold and to facilitate the interpretation of the coefficients which will be expressed in percentage. The empirical analysis journey of the essay started by using the baseline strategy that uses the Ordinary Least Square (OLS) regression when estimating equation (1). By doing so, the parameter β_1^{OLS} therefore measures the sample average treatment effect on the treated. However, given that the group of cotton farmers who subscribed to the 2TIC was not randomly assigned, the pretreatment covariates differ between the subscribed and the non-subscribed farmers. Thus, the OLS estimates from equation (1) may not be consistent or unbiased.

In the literature on methodological strategies used to assess treatment effects, Randomized Control Trials (RCT) and studies employing matching methods have been viewed as robust ways of identifying the sole effect of a treatment. Owing to its ability to minimize allocation and selection biases, RCT is viewed as the favored identification strategy in impact evaluation impact research. Indeed, previous studies involving 2TIC have used RCTs as a strategy to identify the average treatment effect (Elabed et al. 2013; Stoeffler et al., 2016; Stoeffler et al., 2020). However, due to time and financial constraints, RCT was not a viable option for me, therefore leaving me with the alternative approach of studies characterized by matching methods. Matching methods, which consist of matching participants with similar observable characteristics and comparing them to each other, have also been used in previous studies analyzing the effect of insurance on income. In the study exploring the relationship between agricultural insurance and farmers' income in Mongolia, Zhao et al. (2016) used Propensity Score Matching (PSM). However, PSM is an evaluation impact approach which presents limitations, when it comes to balance in the covariates, and model dependence (King and Nielsen, 2018). As an alternative to the above-mentioned strategies, the essay used Coarsened Exact Matching (CEM), an approach informed by the foundational work of Blackwell et al. (2009) and Iacus et al. (2011, 2012). For Blackwell et al. (2009), Iacus et al. (2011), as well as King and Nielsen, (2018), CEM is superior to PSM, as it produces better balance in the covariates found between the treated and control groups, and therefore lowers confounding errors. Blackwell et al. (2009) also attest to the superiority of CEM as a matching approach, by affirming that it performs exact matching on coarsened data to determine matches and then passes on the uncoarsened data from observations that were matched to estimate the causal effect β_1. For these advantages, and given the considerable level of imbalance existing between the treated and untreated units of our sample (76.88% vs 23.11%), CEM was applied in a second estimation aimed at assessing the impact of 2TIC's subscription on cotton-derived income, in a way where the levels of imbalance in matching covariates between treated and untreated will be substantially reduced.

Applying CEM consisted of: (i) coarsening covariates into decently sized meaningful "bins", (ii) matching each participant of the bins to observations within the same bin for all retained covariates, (iii) running the relevant regression estimates using the matched dataset.

(i) Coarsening covariates

This step consists of identifying variables – observable characteristics of the farmers – for which the two groups (the treated and control) are different and coarsened them to make the two groups comparable. To identify those variables, t-tests were conducted on the list of variables – pertaining to sociodemographic, land ownership, farming techniques, and production expenses (See Appendix 2 – collected from the survey and believed to influence farmers' income. With the t-test, the intent is to test the null hypothesis that the difference in the means for the two groups (treated and control) for the variables of interest are equal to zero. Variables whose p-values were statistically significant at 5% level for the two-sided test imply a rejection of the null hypothesis, and that the difference in means are not equal to zero. As noted in Table 1, eight variables (*Education, Family Size, Origin, Off-farm income, Family Labor Force, Premium Paid, Yield, Indemnity Received*) were retained to be coarsened. To coarsen variables into decently sized bins, continuous variables from the aforementioned list (hence*, Family size, Family Labor Force*) were organized into bins following a quartile distribution (Iacus et al. 2011; 2012). Two additional continuous variables (*Premium Paid, Yield, Indemnity Received*) were excluded, since they are directly involved in the calculation of the variable Net Income. Based on their frequency distribution across the sample, the variable *Family size* was fragmented into the following four bins: 0 to 3; 4 to 5; 6 to 7; 8 and more. Previous studies have found *Family Labor Force* to be a significant determinant of agricultural income (Levy, 1985; Kazianga and Makamu 2017). To form four bins for this variable, its results were partitioned as: 0 to 5; 6 to 8; 9 to 11; 12 and more. In pursuing the coarsening step of the CEM, the categorical variable *Education* and the binary variables *Origin* (i.e., is the farmer originally from the study site or an immigrant)*, Off-farm Income*, *Motorized Traction*, were not put in bins. Regarding *Education* evidence suggests that it has a positive impact on the adoption of insurance contract (Dercon et al. 2014; Hill et al. 2016; Vasilaky et al. 2019). Other studies found no impact on insurance uptake, especially if education levels are relatively low (Cole et al. 2013). Assuming that farmers' levels of education could be a relevant factor if not relatively low , the variable *Education* was initially being considered.

From those three binary variables *Motorized traction* appears as a salient characteristic of farming-derived income, based on previous literature (Savadogo et al.,1995; Cunguara and Darnhofer, 2011; Wang et al., 2016). *Off-farm income* is also relevant to farmers' overall income (Stoeffler, 2016, 2020). In this essay, *Off-farm income* describes whether (or not) farmers possess other source of revenues rather than the monetary value of that other stream of income, which would have been more useful for the analyses, had there been no concern on their accuracy. For this limitation, the variable *Off-farm income* was left out. *Origin* was left out, as assumed less relevant with the outcome variable of interest: cotton-derived income. From the group of variables whose p-values were statistically significant, *Education, Family Size,* and *Family Labor Force* were retained as potential candidates for the coarsening exercise.

Variables whose p-values were not statistically significant at 5% level for the two-sided test imply a failure to reject the null hypothesis, and that the difference in means must be considered equal to zero. Those variables (*Age, Experience, Farm size, Motorized Traction, Cost of Cotton Inputs, Cost of Family Labor Force, Cost of Community Labor Force, Cotton Production, Cotton Retail Price, Revenue from cotton*), though comparable for the two groups, were considered for the coarsening exercise, to ensure that units with the same values are substantively similar. However, since the outcome variable of interest in this essay is farmers' net income, only salient factors for agricultural income were given outmost consideration. From the above-mentioned list of variables, these were: *Experience, Farm size, Motorized Traction*. Experience in agricultural practice has been shown to positively affect agricultural income, if we consider that more experienced farmers have acquired abilities that enable them to better manage risks and produce at a level that will generate mor revenues (Foster and Rosenzweig 1995: Ainembabazi et al. 2014). The effect of Farm size on income is mixed in the literature. While evidence suggests that *Farm size* has a positive effect on agricultural income (Dunn and Williams 2000; Noack and Larsen, 2019), other evidence reveals that farm size has no effect (Purdy et al., 1997; Barry et al.,2001). With regards to IBI, a recent study found that farm size is an influential factor, given that farmers who perceive their other group members as larger/(smaller) farm owners ended up purchasing less/ (more) insurance (Vasilaky et al. 2020). Motorized traction if used in a way that does not increase production costs a lower increases agricultural output, therefore more income (Takeshima et al. 2013; Adu-Baffour et al., 2019). Taking into consideration the three salient factors (*Experience, Farm size, Motorized Traction*) mentioned above, the variable *Experience* was organized into the following bins: 0 to 13; 14 to17; 17 to 21; 22 and more. The variable *Farm size* was portioned as: 0 to 3; 4 to 5; 6 to 8; 9 and more. The binary variable *Motorized Traction* was not put in bins. To minimize confounding errors and biases the variables *Cost of Cotton Inputs, Cost of Family Labor Force, Cost of Community Labor Force, Cotton Production, Cotton Retail Price, and Revenue from cotton,* which participate in the calculation of net income (the outcome variable of interest) are excluded. From the group of variables whose p-values were not statistically significant, *Experience, Farm size,* and *Motorized Traction* were retained as potential candidates for the coarsening exercise. Combining potential candidates from the two groups (p-values significant and p-values not significant at the 5% level) yielded a long list of six variables—namely *Education, Family Size,* *Family Labor Force*, *Experience, Farm size,* and *Motorized Traction*—to consider for the coarsening, then the matching.

(ii) Matching coarsened data

To match the covariates, a use was made of the *cem* command in STATA for the long list of six variables mentioned above. The goal was to create a sample where 2TIC non-subscribers resemble 2TIC subscribers on an inventory of covariates. Initially, all six variables from the long list were being considered. However, given the relatively small sample size of 437 observations, including all the six variables led to a lower number of matched observations (224 in total) for both the control (89) and treated groups (135), which considerably decreases the sample size, and therefore the statistical power of the analysis. The fewer the number of covariates, the greater the chance of having a larger number of matched observations with similar characteristics (that is, a larger sample where 2TIC non-subscribers and 2TIC subscribers are comparable). To come up with a short but meaningful list of variables, I relied on evidence from previous studies and preliminary analyses of the dataset. Summary statistics for the studied sample shows relatively low level of education for survey respondents, an observation that is less surprising in rural Burkina Faso where school enrollment is weak. Akin to the study by Cole et al. (2013) who found no impact on insurance uptake once education levels are relatively low, the variable *Education* was left out. Due to the mixed results in the literature regarding the effect of farm size on agricultural income (Dunn and Williams 2000; Noack and Larsen, 2019; Purdy et al., 1997; Barry et al.,2001), the variable *Farm Size* was not included. Likewise, the variable Family Size was not included. In the end, the variables *Experience, Family Labor Force, and Motorized Traction* were retained for the short list. That short list led to 421 matched observations (101 for the control group and 320 for the treated group) compared to the long list of six variables which has only 224 matched observations (See Table 3.2).

Table 3.2: A comparison between the Long-list and Short List of Variables

	Long list		Short list	
Variables	*6: Education, Family Size, Family Labor Force, Experience, Farm size,* and *Motorized Traction*		*3: Experience, Family Labor Force, and Motorized Traction*	
	Control Group	**Treated Group**	**Control Group**	**Treated Group**
Matched	89	135	101	320
Unmatched	12	201	0	16
Total	101	336	101	336

Source: Author's computation from the database used in this essay.

This means that out of the 437 observations obtained in the initial sample, a greater number of observations will be comparable for the variables: *Experience, Family Labor Force,* and *Motorized Traction.* Thus, the short list of variables was retained to be added as explanatory variables in the model that will be estimated. Through the coarsening exercise, CEM assigns weights to matched observations that have been placed in the bins. These weights are used in the regression trials aimed at estimating the outcome.

(iii) Estimating the outcome

From the matched sample that was obtained in the previous section, the analysis assessed the impact of 2TIC subscription on farmers' net income obtained solely from cotton production, by estimating the Average Treatment Effect on the Treated (ATT) where:

$$\mathrm{ATT} = \frac{1}{n_T} \sum_{i \in T} \mathrm{TE}_i$$

With $n_T = \sum_{1=1}^{n} T_i = \{1 \leq i \leq n: T_i = 1\}$

The estimation of the average treatment effect which is aimed at capturing the effect of the 2TIC insurance was conducted using OLS (for comparison purpose) and CEM. The two estimations are presented in Table 3.3. To assess the robustness of the results, alternative matching methods such as Propensity Score Matching (PSM), Kernel Matching (KM), Mahalanobis Distance Matching (MDM) were employed (See Table 3.4).

3.5 Estimation Results and Discussion

Table 3.3 presents results of the effect of 2TIC subscription on farmers' net income. The "OLS" columns show the OLS estimates (equation 1) and (equation3) for respectively the Long List and Short Lists of covariates on the unmatched sample (i.e., the raw data of 437 observations), while the "CEM" columns present the CEM results on the matched sample (n= 312 for the Long List of covariates, and n=421 for the Short List). For simplicity, I only report the coefficients, as well as the respective standard errors (in parentheses), and the p-values (indicated with stars) of each regression. Focusing on the Short List of covariates which has a greater number of comparable observations, the CEM estimation suggests a mean net income that is 35% higher for 2TIC subscribers than that of farmers who did not subscribe. These findings are in line with previous empirical studies that focus on similar topic. For instance, Yamauchi (1986) found that crop insurance in Japan generated a 64% increase in farmers' income from paddy rice cultivation. Likewise, Leatham et al. (1997) found in the state of North Dakota in the USA that purchasing crop insurance was associated with higher personal income estimated at $94 million, which represents 44.5% of the insurance program's contribution in business sales (Leatham et al., 1997). Still in the USA, but more precisely in the state of Iowa, Hart and Babcock (2015) found that insurance indemnity helps farmers maintain their cash-flow in years when yields and revenues are relatively low (Hart and Babcock, 2015). In China, Sheng-wei (2011) found that crop insurance was associated with an increase in farmers' income in the Shandong province.

The 35% higher mean *Net Income* for insured famers is likely explained by the reduction in costly risk coping strategies that 2TIC allows. In incomplete financial market —like it is the case with cotton farmers in Burkina Faso where SOFITEX enjoys a monopsony and a monopoly— previous studies found that it is challenging for farmers to separate production and consumption decisions (Rosenzweig and Wolpin, 1993). Thus, when loss occurs, farmers are forced to liquidate their productive assets, or borrow more from their peers in order to have sufficient funds to overcome the effect of the loss. These ex-post risk management strategies are costly to farmers who pawn their assets and incur more debt. As a preemptive way of addressing risks of losses farmers out of an abundance of caution choose less risky (i.e., low-risk, low-return) projects to avoid income debilitating surprises (Dercon 1996, Stoeffler 2016). However, expected profits for these ex-ante strategies are small compared to high-risk, high return investment strategies. All to say that these measures remain costly to farmers if risks are uninsured. By insuring the risks in exchange of a paid premium, insured farmers may be provided with an indemnity in the event of a loss that could prevent farmers from depleting their assets at a depressed price, or augmenting their debt, two risk coping measures that have a negative impact on farmers income. Additionally, charging an insurance premium in exchange of an indemnity being paid out in an event of loss (that is, when yield fall below the insured level) is supposed to bring farmers' income level to the level it would have been, if loss had not occurred (Zhao et al., 2016). In some cases, purchasing an insurance could lead to an extensification. This was observed with the 2TIC in Burkina Faso, where insured cotton farmers augmented their cultivated areas by roughly 10 percent (Stoeffler et al. 2020). Thus, in addition to having the capacity to bring farmers' income to levels it would have been if loss has not occurred, 2TIC has the potential to increase income through an augmentation in cultivated area.

Another reason that can explain the increase in income is the fact that SOFITEX would still buy back the cotton output from farmers, regardless of the indemnification outcome. For the 2018/2019 cotton production season considered a good year in view of fluctuation in yields observed in previous years, It is not uncommon to see cases where farmers receive funds from SOFITEX (resulting from the sale of cotton output) and from Planet Guarantee (stemming from the indemnification amount issued by Allianz-Burkina). Under those circumstances famers can note an increase in income once revenues from SOFITEX are added to the compensation received from Allianz-Burkina.

Table 3.3: Effects of 2TIC subscription on farmers' net income – OLS and CEM matched sample

	Long List		Short List	
	OLS	CEM	OLS	CEM
	(1)	(2)	(3)	(4)
2TIC Subscription	0.346***	0.356***	0.412***	0.353***
	(0.061)	(0.077)	(0.097)	(0.096)
Experience	0.096	0.122	-0.008	-0.005
	(0.075)	(0.076)	(0.006)	(0.007)
Motorized Traction	0.099	0.089	0.444***	0.461***
	(0.082)	(0.128)	(0.124)	(0.186)
Family Labor Force	0.007	0.004	0.035***	0.032***

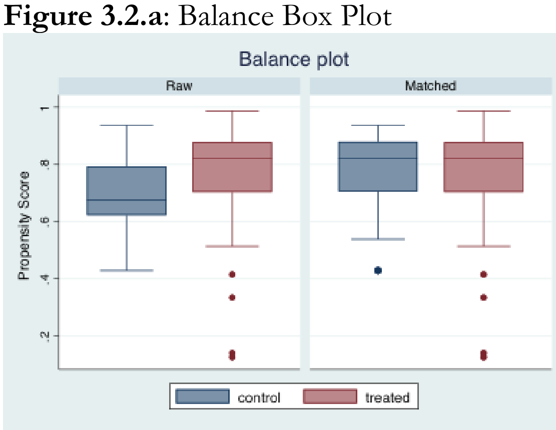
	(0.006)	(0.008)	(0.009)	(0.010)
Farm size	0.052	0.049***	--	--
	(0.005)	(0.006)		
Education	0.012	0.060	--	--
	(0.044)	(0.070)		
Family Size	0.011	0.013	--	--
	(0.043)	(0.048)		
Constant	13.20***	13.152***	13.414***	13.428***
	0.152	0.116	0152	0.134
Observations	437	312	437	421
R-Squared	0.3547	0.3133	0.1243	0.1593

Notes: Dependent variable is log net income. The OLS regression was run on the unmatched data (raw sample), while the CEM concerns the estimates results on matched sample. Standard errors are clustered at the match level and shown in round parentheses. P-values: *: p<0.1, **: p<0.05, ***: p<0.01

To check the robustness of the results, alternative matching methods (PSM, KM, MDM) were conducted on the sample. Like the CEM approach, the different steps involved in the application of each of these matching methods have been followed. For instance, regarding PSM, a balance box plot (Figure 3.2.a) and a balance density plot (Figure 3.2.b) were conducted to check the improved comparability between the raw and matched dataset of the treated and control groups, before proceeding with the estimation of the treatment effect.

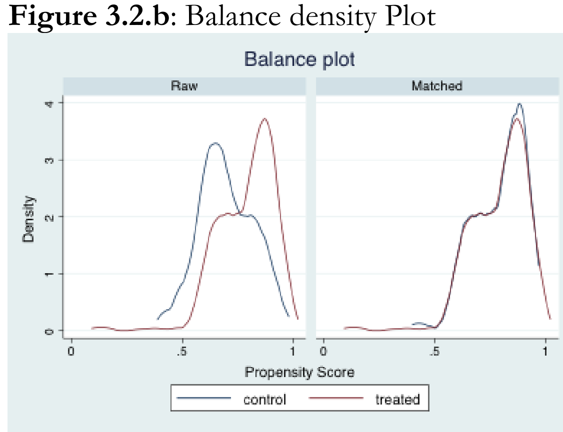
Figure 3.3: Balance Box and Density Plots

Figure 3.2.a: Balance Box Plot



Box plot of the sample obtained (Through the STATA command "*tebalance* box") while conducting PSM.

Figure 3.2.b: Balance density Plot



Box plot of the sample obtained (Through the STATA command "*tebalance* density") while conducting PSM.

Source: Author's computation from the database used in this essay.

Then, a use was made of the STATA command *teffects psmatch* to estimate the treatment effect on the treated. Likewise, the STATA commands *kmatch* and *kmatch md* were used in the treatment-effect assessment of respectively KM and MDM. Results consistently show across the three matching methods that subscribing to the 2TIC insurance is positively and significantly associated with a higher mean *Net Income* (See Table 3.4).

Table 3.4: Robustness check for the Effect of 2TIC subscription on farmers' net cotton income

Variable of Interest	CEM	PSM	MDM	KM
2TIC Subscription	0.353***	0.289***	0.319***	0.367***
	(0.096)	(0.082)	(0.089)	(0.072)
Observations	**421**	**437**	**437**	**437**

Notes: The dependent variable is log of net income. Coefficients for PSM, MDM, and KM indicates Average Treatment on the Treated. Estimations were made on unmatched sample. P-values: *: p<0.1, **: p<0.05, ***: p<0.01.

Table 3.5 reports findings for the impact of 2TIC on farmers' net income changes using quantile regressions (at quantile 0.2. 0.4. 0.6 and 0.8). The results show that 2TIC subscription has a positive and significant effect on net income across all income levels. As expected, the salient characteristics of net income included in the model (such as *Motorized Traction Family labor Force*) also have a positive and significant effects on net income across all income levels. Apart from the 0.101 decrease in regression coefficient observed between quantile 0.2 and quantile 0.4, the other regression coefficients increased with the increase in quantile level. This indicates that 2TIC has an income-increasing potential. However, the fact that the bottom and top income groups have regression coefficients standing in the 0.3 range, while those for the two groups in the middle are in the 0.2 range is a sign that farmers from different income groups do not get identical benefits from the 2TIC.

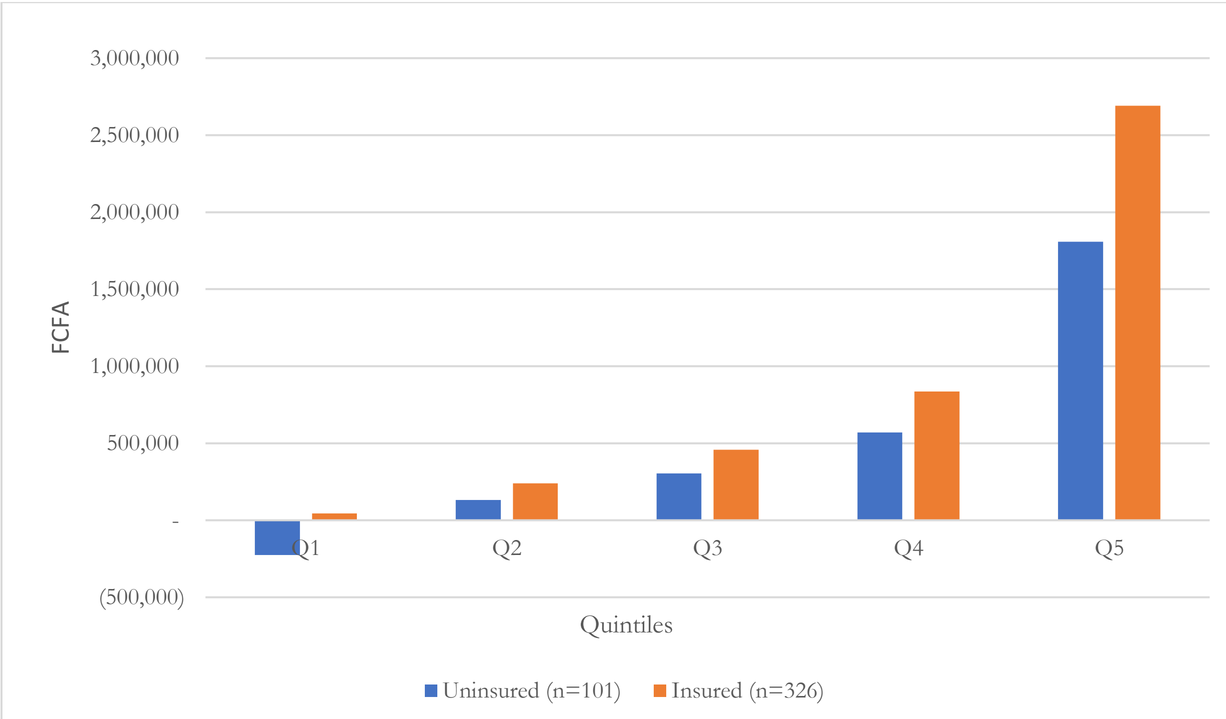
Table 3.5: Effect of 2TIC insurance on farmers' net income (Quantile Regression)

Variables	0.2	0.4	0.6	0.8
2TIC Subscription	0.298***	0.197***	0.206***	0.309***
	(0.070)	(0.003)	(0.059)	(0.072)
Experience	0.001	0.003	0.005	0.004
	(0.004)	(0.076)	(0.003)	(0.004)
Motorized Traction	0.404***	0.459***	0.432***	0.402***
	(0.090)	(0.071)	(0.076)	(0.092)
Family Labor Force	0.021***	0.034***	0.049	0.065***
	(0.157)	(0.005)	(0.006)	(0.007)
Constant	13.172***	13.307***	13.344***	13.365***
	(0.110)	(0.087)	(0.094)	(0.112)
Observations	**437**	**437**	**437**	**437**

Notes: The dependent variable is log of net income. All regressions are estimated by Quantile regression. Estimations were made using the full sample and the weight were derived from the CEM technique. P-values: *: p<0.1, **: p<0.05, ***: p<0.01.

The impacts of 2TIC subscription on Net Income at different income levels can be seen in Figure 3.3, where the income distribution for the 101 uninsured and 336 insured farmers have each been partitioned into five quintiles (of 20 or 21, and 67 or 68 data points respectively). Looking across all quintiles at the aggregate level, mean net income for the uninsured farmers is always lower than mean net income of the insured farmers, suggesting that the 2TIC insurance is associated with a welfare improving effect. The largest, numerical difference (a difference of 883,145 FCFA) is found in the uppermost quintile: a mean of 2,691,174 FCFA for the insured farmers versus 1,808,029 FCFA for the uninsured. The next largest difference (269,710 FCFA) is to be found in the lowest quintile, especially striking since the uninsured farmers actually have a negative mean Net Income from their cotton production (-225,392 FCFA), against 44,319 FCFA for the insured farmers. The middle quintiles have successively smaller differences between the mean values of the insured and uninsured groups, from 264,873 FCFA in the fourth quintile (0.6-0.8), to 153,834 FCFA in the third quintile (0.4-0.6), and only 108,852 FCFA in the second quintile (0.2-0.4).

Figure 3.4: Net Income Distribution by quintile of the Treatment and Control Groups



Source: Author's computation from the database used in this essay.

The importance of 2TIC cannot be overstated here, especially for the highest and lowest income quintiles. Farmers in the top quintile, already well-positioned in terms of their productive potential, are clearly further advantaged in terms of their net cotton income if they subscribe to the 2TIC. However, the fact that the lowest quintile also benefits substantially is an encouraging finding that demonstrates the 2TIC's great potential for pro-poor welfare gains. With quantile regression results showing that *Motorized Traction* was significant at the 1% level across all income groups, and the regression coefficient are relatively constant in the 0.4 range, a plausible interpretation that one can make is that the improvement effect of *Motorized Traction* is balanced. Regarding *Family labor Force,* which passed the significant positive test at the 1% level across all income groups, regression coefficients are increasing with the increase in quantile levels (0.021 for the bottom quantile, and 0.065 for the top quantile 0.8), therefore suggesting that the improvement effect brought by *Family Labor* is greater for people from the top group than those from the bottom. Indeed, with their limited incomes, farmers from the bottom quintile often cannot afford to pay for additional labor force whose contributions could generate more outputs, hence, higher income. Given the possibility of obtaining an indemnity in times of losses, the indemnities that poor farmers may receive could compensate for any net income that might be lost due to their low available labor. As such, it is likely that insurance plays a laborsaving role. However, further analyses are needed to confirm this intuition. The fact that the income boost associated with 2TIC subscription is lowest for the middle quintiles (especially the second and third) suggests that farmers from these groups experience less acute vulnerability. Indeed, since middle income farmers have a healthier financial situation that allow them to better cope with risks, their level of vulnerability compared to that of low-income farmers is relatively low. Middle-income farmers' level of vulnerability is also lower than that of high-income farmers who are at greater risk of loss given the size of their production. As such, it is possible that because farmers from the middle-income group already apply many of the productivity improvement strategies, a risk mitigation tool like the 2TIC, given the extent of vulnerability might not necessarily bring more to their net income as much as it would for farmers from the bottom and top quintiles. A key takeaway of the impact assessment of 2TIC on net income, based on the studied sample, is that 2TIC has a greater impact for farmers belonging to the bottom and top income groups than those belonging to the middle-income groups.

3.6 Conclusion

This essay investigates the effect of the 2TIC on cotton farmers' net income, using survey data from the 2018-2019 production season among 437 cotton farmers based in Houndé and Founzan (Burkina Faso). In this way, this study differs from previous ones in the area, which were conducted soon after the launch of the 2TIC pilot project and encountered important challenges with the product's implementation, or used (quasi-)experimental methods and modeled data rather than surveys.

The subscription to 2TIC was significantly associated with a range of household-level factors, such as more off-farm income, more formal education, and smaller family size and family labor force, as compared to uninsured farmers. Because the cotton farmers were not randomly assigned in the sample, the study used the Coarsened Exact Matching (CEM) approach developed by Blackwell et al. (2009) to estimate the impact of 2TIC subscription and other household-level factors on farmers' net cotton income. Results reveal that 2TIC subscription is associated with 35 percent higher net income for subscribed farmers compared to farmers who did not subscribe. Quantile regressions showed that mean net cotton income for subscribed farmers was consistently higher than that of uninsured farmers at all income levels. Results show that cotton farmers within the lowest income group have a stronger positive impact of 2TIC insurance on net income, compared to cotton farmers within the second to the lowest income group, therefore suggesting that the 2TIC has a differential effect across farmers' income level. With regards to these findings, the essay suggests tailoring the 2TIC to farmers' level of income, in a continual improvement effort of having an insurance scheme that equally improves the wealth of farmers from different income groups.

Some limitations are worth mentioning in this essay. First, given that the CEM technique estimates the effect of a treatment between two groups (in our case, the insured and the uninsured) that are comparable with respect to observable characteristics, not accounting for unobservable characteristics (which could sway the presented results) impel me to only be interpreting the results of this essay as an association rather than a causation. Second, as mentioned earlier in the text, instances of false positive and false negative stemming from the imperfect design of 2TIC may influence farmers' cotton-derived net income, and that could lead to an overestimated ATT. Besides, the fact that farmers' subscription to 2TIC is a voluntary action does not fully exempt ATT from biases. In view of these ATT-related limitations, the use of the Average Treatment Effect (ATE)—which is the average of the ATT and ATU— through a RCT would have been a great alternative if technical and financial resources were available. However, these resources proved to be a constraint at the outset of this research. A third limitation of this study is that data were collected for the 2018-2019 agricultural season. A longitudinal survey data would have been ideal to evaluate the impact of 2TIC on farmers cotton derived net income. But such information was not available at the time of the study. The fourth limitation is that information obtained are from a specific region (Houndé and Founzan). As subscriptions to 2TIC reached other regions following its introduction in 2013, regional heterogeneity is something that can impact results. Due to the third and fourth limitations, results are context-specific and may not be easily generalized to other regions or times.

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Chapter 4 — Essay 3: Actuarially Fair Premium and Commercial Premium: The Case of the 2TIC in Burkina Faso

Wilfried D.J. Nonguierma

Abstract

This essay estimates the cost of the actuarially fair premium of the Double Trigger-index based Insurance Contract (2TIC) implemented with cotton producer groups (GPCs) in Burkina Faso. For this purpose, the essay uses data on GPCs' historical yields for the period 2001-2012 and employs a statistical approach that considers times' effect to determine the cost of the actuarially fair premium. Results show that during the 2013-2014 agricultural season (the first season the 2TIC was offered) where cotton's retail price was set at FCFA 245 per kilogram in Burkina Faso, the actuarially fair premium required for the 2TIC was estimated at FCFA 4,439 per hectare. An estimation of the actuarially fair premium by terciles of GPC's yield distribution show a "U-shape" curve, indicative of an actuarially fair premium that is lower for the middle-level producers, but higher in both the lower and upper ranges of group cotton production. Nevertheless, actuarially fair premiums across all groups are much lower than the commercial premium of FCFA 11,200 per hectare, suggesting that an excessively cautious mark-up was added by the insurer.

4.1 Introduction

Premium payment is the means of access to an insurance coverage. Just as cotton farmers pay for agricultural inputs to produce output, they also need to pay for premium should they want to reap the benefits of an insurance policy. Hence for profit-maximizing farmers who exhibit price sensitivity, the decision to enroll in an insurance policy can be affected by premium levels. Field experiments conducted in Gujarat, India, where local farmers were charged a discounted premium, show that a 10 percent reduction in the price of insurance augmented the probability of purchase by 3.07 percentage points (Cole et al., 2013). In Ghana, Abugri et al. (2017) found that farmers' willingness to pay for a drought-index crop insurance averaged 180 Ghanaian cedis (GHS), or USD 40 per ha, but only 23 percent of the sample population were willing to pay a premium even 12 percent (GHS 21, or USD 4.67) higher than that mean value. In Ethiopia where an Index-Based Livestock Insurance (IBLI) was provided to pastoralists, it was found that reducing the price of a premium via a random distribution of discount coupons increased take-up rates (Takahashi et al. 2016). In Northern Kenya, where a similar IBLI was provided to herders, a study conducted by Chantarat et al. (2016) showed that willingness to pay for the most vulnerable was lower than the commercial premium rate, therefore suggesting that clients (especially those with low incomes) are very price sensitive and may be excluded from potentially beneficial insurance products. In northern Ghana, where three pricing schemes (for a subsidized $4 per acre, an actuarially fair $7.9 per acre, and a commercial rate of $11.90 per acre) were proposed to farmers, take-up was 63.9% once subsidized, 55.6% once offered at the actuarially fair price, and 40% once offered at the commercial price (Karlan et al. 2014). These empirical studies support the hypothesis that lower premium pricing increases take-up, a finding that underscores the important role of pricing insurance schemes.

In insurance pricing, the premium charged to a client (often referred to as the actual premium, which is nothing else than the commercial premium) has two components: the actuarially fair premium (AFP) rate—estimated based of the empirical distribution of historical yields—and the loading premium rate—added by the insurance company to account for operating cost and profit. The actuarially fair premium is commonly understood as the premium that will exactly cover the expected losses or indemnity payments (Landes, 2015). In other words, it is the pure premium that does not account for any operating cost or profit. However, insurance companies think that a loading that accounts for operating cost and profit is necessary for an insurance product to be commercially viable. This raises the complex nature of pricing as it affects both demand (take-up) and supply (sustainability) of the insurance product. Should the needs of both parties (the insured seeking an affordable product, and the insurer seeking a viable product) be met, pricing must be given a thorough look.

In 2013, PlaNet Guarantee introduced the Double Trigger Index Based Insurance Contract (2TIC) to cotton farmers in Burkina Faso. 2TIC is an Area-Based Yield (ARBY) index insurance that protects cotton farmers against yield losses emanating from covariate shocks. In Burkina Faso where cotton farmers are organized in cotton producer groups (Groupements de Producteurs de Coton, or GPCs), 2TIC has been offered in the form of a package "input credit + insurance" upon a premium payment proportional to the area they cultivate. As such, being insured is contingent on the take-up of cotton-farming inputs on credit. Under the contingent risk credit scheme of the 2TIC, cotton farmers pay a commercial premium whose rates are set at the beginning of the agricultural season, and in return are compensated for any yield losses at the end of season based on three levels for those losses (severe, moderate, and minor).

For the first 2TIC product proposed in 2013, the commercial premium was set at FCFA 11,200 per hectare. In paying for that commercial premium, the insured cotton farmer receives FCFA 90,000 per hectare for a severe loss, FCFA 34, 000 FCFA for a moderate loss, and FCFA 11, 200 FCFA per hectare for a minor loss (PlaNet Guarantee, 2014). Barré et al. (2016) found the commercial premium of FCFA 11, 200 charged in Burkina Faso to be three times higher than what their study estimated as the actuarially fair premium, suggesting the addition of a high markup. Barré et al. (2016) find that such high markup, which they attributed to a high loading factor applied by insurance and reinsurance companies, causes the potential welfare gains of index insurance to dissipate for any level of loss aversion, a reason that can cause a low take-up rate. As a result, in 2018 (i.e., five years after the initial product was launched) PlaNet Guarantee proposed a newly priced 2TIC in Burkina Faso, with a premium reduced to FCFA 5,600 per hectare. The new indemnity structure pays back FCFA 45,000 per hectare for a severe loss, FCFA 17,000 FCFA per hectare for a moderate loss, and FCFA 5,600 per hectare for minor loss (PlaNet Guarantee, 2018; UNPCB, 2019). Looking more closely at this pricing structure, we see that not only the premium cost has been cut in half, but so too were the indemnities (FCFA 45 000 from FCFA 90,000; CFA 17, 000 from CFA 34,000; CFA

5,600 from CFA 11,200), inferring that it is basically the same product. On the one hand, the decision by PlaNet Guarantee to introduce a lower priced 2TIC is an implicit signal that commercial premium cost might have been a disincentive for cotton farmers in Burkina Faso. On the other hand, the decision to decrease indemnities by identical proportions suggests that little meaningful changes have been made to the insurance product's risk structure. Furthermore, insurance underwriters typically need to add a commercial mark-up or premium loading for the insurance product to be commercially viable (Benth et al. 2007; Taib and Benth, 2012). Recognizing that an insurance premium, in practice, is less likely to be actuarially fair (due to the loading), gauging the scale of the loading by determining the value of the actuarially fair premium and comparing it to the commercial premium, in the case of the 2TIC in Burkina Faso can be revealing.

Estimating the actuarially fair premium requires estimating the rate where expected total premium equals expected total indemnities, hence, E(premium)= E(indemnities). That is usually completed through calculation involving the averaging of the ratio of indemnities to liabilities. But in the case of the 2TIC, which is an ARBY, making this calculation can be a daunting task given the number of influencing factors involved, such as systemic risk or information asymmetry (Barnett and Mahul, 2007). Besides, the usual long series (at least 25 years) of historical data used for the estimation was lacking. Faced with the data-limitation challenge, Carter, Boucher and Trivelli (2007) proposed a 5-step approach to estimate the premium of an ARBY insurance product that was proposed to cotton farmers in Peru. The overall 5-step approach consisted of using previous seasons' data to estimate a probability distribution of cotton yields, and then used those distributions to calculate an actuarially fair premium. In the first step, the authors used historical yield data to estimate a yield growth trend. In the second step, the estimated yield growth was adjusted to account for a significant deviation that was noted between the historical and expected yields. In the third step, the adjusted yields were used to estimate the probability function that best describes the data. Among several functional forms that were tried, the authors retained the Weibul probability function as it was the functional form that best fit their data. In the fourth step, Carter, Boucher and Trivelli used three strike points (65 %, 85% and 100% of long -term yields) to determine the indemnity payment. In the fifth step, the actuarially fair premium was determined in a kilogram per hectare basis, then converted to a monetary value using the kilogram per hectare retail price of cotton that applies.

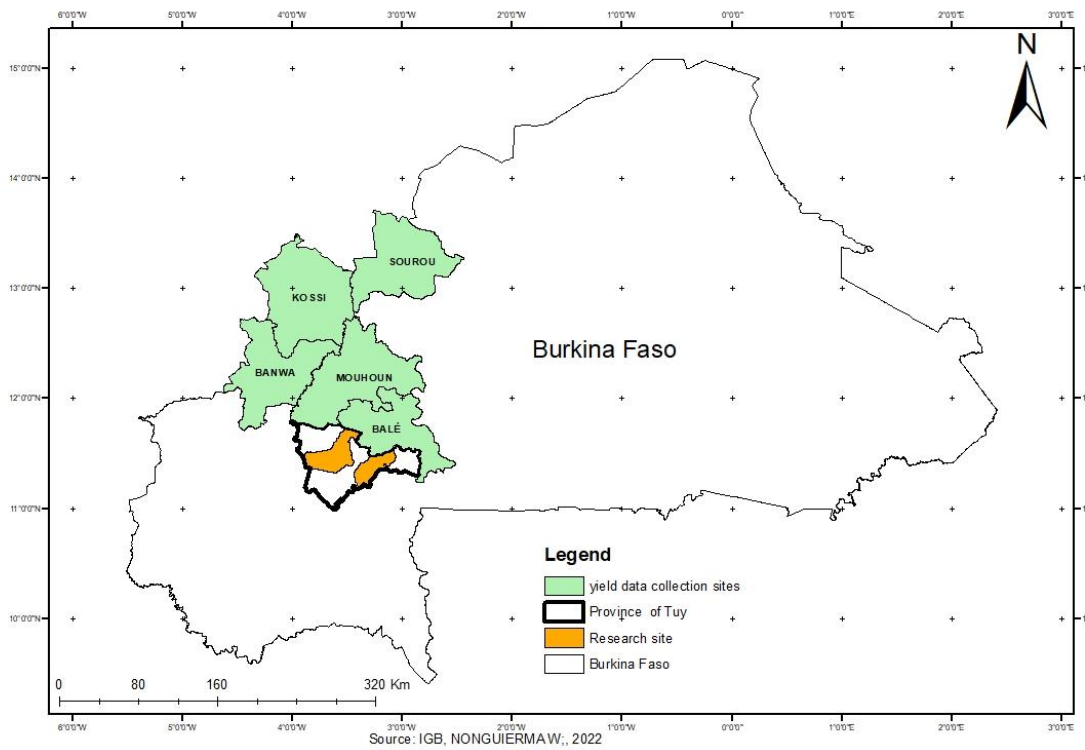
Informed by the approach used by Carter, Boucher, and Trivelli (2007), this essay also uses a 5-step approach to estimate the value of an actuarially fair premium. Like Carter, Boucher, and Trivelli (2007) the essay accounts for time's specific effect to capture heterogeneity related to yearly change (a good year versus a bad year). However, to reflect Burkina Faso's context marked by (i) data limitations stemming from a shorter time series and a sample size with the number of observations being significantly curtailed due to missing data, and (ii) an ARBY index insurance product being offered in a form of a group insurance, this essay made adaptations to the 5-step methodological approach used Carter, Boucher and Trivelli (2007). With regards to the data, after trying several functional forms, the gamma probability function stood out as the function that best fit the data. With regards to the contract being offered to groups (the GPCs) rather than individuals, some characteristics that are inherent to every GPC (such as performance) may enable them to produce higher or lower yields than other GPCs. Thus, a data profiling was conducted, with GPCs from the sample being disaggregated by terciles based on their yields, to see how actuarially fair premium for those subgroups compare to: (i) the overall group's actuarially fair premium and (ii) the commercial premium.

By making those adaptations, the essay contributes to the literature in two ways: (i) using a gamma probability function (deemed, the best fit to GPCs' yields data obtained from SOFITEX) to estimate the actuarially fair premium, and (ii) conducting a premium differentiation to see how actuarially fair premiums fare with the commercial premium that was in force. Results reveal that based on the studied sample and the 2013-2014 agricultural season where the cotton price was FCFA 245 per kilogram in Burkina Faso, the actuarially fair premium that would be required for the 2TIC is equal to FCFA 4,439 per hectare. Actuarially fair premium per tercile show that the bottom tercile has the lowest value FCFA 5,198 while the top tercile has the highest value: FCFA 9,528. While those premiums are much lower than the commercial premium of FCFA 11,200 that was in force, the gap is wider for low-performing GPCs, and slimmer for high performing GPCs. The rest of the paper is organized as follows: In the next section, I present the dataset. In section 3, I outline the methodology, and later discuss the results in section 4. I conclude the paper in section 5.

4.2 Data

This paper uses the GPC yield data that the cotton company SOFITEX employed when designing the 2TIC. The dataset includes historical yield information (2001-2012) from GPCs in the five provinces (Balé, Banwa, Kossi Mouhoun, Sourou) where most cotton is produced in Burkina Faso (see Figure 4.1).

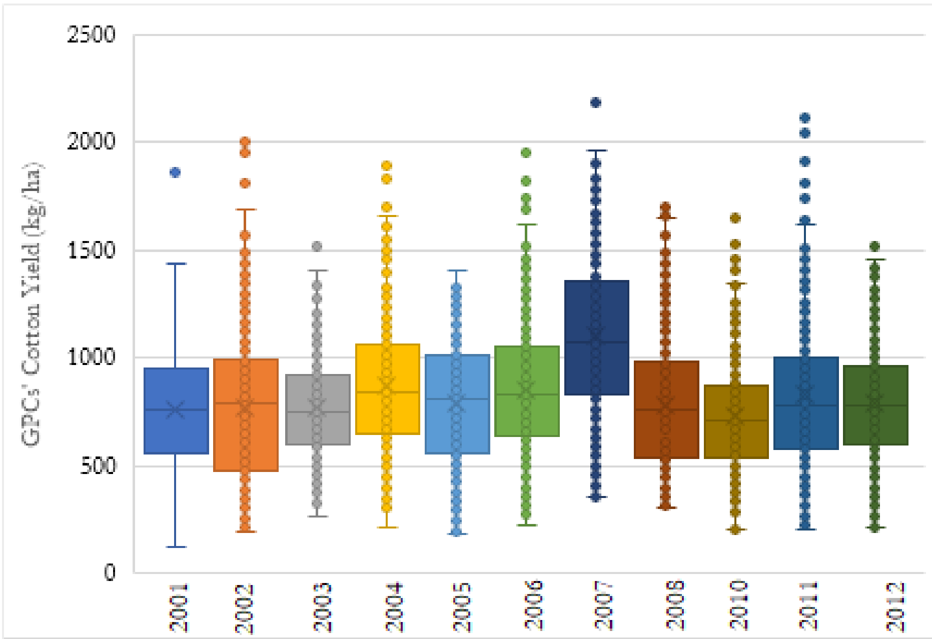
Figure 4.1: Map of Provinces where Historical Yield Data were obtained



Source: Author's drawing based on data obtained from SOFITEX.

The yield represents the rate of cotton production in kilograms per hectare, calculated from the total quantity of cotton produced by farmers within the GPC on the total areas of land each had cultivated that season. Whenever available, these annual data were obtained for each GPC, over the period 2001 to 2012. The initial data contained 1,362 GPCs whose yields were observed over the period 2001 to 2012. However, the database had many missing values for several GPCs. Indeed, some GPCs had only one value out of 12, others had two values out of 12. For 2009, yield data was missing for all GPCs. Following the Mean-Imputation technic, the yield value for 2009 was imputed with the average yield of the years for which the GPC presented a value. As a result of those data management, the initial dataset was reduced to a database consisting of 330 GPCs.

Figure 4.2: Historical cotton yields (kg/ha), 2001-2012



Source: Author's drawing based on data from SOFITEX

Figure 4.2 displays the historical fluctuations in the average cotton yields over the period 2001-2012. The box and whisker format displays the distribution of GPC performances (the dots) within each given year, with the central horizontal bar indicating the median yield, the upper and lower boxes the 25th and 75th percentiles, and the outer "T" of each plot the boundaries of two times the inter-quartile range (IQR). The data show the incredible variability in cotton yields within and between years, with as much as a fivefold difference between the lowest and highest performances in a given year for the 330 GPCs. Interannual variation is less pronounced, if one only considered median values for the sample as a whole, but is substantial for any given GPC, which might find itself in the bottom quartile one year and in the top quartile the next. Overall, the extreme scatter in the Figure's distributions suggests the importance of mitigating the risks of shocks that appear to drive these fluctuations, and therefore the need for reliable crop insurance in this context.

4.3 Methodology

Drawing substantially from the approach used by Carter, Boucher, and Trivelli (2007) to characterize and price the premium of the ARBY insurance product offered in Peru, the essay estimates an actuarially fair premium of the 2TIC in the 5-steps below:

Step 1: the essay used the historical yield data to predict the value of the yield Y_{it} as shown by the following equation:

$$\text{Log}\ (Y_{it}) = a_0 + b_t + \varepsilon_{it}\ ,\ \text{i=1 to 330 and t=2001 to 2012 (1).}$$

where Y_{it} denotes the GPC i's yield in year t ; a_0 is the constant, b_t (temporal dummies), denotes the effect of the year on the productivity of the yield ; and ε_{it} stands for the error term that captures the unobserved factors that may be relevant for affecting the yield Y_{it} and which are not included in the model (1). An Ordinary Least Square (OLS) regression was relied on to estimate equation (1). Also, a logarithmic transformation was used to change the scale of the coefficient to facilitate their interpretation. Therefore, the associated coefficients are interpreted in term of elasticities, meaning that Y in year t changes (positively or negatively depending on the sign) by the associated coefficient when compared to Y in year 2012.

Step 2: in this step, I modified the approach[4] proposed by Carter, Boucher and Trivelli (2007), and consider the predicted values of the yield Y_{it} obtained from the estimation of equation (1). In other words, the predicted yields are obtained as follows:

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[4] In fact, Carter et al. (2007) suggest to standardize the historical yields data to account for the estimated yield growth as follows: $\hat{Y}_{it} = \bar{Y}_{i2012} + \left(\frac{\bar{Y}_{i2012}}{\bar{Y}_{it}}\right) \hat{\varepsilon}_{it}$; where is the predicted yield from equation (1); $\bar{Y}_{i2012}$ is the average yield of the cotton farmer during the period 2001-2012 and $\bar{Y}_{it}$ is her yield up to the period t . When applying this formula to our data, we observe that the predicted yield remains constant over the period 2001-2012. Since this does not fit with our initial data, we therefore decide to modify their approach.

$$\hat{Y}_{it} = \exp\left(\hat{a}_0 + \hat{b}_t \right) \quad (2).$$

where $\hat{\alpha}_0$ and $\hat{b}_t$ are OLS estimates from the equation (1).

Step 3: the predicted time series are then used to estimate the probability that best describes the data. Several functional forms (Exponential, Gamma and Weibull) were tried. For each distribution the parameter of the distribution was estimated using the maximum likelihood method. Among the three distribution function forms used, the gamma distribution presents the highest maximum likelihood closest to zero, as shown in (Table 4.1).

Table 4.1: Comparison of the Maximum likelihood

Probability Distribution Function	Maximum Likelihood
Exponential	-30 248.05
Weibull	-24 303.93
Gamma	-23 318.74

Source: Author's Computation from the finalized dataset.

Applying the Gamma distribution, the probability p_{it} for the GPC$_i$ in year t is therefore as follows:

$$P_{it} = \frac{\frac{a^b}{G(b)} e^{-a*Y_{it}*Y_{it}}{}^{b-1}}{\sum_{t=2001}^{2012} \sum_{i=1}^{330} \left(\frac{a^b}{G(b)} e^{-a*Y_{it}*Y_{it}}{}^{b-1} \right)}, \quad \text{with } G(b) = \int_0^{+\infty} e^{-x} * x^{b-1}\, dx \qquad (3)$$

where a and b are the parameters of the Gamma distribution. They have been estimated using the predicted yields data. Using this probability distribution, we calculate the expected yield standing for the long run yield as follows:

$$\Upsilon = \sum_{t=2001}^{2012} \sum_{i=1}^{330} \hat{Y}_{it} * P_{it} \quad (4)$$

Where $\hat{Y}_{it}$ is the predicted yield computed in Step 2.

Step 4: Indemnity payments under the 2TIC are triggered if and only if the current yield of the GPC falls below its average for the twelve preceding years, and if the current yield of neighboring GPCs falls below their average yield for a similar twelve-year period. To compute the indemnity payments under the 2TIC, indemnity payments W_{it} were defined as follows:

$$Payment_{it} = \begin{cases} W_{it} \; if \; Y_{GPC_{it}} < \frac{1}{t-1}\sum_{k=1}^{t-1} Y_{GPC_{ik}} \; and \; for \; each \; k = 1, \ldots, t-1, \; Y_{GPC_{jt}} < Y_{GPC_{jk}} \\ 0 \qquad Otherwise \end{cases};$$
$$j \neq i, is \; the \; neighbourhood \; GPCs$$

Step 5: the actuarially fair premiums that would be required for the 2TIC was calculated as follows:

$$\text{Payment} = \sum_{t=2001}^{2012} \sum_{i=1}^{330} W_{it} * P_{it} \quad (6)$$

The 5-step approach of Carter Boucher and Trivelli used above was applied to our sample of GPCs, now disaggregated by terciles based on their yields. This disaggregation by terciles is intended to explore the merit of using GPCs' performance to price 2TIC. By fragmenting the population in terciles and estimating the actuarially fair premium of each, this additional analysis will allow us to see how actuarially fair premiums of the various terciles fare (i) among each other, (ii) with the overall sample's actuarially fair premium and (iii) with the commercial premium charged to cotton farmers. A benefit of this additional analysis is to obtain cues as to the merit of considering a premium differentiation in the case of 2TIC. Results of these two estimations are discussed in the next section.

4.4 Results

In this section, the essay presents the outputs from the steps described in the previous section. Table 4.2 presents the estimation results of the interplay between the cotton production year and the average GPCs' yields (equation (1)). Results indicate that GPCs' yields were below the expected mean during several cotton production years namely 2001, 2002, 2003, 2005, 2008, 2010, 2012, while performing above average during the years 2004, 2006, 2007, 2009, 2011.

Table 4.2: Agricultural Campaign and Cotton Yields – OLS Estimates

Year	Estimates
2002	15.44
	(0.672)
2003	11.96
	(0.520)
2004	118.37 ***
	(5.152)
2005	35.53
	(1.546)
2006	92.71 ***
	(4.035)
2007	350.12 ***
	(15.237)
2008	29.37
	(1.278)
2009	67.11 **
	(2.921)
2010	-26.69
	(-1.161)
2011	75.73 ***
	(3.296)
2012	35.56
	(1.548)
Constant	753.37 ***
	(46.333)
Observations	**3,217**
Number of GPCID	**330**

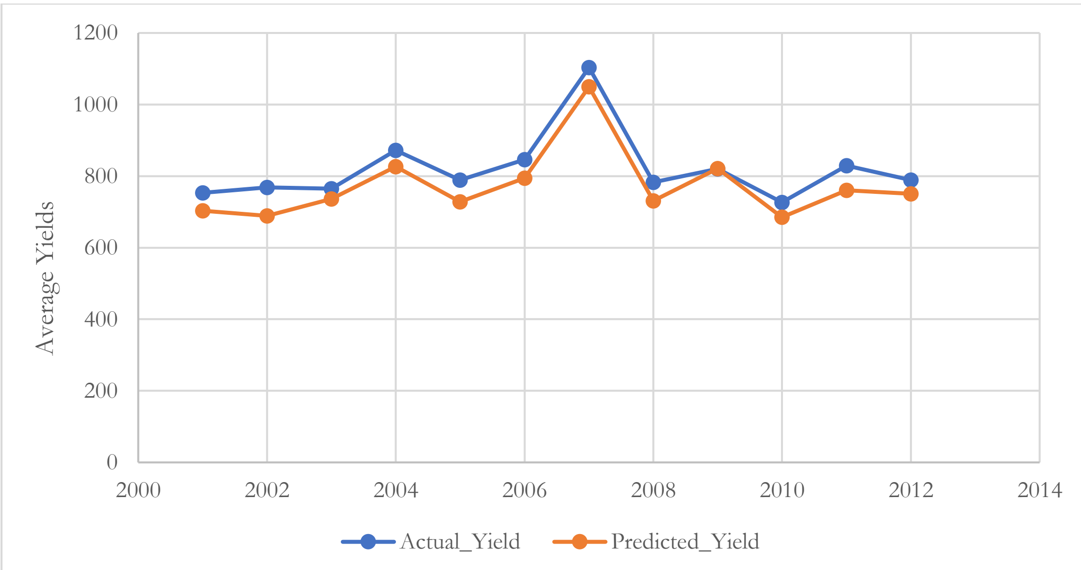
Robust t-statistic in parentheses

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

Source: Author's Computation from the finalized dataset.

Figure 4.3 presents the actual and predicted yields, and therefore shows minor historical deviations between the two. It confirms that the essay's estimated parameters are relevant for replicating the historical yields data.

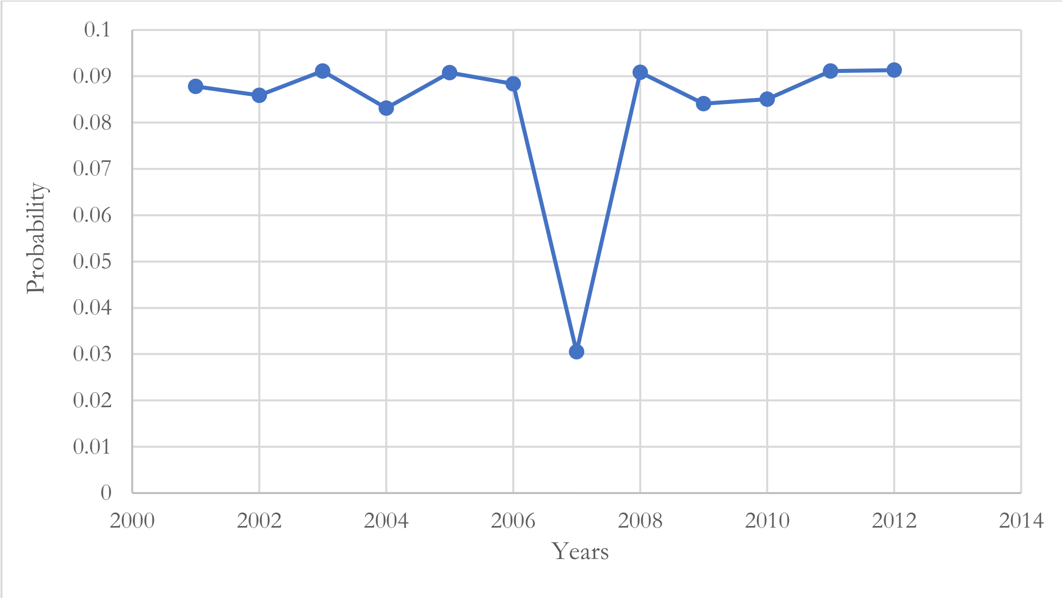
Figure 4.3: Cotton Farmers Yields – Actual and Predicted



Source: Author's drawing from database used in this essay.

Figure 4.4 presents the estimated probability distribution function (P) for the predicted yields. Under this distribution, the essay estimated the likelihood of payouts for a set of cotton prices (Step 5).

Figure 4.4: Estimated Probability Distribution for Average Yields



Source: Author's drawing from database used in this essay.

Results are presented in Table 4.3. It reveals that during the 2013-2014 agricultural season, when the 2TIC was launched, and the cotton price was FCFA 245 per kilogram in Burkina Faso, the actuarially fair premium that would have been required for the 2TIC was equal to FCFA 4,439 per hectare, the equivalent of USD 8.98 per hectare. This per hectare actuarially fair premium is much lower than the FCFA 11,200 that has been charged by Allianz-Burkina (USD 11.22 at the 2013 exchange rates). The difference between the commercial premium and the actuarially fair premium (known as commercial mark-up or loading premium) is FCFA 6,761. In percentage terms, the loading by itself represents 152 % of the actuarially fair premium. Encompassing the loading, the commercial premium of FCFA 11, 200 charged to cotton farmers is 2.52 times higher than the actuarially fair premium. This comparison is in line with previous, unpublished research results by Barré et al. (2016) who found a threefold increase between commercial premium and actuarially fair premium, based on estimates derived from their data.

Table 4.3: Estimation results for the 2TIC's actuarially fair premium prices under different cotton prices

Agricultural Season	Cotton Price	Actuarially Fair Premium
2021-2022	270	4892
2020-2021	240	4349
2019-2020	265	4802
2018-2019	245	4439
2017-2018	245	4439
2016-2017	235	4258
2015-2016	235	4258
2014-2015	225	4077
2013-2014	**245**	**4439**
2012-2013	253	4584
2011-2012	274	4965
2010-2011	210	3805
2009-2010	168	3044
2008-2009	165	2990
2007-2008	155	2809
2006-2007	165	2990
2005-2006	175	3171
2004-2005	210	3805
2003-2004	185	3352
2002-2003	175	3171
2001-2002	200	3624
2000-2001	170	3080
Observations		**330**

Source: Author's Computation from the finalized dataset.

While Figure 4.2 demonstrates the extreme variability of production within the sample, the dataset included no socioeconomic, geographic, or agronomic variables on which to differentiate the 330 GPCs. Nevertheless, we can infer a proxy for some of these possible characteristics by partitioning our final sample into terciles, based on each GPC's average yield levels over the 12 years of data. Table 4.3 compares the calculated actuarially fair premiums for each tercile and for the sample as a whole. Taking as an example the 2013-2014 agricultural season (the first year the product was launched),the actuarially fair premium was FCFA 5,422 for the first tercile, FCFA 4,307 for the second tercile, and FCFA 8,115 for the third tercile. Of these, only the second tercile's AFP is lower than that of the full sample (FCFA 4,439). All of these actuarially fair premiums remain lower than the commercial premium.

Table 4.4: Estimation results for the 2TIC's actuarially fair premium prices under different cotton prices, disaggregated by yield terciles

Agricultural Season	Cotton Price	Actuarially Fair Premiums			
		All	1st Tercile	2nd Tercile	3rd Tercile
2021-2022	270	4892	5976	4746	8943
2020-2021	240	4349	5312	4219	7949
2019-2020	265	4802	5865	4658	8777
2018-2019	245	4439	5422	4307	8115
2017-2018	245	4439	5422	4307	8115
2016-2017	235	4258	5201	4131	7784
2015-2016	235	4258	5201	4131	7784
2014-2015	225	4077	4980	3955	7453
2013-2014	**245**	**4439**	**5422**	**4307**	**8115**
2012-2013	253	4584	5599	4447	8380
2011-2012	274	4965	6064	4817	9076
2010-2011	210	3805	4648	3692	6956
2009-2010	168	3044	3718	2953	5565
2008-2009	165	2990	3652	2901	5465
2007-2008	155	2809	3430	2725	5134
2006-2007	165	2990	3652	2901	5465
2005-2006	175	3171	3873	3076	5796
2004-2005	210	3805	4648	3692	6956
2003-2004	185	3352	4094	3252	6128
2002-2003	175	3171	3873	3076	5796
2001-2002	200	3624	4426	3516	6624
2000-2001	170	3080	3762	2988	5631
Observations		**330**	**110**	**110**	**110**

Source: Author's Computation from the finalized dataset.

4.5 Discussion

Comparing the actuarially fair premium (of the entire sample estimated at FCFA 4,439 in 2013-14) to the commercial premium (set at FCFA 11,200 by the insurer) this essay shows a premium loading of 152%. That percentage of loading exceeds the hypothetical 15% add-on rate over the actuarially fair premium that Castellani's modeling exercise deemed is necessary for insurance companies to account for their operating costs (Castellani et al. 2015). The 152% loading also exceeds the typical 20% mark-up over actuarially fair premium that is commonly used to cover operational costs borne by the insurer (Smith and Glauber 2012; Elabed and Carter 2015; CNAAS and Swiss Re, 2018). The noted mark-up speaks to the much more complex nature of pricing insurance contracts. Beyond the demand side, where it has been demonstrated that pricing can be a(n) dis/incentive for contracting insurance products, pricing can also be a(n) dis/incentive for the sustainability of insurance product and on this end will affect the supply side. For the latter (supply side) it is worth noting that insurance companies commercialize an insurance product only when they have a Re-insurance company insuring them in return for the risks they assume. Thus, depending on how the re-insurance company gauges the level of liability that insurance companies have vis-à-vis the risks they assume with a specific insurance product, pricing can be affected. Noting that re-insurance companies offer their services in exchange for a share of the insurance premium, their service alone explains the add-on to the actuarially fair premium. In addition, the insurance company may charge more on top of the actuarially fair premium, if in consultation with the re-insurance company it was determined that such an addition could serve as a safe cushion to withstand possible excessive claims, in the aim of keeping the 2TIC viable. It is also possible that the charged premium loading was arranged to seek a certain profit margin. However, lacking any data about which percentage of the premium loading goes to what stakeholder precludes us from concluding unambiguously. While future research with granular data on the costs of premium could shed light on the driver(s) of the loaded premium noted with the 2TIC, results from the first analyses suggest that stakeholders from the insurance supply side (i.e., the broker, the insurer, the re-insurer) were exercising a likely excessive caution with pricing.

Disaggregating the actuarially fair premium by terciles indicates a lower value in the second tercile, and higher values in both the first and third tercile, suggestive of a "U-shaped curve" for the price variation. At first glance, this is a puzzling distribution: the lowest yielding GPCs (the first tercile) might be expected to have the lowest actuarially fair premium, but in fact it is the middle (second) tercile that does. This variation in actuarially fair premium can be attributed to variance in the scale of liability (or riskiness) that the insurance company face when protecting GPCs (belonging to each of those terciles) against risks. For the first tercile, GPCs' overall yields are relatively low, due to the group's weak performance with cotton production that can be explained by their limited resources. As such, GPCs within this group are at risk of losing everything, should a shock occur. The inter-annual variability of production in this tercile is also higher than for the other two, meaning they have the highest frequency for receiving indemnities from the insurer. For that reason, the actuarially fair premium for the lower tercile is likely to be high, given that the insurance will be liable for covering these important losses. GPCs belonging to the middle tercile produce at a quantity per hectare that does not make them as vulnerable as the bottom group, nor at greatest risks of nominal losses as compared to the upper tercile. As a result, the actuarially fair premium is lower for this group. For the upper tercile where GPCs' yields are the highest, indicative of the group's comparatively strong performance with cotton production, the nominal value of losses is likely to be larger in an event of a peril. Consequently, the actuarially fair premium for this group is likely to reach higher figures.

Comparing the 2TIC's commercial premium (of 11,200 FCFA) to actuarially fair premiums of the various terciles (FCFA 5,422; FCFA 4,307; FCFA 8,115) reveals a mark-up that is wider for the lower and middle groups. Compared to the upper group where the mark-up represents 28% of the commercial premium, the mark-up are respectively 52% and 62% for the lower and middle groups. This shows variation in the way premium loading was applied to the different groups. While these variation in loadings can be explained by the difference in riskiness across the various groups, they prove to be a disincentive for clients who want to subscribe to 2TIC. That may have explained PlaNet Guarantee's decision in 2018 to introduce a more lower priced 2TIC whose commercial premium of FCFA 5,600 per hectare (UNPCB, 2017) is much closer to the actuarially fair premiums estimated for the first and second terciles (FCFA 5,422; FCFA 4,307). Considering the actuarially fair premiums estimated for the terciles, adding the same premium loading rate obtained for the first tercile (i.e, FCFA 5,778 , the result of FCFA 11,200 - FCFA 5,422) across all terciles would have hypothetically led to the following commercial premiums: FCFA 11,200 for the first tercile, FCFA 10, 085 for the second tercile, FCFA 13,393 for the third tercile. At those values, commercial premiums will be higher, and in excess of FCFA 2,194 for the third tercile, if compared to the FCFA 11,200 that was in force. Any premium loading rate added uniformly across terciles will always be less for farmers belonging to the middle range, and higher for those located in the first and third terciles. Thus, for the same product, should famers be charged based on the yield level of the GPCs they belong?

While the objective of this essay is more about comparing actuarially premium to commercial premium than answering whether GPCs should be charged differently, thoroughly answering the question may require an arbitrage between data and ethics. From a data perspective, the above analyses show that the insurance company is more likely to incur a loss by insuring farmers whose GPCs belong to the first and third terciles. Hence it is understandable that the insurance company will charge them a higher premium. In the same line of thought, the insurance company is less likely to incur a loss by insuring GPCs from the middle tercile. Hence it would be reasonable to charge them a lower premium. While a premium differentiation could make sense from a data standpoint, one can argue that it might not be the right thing to do from an ethical standpoint, since the most vulnerable group (the first tercile) would be charged a higher premium than their better resourced counterparts in the second tercile. There is certainly an argument to be made whereby certain target groups (women-headed households, smallholders, etc.) might benefit from a subsidized premium, assuming other, more privileged farmers are able to pay higher premiums to support the program, in the absence of good data or a strong moral argument to justify differential pricing, it seems problematic to charge different rates for the exact same exact 2TIC product.

A key takeaway is that premium differentiation in the case of 2TIC can be beneficial to farmers if premium loadings are applied in a way that is advantageous to each group. Given that commercial premium is the ticket to the risk protection and the kind of safety that insurance provides, the role of premium loading is important. From a developmental lens, drawing from Amartya Sen's five Instrumental Freedoms—(1) political freedoms, (2) economic facilities, (3) social opportunities, (4) transparency guarantees, (5) protective security— which are viewed as key ingredients in an individual's ability to thrive it is reasonable to say that premium loading (if high) can bar poor farmers from accessing insurance. In this way, premium loading can infringe upon the fifth instrumental freedom "protective security" and therefore could constitute an obstacle to the path of being insured. The obstacle to insurance increases clients' vulnerability to climate-related stresses, and therefore, constrains their developmental prospects, should an unforeseen event occur. As such, the premium loading noticed in the case of 2TIC is factor that needs to be addressed given the continuing efforts of guaranteeing financial inclusion for all.

4.6 Conclusion

This essay contributes to the literature on the affordability of index insurance schemes by providing new evidence on the difference between the 2TIC's actuarially fair premium and the commercial premium that was in effect. Indeed, a previous study revealed that 2TIC, as it was sold to Burkinabe cotton farmers, had a high loading factor that rendered the product expensive for smallholders, a situation that can explain the disappointing decrease in take-up rate after an initial interest in the product (Barré et al. 2016). Using a Gamma functional form informed by the concept paper developed by Carter, Boucher and Trivelli (2007), this essay shows that the commercial premium charged to farmers is 2.52 times higher than the estimated actuarially fair premium.

The gap reflects the premium loading that was in effect, and its rate outweighs the typical 15 to 20% increase over the actuarially fair premium that is often used to cover operating costs borne by the insurer (Smith and Glauber 2012; Elabed and Carter 2015; CNAAS and Swiss Re, 2018). Our estimation of the actuarially fair premium across terciles shows that premium differentiation in the case of 2TIC can be beneficial to farmers from GPCs located in the bottom and middle terciles based on overall yields, if their premium loading rates are low. This finding has important implications on premium pricing, especially for an insurance product, which is foreseen to be rolled out nationwide (Sidibé, 2018).

Limitations to this essay that are worth mentioning relate principally to data. The scope of this essay was limited by the timespan (12 years from 2001-2012), size (330 GPCs) and nature (yield reported only as group-level averages) of data available. To respond to those limitations, future research could use data on the size of observed losses, and employ index modeling to price the 2TIC based on the distribution of observed losses. Such an approach to pricing insurance contracts could be useful, as it has the advantage of accounting for losses outside the range of observed data.

To conclude, the commercial premium of 2TIC as it was proposed to cotton farmers in Houndé and Founzan had a premium loading that was consistently higher than the actuarially fair premium. This gap could explain the decrease in sign-ups, as well as certain farmers' reluctance to subscribe. Even though the pricing of insurance contract is a much more complex task given the delicate interplay between supply and demand, the findings of Essay 3 suggest that there should be a continuing effort towards minimizing premium loading.

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Chapter 5: Conclusion

5.1 Introduction

In light of the three essays that have been carried out to answer the research questions stemming from the identified research gaps, this chapter revisits the purpose and objectives of the thesis, then provides an overview and closing remarks on the overall analyses. Following the introduction, which presents an outline of the chapter, section 2 of the chapter provides a recapitulation of the three research objectives and questions. Section 3 summarizes the main findings from each essay and brings their findings together. Section 4 presents the implications of the study for specifics such as: literature, policy and practice, limitations and directions for future research. The conclusion of section 5 closes the entire thesis.

5.2 Recapitulation

The overall research thesis was conducted to understand the implications of implementing a 2-tier trigger mechanism of Area yield-based insurance (like the 2TIC) for a client-farmer.

For that overarching objective, three specific objectives of interest were to:

(i) Explore cotton farmers' judgments of fairness vis-à-vis the 2TIC indemnification system and see if/how these judgments affect decision to subscribe,

(ii) Assess the impact of 2TIC on farmers' cotton-derived net income, and

(iii) Compare the actuarially fair premiums (overall and the sub-groups levels) of the 2TIC with the commercial premium paid by cotton farmers.

For these objectives, respective research questions considered throughout the analyses were the following:

(i) Does perceived fairness of the 2TIC indemnification systems influence cotton farmers' decisions to subscribe?

(ii) What is the effect of 2TIC on farmers' cotton-derived net income?

(iii) How do actuarially fair premiums (overall and the sub-groups levels) of the 2TIC compare to the commercial premium being paid by cotton farmers?

In an attempt at responding to the above-mentioned research questions three distinct analyses were conducted generating the following essays:

(i) Essay 1 titled *Perceived Fairness of Indemnities and the Double Trigger-Index Based Insurance Product: Evidence from Cotton Farmers in Burkina Faso*

(ii) Essay 2 titled *The Effects of Index-Based Insurance on Farmers' Income: Evidence from Cotton Farmers in Burkina Faso*

(iii) Essay 3 titled *Actuarially Fair Premium and Commercial Premium: The Case of the 2TIC in Burkina Faso*

5.3 Summary of Findings

5.3.1 Findings from Essay 1

Essay 1 responds to the question "Does perceived fairness of the 2TIC indemnification systems influence cotton farmers' decisions to subscribe?" by (i) using Principal Component Analysis (PCA) to compute five indicators related to farmers' perceptions of fairness regarding the 2TIC (i.e., insurance reliability product, strike point external, strike point internal, quality of the relationship between farmers and their insurer, and insurance literacy), and (ii) running logistic regression to identify factors that are relevant for shaping farmers' decision to subscribe to the 2TIC.

Results show that four of the five fairness related indicators had a significant impact on the subscription decision, demonstrating the importance of taking farmers' perceptions of the 2TIC into consideration. Insurance Product Reliability (i.e., the judgment farmers make about the scale and reliability of the indemnity they think they will receive in relation to losses they may have incurred) had the largest coefficient and is positively and significantly correlated with farmers' decision to subscribe to the 2TIC. That means that **the more farmers perceive an insurance payout as probable and aligned with their incurred losses, the more likely they are to subscribe to the 2TIC**.

Findings of Essay 1 also reveal a positive association between Insurance Literacy (i.e., farmers' judgment of the quality of information about the 2TIC and its mechanisms they were given) and the decision to subscribe to 2TIC. That finding indicates that **the more farmers considered they have received (and understood) sufficient information about the 2TIC**

insurance scheme, the greater their likelihood of subscribing to it. Analyses also show that Relationship Quality – the level of credence that cotton farmers have towards the various stakeholders from the insurance supply chain – has a negative and significant decrease in their probability to subscribe to the 2TIC. That finding suggests that **the more cotton farmers lend credence to support provided by the various stakeholders from the supply chain the less likely they are to subscribe to 2TIC.** This rather paradoxical finding could be explainable in part by the fact that as farmers interact with stakeholders from the insurance supply chain, they will learn more about 2TIC (i.e., Insurance Literacy increases). As their Insurance Literacy increases, it may be the case that cotton farmers become more knowledgeable but also apt to judge the insurance product as not as attractive as it first seemed. The decrease in the number of subscriptions noted by Planet Guarantee-Burkina Faso between the 2013-14 agricultural season and that of 2018-19 could be evidence of such an effect.

Analyses in Essay 1 also finds a negative correlation between farmers' judgment of fairness vis-à-vis the two strike points (internal and external) and decision to subscribe. The negative correlation was not statistically significant for the strike point set externally (i.e., the second trigger finally qualifying the insured farmer for an indemnity payment). The lack of statistical significance indicates that **there is no evidence to suggest that farmers' judgement of fairness vis-à-vis the strike point set externally affects their decision to subscribe.** However, the negative correlation was statistically significant for the strike point set internally (i.e., the first trigger pre-qualifying the insured farmer for the indemnity payment) therefore suggesting that **the less that cotton farmers find the strike point set internally to be problematic, the greater their likelihood of subscribing to 2TIC**.

Essay 1 also tested the robustness of the fairness indicators by including both socio-demographic factors (of the respondent farmers) and non-behavioral factors (characteristics of the 2TIC product). Including these factors in the model did not change the magnitude, rank order, or significance levels of any of the coefficients. The most important socio-demographic characteristic was Education, with a positive relationship between higher levels of formal education (secondary schooling rather than primary only, or no formal education) and an increased likelihood to subscribe. For the factors related to the product itself, only the perception of Basis Risk was significant, which is consistent with previous findings in the literature.

5.3.2 Findings from Essay 2

Essay 2 addresses the question "What is the effect of 2TIC on farmers' cotton-derived net income?" by employing CEM to estimate the average treatment effect of 2TIC on farmers' net income obtained solely from the cotton production. Results show that the mean net income for the 2TIC subscribers was significantly higher (+35%) than the mean net income of those who did not subscribe. This means that **the decision to subscribe to 2TIC in the context of Burkina Faso is associated with a significant and important welfare gain (+35% mean net income derived from cotton) compared to the decision of not subscribing.** Quintile regression showed that 2TIC subscription was associated with higher mean net incomes for subscribers compared to uninsured farmers at all income levels (five quintiles). The differences in mean net incomes were greatest for cotton farmers in the top and bottom quintiles (+ FCFA 883,145 FCFA and + FCFA 269,710 respectively). Results for the middle quintiles were more modest, but still positive. This finding, that the impact of 2TIC on cotton-derived income is greatest for the bottom and top income quintiles, suggests that **the 2TIC has important potential both as a pro-poor intervention, and one that can support welfare gains for the most dedicated cotton farmers.**

5.3.3 Findings from Essay 3

Essay 3 answers the question "How do actuarially fair premiums of the 2TIC (for the overall sample and at the sub-group levels) compare to the commercial premium?" by using statistical steps to estimate the price of the actuarially fair premium, and compare it with the value of the commercial premium. Results reveal that the estimated actuarially fair premium of 2TIC for the overall sample is FCFA 4,439 per hectare. Actuarially fair premiums for the first, second, and third terciles were estimated at respectively FCFA 5,422; FCFA 4,307; FCFA 8,115. Whether at the overall sample or subgroup levels, Essay 3 reveals that the actuarially fair premiums are lower than the commercial premium of FCFA 11, 200 charged to farmers. The difference between the commercial premium and actuarially fair premium suggests that **a mark-up exceeding the value of the actuarially fair premium has been added to the actuarially fair premium, therefore, generating a highly loaded commercial premium**.

5.4 Implications of the Study

5.4.1 Implication for the literature

The existing literature on IBI had explored ways to improve the take-up of insurance schemes. Whether through identifying salient factors for take-up, undertaking field experiments to learn about farmers' decisions under risks, conducting impact assessment of novel products, the ultimate goal sought with studies involving IBI, is about aligning the products with farmers' real risks and needs, in so that they will be more inclined to take it.

Fairness

By examining how the different dimensions of fairness affect the demand for 2TIC (i.e., Essay 1), the boundaries for behavioral factors affecting insurance uptake have been pushed outward to include perceived fairness. For instance, previous studies, which looked at behavioral factors affecting insurance take-up, found trust (in the product and in financial institutions) to be significant determinants of index insurance take up (Karlan et al., 2014). Other studies in Burkina Faso (Stoeffler et al. 2020), have addressed fairness issues only through focus group discussions around the time 2TIC was introduced, but identified concerns with predictability, reliability, and responsiveness as potential issues affecting subscription decisions.

The current study utilized the four dimensions of fairness found in the literature and obtained five distinct indicators, of which four were significant at the 0.05 level. The indicator with the largest coefficient, which was positively associated with subscription, was Insurance Product Reliability. This indicator was a measure of how probable farmers felt a payout would occur, and whether it would cover their incurred losses. This perception of whether the payout would be 'fair' (predictable, on time, and adequate) speaks to some of the concerns raised in the early years of the 2TIC that were mentioned in Essay 2, and by Stoeffler et al (2020). It is worth noting that the other, existing studies of the viability and acceptability of 2TIC in Burkina Faso were only conducted around the time of its introduction, e.g., Stoeffler et al (2016; 2020) in its second agricultural campaign (2014-2015) or Barré et al (2016) in its first (2013-2014), with reference to the seasons prior to 2TIC's launch. The authors note that those early years were also fraught with implementation challenges (late sale of the insurance, delays in payouts), which understandably colored farmers' assessment and interest in the 2TIC. The present study was able to gather data on perceptions five years after 2TIC's arrival. This provides a unique set of findings, which describe a period when farmers were more familiar with the product, and also when the implementation of 2TIC had become more stable and reliable. It is important, therefore, to note, that both the Insurance Product Reliability and farmers' Insurance Literacy indicators related positively and significantly to their decision to subscribe to the product. It is also worth noting that (as shown in Essay 2) subscribers to the 2TIC obtained significantly higher mean net incomes from their cotton production than non-subscribers. Communicating these important welfare gains, observable across all income levels (five quintiles), would likely further enhance farmers' favorable perceptions of the 2TIC.

Income

By assessing the impact of 2TIC on farmers' cotton-derived income (i.e., Essay 2) findings of the study adds to the body of literature that evaluates the welfare impact of IBI schemes. Previous studies found that subscribing to 2TIC has a spillover impact on the non-cotton farming activities constituting farmers' total income portfolio (Barré et al. 2016; Stoeffler et., 2020). Although some studies (Elabed and Carter 2013) have shown that insurance encouraged farmers in Mali to undertake profitable but risky activities like cotton farming, they could find no significant change in income from cotton, only an increase in the crop's planted area. In the absence of studies that show a direct relationship between 2TIC and income farmers derived from the insured crop, this study has important contributions. Not only was subscription to 2TIC shown to be related to a higher (+35%) mean net income derived from cotton, but quantile regression demonstrated that this positive association was actually greatest for both the uppermost and lowest income quintiles in the sample. These encouraging findings deserve to be furhter explored in future studies.

In addition to exploring the relationship between 2TIC and cotton-derived net income, the CEM methodology employed in Essay 2, is groundbreaking as it has not yet been applied in the cotton sector of Burkina Faso. The application of CEM to this topic makes the thesis a pioneer study of its kind in the relatinship between index insurance and income.

Pricing

By estimating the price of the actuarially fair premium and comparing it with the price of the commercial premium charged to cotton farmers (i.e., Essay 3), these findings contribute to the literature on pricing of IBI products. In previous studies, methodologies such as burn analysis (Jewson and Brix, 2005), Black Scholes framework (Okine 2014), index modelling (Benth et al. 2011; Taib et al., 2012), and dynamic modelling (Doms et al. 2017) are approaches that have been used to price index insurance. While these approaches often require long historical datasets (e.g., at least 20 years for a reinsurance company to find them satisfactory), in the case of the 2TIC, providing a 20-year historical dataset on GPCs that is also complete proved challenging for SOFITEX. Confronted with that challenge, Carter Boucher and Trivelli (2007) used statistical approaches to estimate the actuarially fair premium in the context of an ARBY product. By building on this approach and using a gamma distribution which best fits our data rather the Weibull function used in Carter, Boucher and Trivelli (2007), the methodology used in this essay adds to the list of approaches in the literature that can be used to estimate actuarially fair premium.

The gap between actuarially fair premium and commercial premium speaks to the size of premium loading being charged by the insurer. While farmers' opinion about the price of the 2TIC subscription did not figure as a significant variable in the analyses of Essay 1, it is clear from Essay 3 that the current commercial price includes a loading, which likely acts as a disincentive to subscriptions, especially by low-income farmers. In this way, Essay 3 suggests that the commercial price is much higher than warranted by the actuarial fair prices. Evidence from Essay 2 also implies that those farmers in the lowest income quintile that have decided to subscribe to 2TIC have realized an important improvement in their mean net income derived from cotton production. This finding is an important contribution to the search for pro-poor interventions to support income stabilization and resilient livelihoods in semiarid rural contexts.

5.4.2 Implication for Policy and Practice

Evidence on how farmers' perceived fairness of indemnity affects their subscription to 2TIC, (demonstrated in Essay 1) sheds some light on how local perceptions of fairness affect demand for agricultural insurance product. As such, findings of the study reveal farmers' implied preferences for the 2TIC product. The reveals of farmers' preferences vis-à-vis fairness are information that can be valuable for the design of future index insurance contracts. Hence, further integrating farmers' point of view in the design and implementation phase of IBI products could contribute to the advancement of insurance schemes that meet the needs of the locals. From a practical standpoint, this suggests the need for the application of participatory approaches in the design process of insurance products. With a community-based model involving UNPCB, the insurance company (Allianz- Burkina), and the insurance broker (PlaNet Guarantee), the different stakeholders can work collaboratively to propose or amend an index insurance product that more directly incorporates farmers' perceptions (especially relating to the reliability and scope of indemnification). A collaborative approach to designing index insurance has the potential of proposing products that will better align with farmers' perceived view of fairness. For instance, as it was shown in Essay 1 that (i) farmers' judgement of the scale to which the indemnity is in line with the amount or value of the incurred loss matters, **designing a product for which indemnities paid are close enough to losses can be more attractive to farmers.** As it was down that farmers' judgment of the suitability of the first trigger criteria leading to the indemnification matter, **getting local farmers involved in the choice/selection of threshold pertaining to the first trigger could increase the attractiveness of the product.** Moreover, Essay 1 reveals that (iv) farmers' judgement of the level of credence that they have towards the various stakeholders from the insurance supply chain, and (v) farmers' judgment of the quantity of information about the insurance contract they have obtained are important, **transparency in information sharing and building insurance literacy can further improve the take-up of 2TIC**.

Evidence generated by the impact assessment of 2TIC on farmers' net income (i.e., Essay 2) shed some light on the income improvement potential of 2TIC. A 35% increase in net income of cotton farmers who subscribed to 2TIC, compared to those who did not, shows the income benefit associated with 2TIC. Thus, findings of the study serve as evidentiary knowledge for enacting and implementing policies related to 2TIC. For the practical implications, the evidence of positive and significant correlation between 2TIC subscription and net income from cotton farming suggest that 2TIC can have a wealth-improving effect for subscribers.

As shown by the quantile regressions, this effect held true across all different income groups, even the lowest income quantile.

Evidence resulting from the comparison between actuarially fair premium and commercial premium (demonstrated in Essay 3) reveals that the commercial premium of the 2TIC set at CFA 11,200 is 152% higher than the actuarially fair premium of FCFA 4,439. This 152% commercial mark-up is much greater than the 15% to 20% loading factor deemed necessary to cover operational costs in the case of index insurance products (Castellani and Vigano, 2015). As noted above, the magnitude of this premium loading makes 2TIC a very costly risk mitigation strategy to access and is likely a barrier for lower income farmers with limited financial resources. This loading could derive from the high costs of managing and implementing the product, but likely also reflects the insurer's inability to adequately quantify their risks. Better research could help characterize these risks.

In practice, evidence of the high mark-up shown in Essay 3 suggests that **there is room to consider bringing the commercial price closer to the actuarially fair premium level.** While as such idea may require negotiations between the insurance and re-insurance companies, going beyond the review of historical yield data and the quality of the index, to account for farmers perspective can be beneficial to all stakeholders.

5.4.3 Limitations and directions for future works

One of the main limitations of this study is the regional clustering in which 2TIC was provided. For the analysis quantifying perceived fairness and its effect on decision to subscribe, although the perception of fairness is in reference to the indemnification system of 2TIC, characteristics proper to the cotton region of the study site as a whole could also explain the opinions farmers have on perceived fairness. By addressing 'cotton farming' from the point of view of 'farmers located in Houndé and Founzan', the study focuses on 'cotton crop' and the departmental regions of 'Houndé and Founzan'. As such, the study is context-specific, and results can hardly be generalized unless further investigations are conducted. It therefore appears interesting to continue the reflection by expanding the scope of the study to other regions or contexts. Since a 2TIC insurance is offered to cotton farmers in Mali, it could be of a great value to the literature to conduct a comparative study, to see if the different dimensions of fairness affect insurance demand the way they did in Burkina Faso.

For the analysis exploring the effect of 2TIC on farmers' net income where CEM was employed, our sample size of 437 observations is not considered a large dataset for a study of that nature (i.e., using matching methods to identify treatment effect). So, for future research if funds permit, it could be useful to have a much larger dataset. A larger dataset will increase the size of subgroups for the quantile regressions, and therefore lead to a more robust inference. Likewise, as the analysis comparing actuarially fair premium to commercial premium was limited by the timespan (12 years from 2001-2012) and finalized sample size with complete time series (330 GPCs), a much larger dataset could be useful. In three years (that is, 2025), SOFITEX will be able to provide a 25-year historical dataset for GPCs yields. Since 25 years, is often viewed as the minimum time span required by reinsurance companies, there is an opportunity to reassess the actuarially fair premium in the coming years.

On the same topic, as it was suggested that premium subsidies can be beneficial to cotton farmers. Given the highly loaded commercial premium, it would be useful to understand how possible remedies, such as premium subsidies could affect demand for 2TIC, and under what circumstance a premium subsidy could be most beneficial to cotton farmers given their heterogeneity across the sample. The 152 % commercial mark-up (equivalent to FCFA 6,763) being added to the actuarially fair premium implies that cotton farmers lose an expected consumption equivalent to that mark-up. Determining the optimal subsidy level, for which cotton farmers will find it worthwhile to subscribe to 2TIC is a research question that is worth pursuing.

5.5 Conclusion

The 2TIC has been proposed to Cotton farmers of Burkina Faso to protect them against yield losses—emanating from adverse natural events, such as droughts or floods—that can negatively affect their cotton-derived income, and thereby, constrain their livelihood options. This novel insurance scheme has an indemnification system that depends on the concomitant realization of a trigger set internally (relevant to the client's past performance) and a second trigger set externally (relevant to the performance of the client's neighbor). The implication for farmers of implementing this double trigger system has been the focus of this thesis, organized in a three-essay format.

The thesis had three research objectives: (i) explore cotton farmers' judgments of fairness vis-à-vis the 2TIC indemnification system and examine how these judgments affect decisions to subscribe, (ii) assess the effect of 2TIC on farmers' cotton-derived net income, and (iii) compare the actuarially fair premium of the 2TIC with the commercial premium paid by cotton farmers. The thesis throughout its analytical course achieved these objectives by presenting discerning evidence. First, there is evidence that perceived fairness of the 2TIC indemnification system matters in the decision to subscribe. Second, there is evidence that subscribing to 2TIC was associated with a higher (+35%) mean net income derived from cotton production, as compared to that of farmers who did not subscribe. Evidence also shows that the effect was greatest for farmers from the bottom and top quintiles, suggesting the 2TIC has potential both as a pro-poor intervention and in support of farmers seeking to intensify their cotton production. Third, there is evidence that a high mark up (equivalent to 152% to 202% of the actuarially premium price) has been added to the actuarially fair premium, making 2TIC an expensive product for smallholder farmers.

These findings provide insights into the implications for cotton farmers of having a 2TIC scheme in place. Referring to Sen's Capability approach, which supports the idea of expanding people's instrumental freedoms (Sen, 1999), it is reasonable to state that 2TIC as it is currently implemented with Burkinabe cotton farmers could have a positive welfare impact (Essay 2) but could be more affordable to the average cotton farmer (Essay 3). Should there be an opportunity to improve the 2TIC, perceived fairness should be given more consideration (Essay 1) and a more inclusive, participatory approach employed. While those findings pertain to the Burkina Faso context, due caution should be exercised in their generalizability. Nevertheless, they provide insights into the implications of designing an ARBY with a double trigger index insurance scheme in a developing country. Further investigations can be conducted to heighten generalizability and increase the depth and breadth of the literature on index-based insurance.

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Appendices

Appendix 1 : Survey questionnaire

Dear Farmer Participant,

I am a student at the University of Ottawa's School of International Development and Global Studies, and this survey questionnaire was developed for academic purposes, with the objective of understanding how factors, including farmers' perception of fairness affect the demand for the Double Trigger Index insurance Contract (2TIC).

Introduced to cotton farmers in 2013, 2TIC has been heralded as a promising insurance scheme that can protect farmers against covariate shocks, and promote their productive investments. These purported advantages of the 2TIC have been demonstrated in theory, and I am interested in knowing how you view them in practice.

Your answers will provide greater insights on the local perception of the 2TIC product, and in this way, generate new knowledge on decision-marking related to agricultural insurance. I therefore entreat you to provide information as accurate as possible for true results. Rest assured that your answers will be anonymous, and that any view expressed in relation to this research will remain strictly confidential.

Thank you in advance for your kind cooperation.

Survey Questionnaire Number :
Name of the Participant:
GPC of the Participant :
GPC Code of the Participant:
Date of the Survey :

Section 1: Sociodemographic Characteristics of the Respondent

1.1. The Respondent's Profile

1.1.1. Sex of the Respondent

☐ Male ☐ Female

1.1.2. Age of the Respondent

1.1.3. Origin of the Respondent

☐ Born and raised in the village ☐ Foreigner to the village

1.1.4. Origin of the GPC

☐ From the Village ☐ Transfer

1.1.5. GPC's tenure within the village

☐ Less than 12 years ☐ 12 years and more

1.1.6. Respondent's level of Scholarly Education

☐ Never Attended School
☐ Attended Elementary School
☐ Attended Secondary School and more

1.1.7. Respondent's Household Size

1.1.8. Respondent's membership length with their current GPC

☐ Less than 12 years ☐ 12 years and more

1.1.9. Do you have income from non-cotton farming activities ?

☐ Yes ☐ No

1.1.9.1. If yes, please specify what type of activity

1.2. The Respondent's Opinion on Cotton Farming

1.2.1. The respondent's motive for farming cotton

I pursue cotton farming

	Strongly disagree (1)	Disagree (2)	Neither agree or Disagree (3)	Agree (4)	Totally Agree (5)
Because of Family Tradition	☐	☐	☐	☐	☐
For its revenue-making potentials	☐	☐	☐	☐	☐
Because I can have access to inputs-on-credits	☐	☐	☐	☐	☐
Because it is the main farming activity	☐	☐	☐	☐	☐
To try something new	☐	☐	☐	☐	☐

1.2.2. How long have you been farming cotton ?

☐

1.2.3. Have you been a member of the same GPC since 2013?

☐ Yes ☐ No

Section 2: The Respondent's Opinion on the Factors of Production

2.1. The Respondent's Opinion on Capital

2.1.1. The respondent's ownership status on the cultivated land

☐ Own ☐ Rent ☐ Authorized to farm

2.1.2. Is your cotton farm field located contiguously on a single lot, or spread over several plots?

☐ on a single lot ☐ over several lots

2.1.3. If your cotton farm field is located on several lots, please indicate the number of lots

2.1.4. If your cotton farm field is contiguously located on a single lot, please indicate the location of the single lot

☐ In the village of the GPC ☐ Outside the village of the GPC

2.1.5. If your cotton Farm field is spread over several lots, please specify the location of each lot

Lots	Location	
Lot #1	☐ In the village of the GPC	☐ Outside the village of the GPC
Lot #2	☐ In the village of the GPC	☐ Outside the village of the GPC
Lot #3	☐ In the village of the GPC	☐ Outside the village of the GPC

2.1.6. If your cotton farm field is spread over several lots, what distance separates the different lots?

Distance between the lots	in kilometers or meters
Distance entre lot #1 and lot #2	
Distance entre lot #1 and lot #3	
Distance entre lot #2 and lot #3	

2.1.7. If your cotton farm field is spread over several lots, please indicate your ownership status with the lot

	Own	Rent	Authorized to farm
Lot #1	☐	☐	☐
Lot #2	☐	☐	☐
Lot #3	☐	☐	☐

2.1.8. What type of farming practice(s) have you been using?
☐ Manual Traction
☐ Animal Traction
☐ Motorized Traction

2.2. The Respondent's Opinion on Labor

2.2.1. Do you use Family Labor?
☐ Yes ☐ No

2.2.1.1. If yes, how many family members are involved in your cotton-farming work?

2.2.2. Do you reward (in-kind or in cash) members of your family who have cultivated your cotton farmlot(s) during the agricultural season ?
☐ Yes ☐ No

2.2.2.1.If yes, please specify the number of family workers participating in all cotton-farming work, as well as the total cost of reward per agricultural campaign?

Agricultural Season	Number of family members	Cost of reward (whether cash or in-kind)
2017-2018		
2016-2017		
2015-2016		
2014-2015		
2013-2014		

2.2.3. Do you use non-family labor force ?
☐ Yes ☐ No

2.2.3.1. If yes, please specify the type of labor , the number of non-family workers participating in all cotton-farming work, as well as the total cost of reward per agricultural campaign?

Agricultural Season	Type of Labor	Number of non-family labor force	Cost of reward (whether cash or in-kind)
2017-2018	Community Labor		
	Contract Labor		
2016-2017	Community Labor		
	Contract Labor		
2015-2016	Community Labor		
	Contract Labor		
2014-2015	Community Labor		
	Contract Labor		

Agricultural Season	Type of Labor	Number of non-family labor force	Cost of reward (whether cash or in-kind)
2013-2014	Community Labor		
	Contract Labor		

2.2.4. Do you pay transport costs for your cotton output, from the field to the point of purchase ?

☐ Yes ☐ No

2.2.4.1. If yes, please specify the costs per agricultural season

Agricultural Season	Costs related to the transport of cotton
2017-2018	
2016-2017	
2015-2016	
2014-2015	
2013-2014	

2.2.5. Do you pay for caretaking and surveillance of your cotton output before it gets to the point of purchase ?

☐ Yes ☐ No

2.2.5.1.If yes please specify the cost per agricultural season

Agricultural Season	Costs of caretaking and surveillance
2017-2018	
2016-2017	
2015-2016	
2014-2015	
2013-2014	

Section 3: The Respondent's Opinion on Production and Climate Risks

3.1. The Respondent's Figures on Cotton Production

3.1.1. Please indicate your area planted, and quantity of cotton produced in the following agricultural season

Agricultural Season	Area Planted	Quantity Produced in kilograms or tons
2017-2018		
2016-2017		
2015-2016		
2014-2015		
2013-2014		

3.2. The Respondent's thought on agricultural and climatic risks

3.2.1. Have you observed any change in rainfall variability?

☐ Yes ☐ No

3.2.1.1. If yes, please indicate what have been the changes

Observed changes	Selection
Increased in number of rainfall events	☐
Decreased in number of rainfall events	☐
Distribution of rainfall events	☐
Increased in rainfall duration	☐
Decreased in rainfall duration	☐
Increased in rainfall intensity	☐
Decreased in rainfall intensity	☐

3.2.2. Have you made any change(s) /adjustment(s) in your farming operations in response to the aforementioned observations?

☐Yes ☐ No

3.2.2.1. If yes, what change(s)/adjustment(s) have you made in your farming operations

Adaptation Measures	Selection
Early sowing	☐
Farm near river on low land	☐
Farm near river on hills	☐
Reduce size of land allocated to cotton	☐
Augment size of land allocated to cotton	☐
Subscribe to an insurance policy	☐

3.2.2.2. Do you receive any external support as a coping measure in addition to the adaptation measures mentioned above?

☐Yes ☐ No

3.2.2.3 If yes, please indicate the nature of the support and its supplier

Support: Supplier of such support:

3.2.3. Have you ever subscribed to an agricultural insurance policy?

☐Yes ☐ No

3.2.3.1. If yes, please provide the following information

Name of the Insurance Product	
The per hectare premium cost	
Name of the Insurer providing the insurance product	

3.2.4. In case you have subscribed to an agricultural insurance product, please select the agricultural season pertaining to your subscription

Agricultural Season	Selection
2017-2018	☐
2016-2017	☐
2015-2016	☐
2014-2015	☐
2013-2014	☐

3.2.5. Why did you subscribe to the agricultural insurance policy?

	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
Because the per hectare premium is affordable	☐	☐	☐	☐	☐
Because I was compensated when I suffered a loss	☐	☐	☐	☐	☐
Because I understand the product well	☐	☐	☐	☐	☐

Section 4: The Respondent's Opinion on the 2TIC Product

4.1. The respondent's Awareness of the 2TIC product

4.1.1. Have you ever heard about the 2TIC product?
☐Yes ☐ No

4.1.2. Did your GPC ever subscribe to 2TIC since its launch in 2013?
☐Yes ☐ No

4.1.3. Have you ever subscribed to 2TIC since its launch in 2013?
☐Yes ☐ No

4.1.4 Would you like your GPC to subscribe to the 2TIC in the future?
☐Yes ☐ No

4.1.5. Why did you subscribe to the 2TIC?
☐ By own conviction
☐ By advice
☐ By way of a fashionable trend
☐ By obligation

4.1.6. Please indicate the agricultural season when your GPC and/or yourself have subscribed to the 2TIC

Agricultural Season	Subscription	
	Your GPC	Yourself
2017-2018	☐	☐
2016-2017	☐	☐
2015-2016	☐	☐
2014-2015	☐	☐
2013-2014	☐	☐

4.1.7. Are you informed of the threshold of your GPC set by the insurer?
☐Yes ☐ No

4.1.7.1. If yes, please indicate when the information was given to you

☐ During an information session that took place before the GPC's decision to subscribe
☐ During an information session that took place after the GPC's decision to subscribe

4.1.8. Are you informed of the threshold set by the insurer for the neighboring GPC?
☐Yes ☐ No

4.1.8.1. If yes, please indicate when the information was given to you
☐ During an information session that took place before the GPC's decision to subscribe
☐ During an information session that took place after the GPC's decision to subscribe

4.1.9. What do you think of the premium cost set at FCFA 11,200 per hectare?

Very Cheap (1)	Cheap (2)	Fair (3)	Expensive (4)	Very Expensive (5)
☐	☐	☐	☐	☐

4.1.10. What do you think of the premium cost set at FCFA 5,600 per hectare?

Very Cheap (1)	Cheap (2)	Fair (3)	Expensive (4)	Very Expensive (5)
☐	☐	☐	☐	☐

4.1.11. How much per hectare would you like to pay for the premium ?

☐

4.1.12. Are you aware of the two conditions that must be met for the insurer to compensate you?

☐Yes ☐ No

4.1.13. How satisfied are you of the two conditions required for the insurer to compensate you?

Very Unsatisfied (1)	Unsatisfied (2)	Neutral (3)	Satisfied (4)	Extremely Satisfied (5)
☐	☐	☐	☐	☐

4.1.14. What do you propose as condition(s) to be fulfilled for the insurer to compensate you?

☐

4.1.15. How would you rate the level of protection that 2TIC brings to its client(s)

Very Poor Protection (1)	Below Average Protection (2)	Neutral (3)	Above Average protection (4)	Excellent Protection (5)
☐	☐	☐	☐	☐

4.2. The Respondent's Thought on Basis Risk

4.2.1. Did you know that an insured client could receive a payout without incurring a loss?

☐Yes ☐ No

4.2.2. Have you ever received a 2TIC payout without incurring a loss?

☐Yes ☐ No

4.2.3. Has someone you know or heard of, ever received a 2TIC payout without incurring a loss?

☐Yes ☐ No

4.2.4. Did you know that an insured client may suffer a loss and not be compensated?

☐Yes ☐ No

4.2.5. Have you ever suffered a loss (while holding a 2TIC) without being compensated?

☐Yes ☐ No

4.2.6. Has someone you know or heard of, ever suffered a loss (while holding a 2TIC) without being compensated?

☐Yes ☐ No

4.2.7. Have you ever been informed that a subscription does not necessarily guarantee compensation?

☐Yes ☐ No

4.2.7.1. If Yes, please indicate who provided you with that information

Another cotton farmer	☐
An ATC agent	☐
An Agent from PlaNet Guarantee	☐
An agent from UNPCB	☐
All of the above	☐

4.2.8. What do you think of PlaNet Guarantee's 2TIC product on its current form ?

4.2.9. What suggestion(s) do you have on the current form of PlaNet Guarantee's 2TIC product ?

Section 5: The Respondent's Thoughts on Fairness of the Indemnification

5.1. Distributive Fairness of Indemnity

5.1.1. How would you rate deservingness of an indemnity, for an insured cotton farmer who received a payout without having a loss?

Not at all deserve it (1)	Minimally Deserve it (2)	Neutral (3)	Deserve it (4)	Really Deserve it (5)
☐	☐	☐	☐	☐

5.1.2 How would you rate deservingness of an indemnity, for an insured cotton farmer who does not receive an indemnity after suffering a loss?

Not at all deserve it (1)	Minimally Deserve it (2)	Neutral (3)	Deserve it (4)	Really Deserve it (5)
☐	☐	☐	☐	☐

5.2.3. What do you think of the different amounts of compensation offered in the event of a loss?

Totally Unacceptable (1)	Unacceptable (2)	Neutral (3)	Acceptable (4)	Perfectly Acceptable (5)
☐	☐	☐	☐	☐

5.2.4. How equitable were the issuance of 2TIC indemnities from your perspective?

Not at all equitable (1)	Minimally Equitable (2)	Neutral (3)	Equitable (4)	Extremely Equitable (5)
☐	☐	☐	☐	☐

5.2.5? How confident are you that the insurer can indemnify insured cotton farmers screened out by the second trigger?

Not at all confident (1)	Slightly Confident (2)	Neutral (3)	Moderately Confident (4)	Extremely Confident (5)
☐	☐	☐	☐	☐

5.2.Procedural Fairness of indemnity

5.2.1. How would you rate the process by which neighboring GPCs' performance are used as a condition for indemnity payout?

Poor (1)	Fair (2)	Neutral (3)	Good (4)	Excellent (5)
☐	☐	☐	☐	☐

5.2.2. How would you rate the process by which GPCs' performance are used as a condition for indemnity payout?

Poor (1)	Fair (2)	Neutral (3)	Good (4)	Excellent (5)
☐	☐	☐	☐	☐

5.2.3. What is your level of acceptability vis-à-vis the threshold set at the GPC level, used to allow indemnity payout?

Totally Unacceptable (1)	Unacceptable (2)	Neutral (3)	Acceptable (4)	Perfectly Acceptable (5)
☐	☐	☐	☐	☐

5.2.4. What is your level of acceptability vis-à-vis the threshold set at neighboring GPCs' level, used to allow indemnity payout ?

Totally Unacceptable (1)	Unacceptable (2)	Neutral (3)	Acceptable (4)	Perfectly Acceptable (5)
☐	☐	☐	☐	☐

5.2.5. What is your level of satisfaction with regards to the group format of the double trigger insurance contract?

Very Dissatisfied (1)	Dissatisfied (2)	Neutral (3)	Satisfied (4)	Very Satisfied (5)
☐	☐	☐	☐	☐

5.3. Interpersonal Fairness of Indemnity

5.3.1. What is your degree of faith in the insurer's willingness to indemnify you in an event of loss ?

None (1)	Little (2)	Neutral (3)	Quite a bit (4)	A lot (5)
☐	☐	☐	☐	☐

5.3.2. How would you rate your level of satisfaction with support obtained from financial institutions (i.e., banks) regarding the 2TIC product?

Very Dissatisfied (1)	Dissatisfied (2)	Neutral (3)	Satisfied (4)	Very Satisfied (5)
☐	☐	☐	☐	☐

5.3.3. How would you rate your level of satisfaction with support obtained from SOFITEX regarding the 2TIC product?

Very Dissatisfied (1)	Dissatisfied (2)	Neutral (3)	Satisfied (4)	Very Satisfied (5)
☐	☐	☐	☐	☐

5.3.4. How would you rate your level of satisfaction with support obtained from PlaNet Guarantee regarding the 2TIC product?

Very Dissatisfied (1)	Dissatisfied (2)	Neutral (3)	Satisfied (4)	Very Satisfied (5)
☐	☐	☐	☐	☐

5.3.5. How would you rate your level of satisfaction with support obtained from UNPCB regarding the 2TIC product?

Very Dissatisfied (1)	Dissatisfied (2)	Neutral (3)	Satisfied (4)	Very Satisfied (5)
☐	☐	☐	☐	☐

5.4. Informational Fairness of indemnity

5.4.1. How would you rate the amount of information you may have received on the 2TIC's lower premium (FCFA 5,600) indemnification streams?

None (1)	Little (2)	Neutral (3)	Quite a bit (4)	A lot (5)
☐	☐	☐	☐	☐

5.4.2. How would you rate the amount of information you may have received on the initial 2TIC's (FCFA 11,200) system ?

None (1)	Little (2)	Neutral (3)	Quite a bit (4)	A lot (5)
☐	☐	☐	☐	☐

5.4.3. How much information did you receive on how the thresholds at the GPC level are calculated?

None (1)	Little (2)	Neutral (3)	Quite a bit (4)	A lot (5)
☐	☐	☐	☐	☐

5.4.4. How much information did you receive on how the thresholds at the Neighboring GPC level are calculated?

None (1)	Little (2)	Neutral (3)	Quite a bit (4)	A lot (5)
☐	☐	☐	☐	☐

5.4.5. How much information did you receive on how Neighboring GPCs were selected?

None (1)	Little (2)	Neutral (3)	Quite a bit (4)	A lot (5)
☐	☐	☐	☐	☐

Appendix 2: Variable Descriptions

VARIABLE	MEANING	DESCRIPTION	TYPE
Sociodemographic			
Age	Age of the Respondent during the agricultural season 2018-2019	Number of years	Continuous
Education	Education level of the Respondent during the agricultural season 2018-2019	1= Not educated; 2= Elementary School; 3= Secondary School and more	Categorical
Family Size	Number of individuals considered dependents of the respondent's household during the 2018-2019 cotton production season	Number of individuals	Continuous
Farm size	The respondent's farm size (that is, area planted) during the 2018-2019 cotton production season	Number of individuals	Continuous
Family Labor Force	The respondent's member(s) of family participating in cotton farming during the 2018-2019 cotton production season	Number of individuals	Continuous
Origin	Origin of the respondent vis-a-vis the village where he farms during the 2018-2019 cotton production season	1= from the village; 0= from outside the village	Binary
Off-farm income	Income earned outside of cotton-farming during the 2018-2019 cotton production season	1= Yes; 0=No	Binary
Experience	Years of experience earned in cotton-farming, at the beginning of the 2018-2019 cotton production season	Number of years	Continuous
Farmlot Contiguity	Distribution of respondent's farm lots during the 2018-2019 cotton production season	1= Contiguous; 0= Not contiguous	Binary
Number of Lots	Number of farmlot(s) used by the respondent during the 2018-2019 cotton production season	Number of farmlots	Continuous
Subscription	The respondent's subscription status to the Double Trigger Insurance Contract (2TIC) during the agricultural season 2018-2019	1= subscribed; 0 = did not subscribe	Binary
Land Ownership			
Land own	The Respondent's ownership status of the Farmland being cultivated	1= own the cultivated land; 0=doesn't own the cultivated land	Binary
Land rent	The Respondent's renting status of the Farmland being cultivated	1= rent the cultivated land; 0= doesn't rend the cultivated land	Binary

VARIABLE	MEANING	DESCRIPTION	TYPE
Land aut.	Authorization given to the respondent to use a farmland without any financial obligation	1= is authorized to use the farmland without paying; 0= is not authorised to use the farmland without paying	Binary
Farming Technique			
Manual Traction	The Respondent's stance on using Manual traction as a farming technique during the 2018-2019 cotton production season	1= use manual traction; 0= does not use manual traction	Binary
Animal Traction	The Respondent's stance on using Animal traction as a farming technique during the 2018-2019 cotton production season	1= use animal traction; 0= does not use animal traction	Binary
Motorized Traction	The Respondent's stance on using Motorized traction as a farming technique during the 2018-2019 cotton production season	1= use motorized traction; 0= does not use motorized traction	Binary
Production Expenses			
Cost of Cotton Inputs	The monetary value in cotton inputs that the respondent contracted from SOFITEX during the 2018-2019 cotton production season	in FCFA	Continuous
Cost of Family Labor Force	The amount of money that the respondent spent on family labor during the 2018-2019 cotton production season	in FCFA	Continuous
Cost of Community Labor Force	The amount of money that the respondent spent on community labor during the 2018-2019 cotton production season	in FCFA	Continuous
Premium Paid	The monetary value in premium that the respondent contracted from Planet Guarantee during the 2018-2019 cotton production season	in FCFA	Continuous
Production Revenues			
Production	The quantity of cotton produced by the respondent during the 2018-2019 cotton production season	in Kilogram	Continuous
Retail Price	The (per hectare) price at which SOFITEX bought the cotton from the respondent	245= Price 1st choice; 220= Price 2nd choice	Dichotomous
Indemnity Received	The amount of money that the respondent received from the Insurer	in FCFA	Continuous