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13

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Modelling Risk of Financing Agribusiness in Kenya

By *Philip Ngare, **Martin Kweyu and **Chris Huka

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Abstract

We review agricultural financing strategies in developed and developing economies in light of the risks that agricultural businesses face due to variations in weather conditions among other challenges. We specifically review Kenyan farmers' agricultural risk management strategies and credit products that are offered by banks, insurance companies and other organizations, that are intended to minimize the negative impacts of agricultural risks. We discuss the application of index-based agricultural insurance and credit products in Kenya. We analyze reasons for low uptake of the product and propose an innovative credit-insurance model that can effectively link the small scale farmers to two potentially important players, commercial banks and the Kenyan government. Our model aims at persuading the commercial banks that there is more business to tap in the agribusiness credit for small scale farmers with reduced exposure to the risk of default. Also, it is aimed at convincing the government of the effectiveness of extending agricultural development funds to groups of farmers through commercial banks that have experience in managing credit. The structured model will increase the uptake of index-based insurance and agricultural credit and therefore enhance agricultural production hence Kenya's food security. We show that banks who lend to farmers with index linked insurance products are likely to face low credit risks. Furthermore, we design a product to transfer some of the weather-related risks to the financial market.

Keywords: *Financial risk management, Index linked securities, Investment decisions, Insurance and Credit products, Securitization.*

* *University of Nairobi, ** The Catholic University of Eastern Africa, Kenya*

Introduction

The important role of agriculture in the Kenyan economy cannot be overemphasized: it is the main foreign exchange earner, a substantial number of the Kenyan population earns its living from agricultural activities, and it contributes a substantial amount of food required by the nation.

Farmers in Kenya have suffered heavy losses from the effect of climate change: weather patterns such as rainfall and temperature have become quite unpredictable leading to a devastating crop failure and credit defaults by farmers. If these agricultural-based risks are not effectively managed, the result could be reduced funding to the agricultural sector, reduced incomes for farmers, fluctuation in foreign exchange earnings, a worsening food shortage situation, and generally, a negative impact on the country's economic growth.

The affective management of weather-based agricultural risks has always posed challenges, especially in developing countries where agriculture accounts for a substantial percentage of their GDP and financial muscle and infrastructural development to mitigate against such risk is limited. In developing countries, including Kenya, it is the small-scale farmers who largely shoulder the negative effects of the bad weather events such as failed crops due to drought or flooding. Although some of the large-scale farmers may be able to mitigate against this risk through accumulated savings, diversifying their production, and attracting more credit from financial institutions, review of literature on agricultural credit extension in Kenya shows that it is way far below what the sector requires. Commercial banks have limited lending to the agricultural sector due to perceived high risks associated with it. Despite its contribution to the country's GDP, the agricultural sector was only receiving three percent of total credit extended to the economy (ACCI Report, 2012, Kamenchu, 2013, Mude at al, 2013, FSD, 2013).

While the appeal for increased lending to the agricultural sector by commercial banks has grown, the growth in lending will still be hampered by factors from the supply side (creditors such as commercial banks) or from the demand side (debtors such as small scale farmers) unless innovative credit systems that are attractive to both sides are developed. Private insurance markets are viewed as having failed to provide affordable and comprehensive crop insurance due to among other, the fact that weather events that impact crop yields are often spatially correlated, thus creating problems for traditional insurance, which is designed to cover the damage caused by infrequent, high-loss events rather than relatively high-probability limited-loss events (Carter et al, 2014).

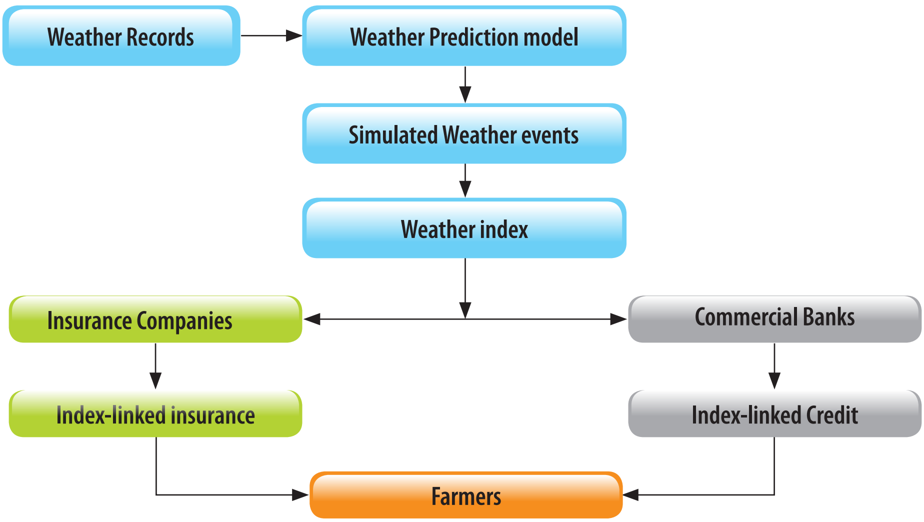
The development of index-based agricultural insurance products in Kenya has also experienced low uptake of the products (FSD, 2013). In order to increase the uptake of these innovative agricultural-based risk management products, a product development that applies an integrated strategy that effectively incorporates all the stakeholders: the commercial banks, the insurance companies, the agribusiness, the government, together with the opportunities provided by the financial markets, and which combines index-based and other credit products, needs to be considered. Indeed, the need to reconsider the development of the index-based agriculture insurance which is tooted as having much potential to mitigate agriculture risk (and it does) that has not been realized is required. Binswanger-Mkhize (2012) clearly analyzes and points out its failure and he advocates for tool to be re-designed and tested.

Similarly, innovative agribusiness index-based weather risk management tools have been developed and are being tested in Kenya, the evidence is that their uptake is low or even dismal. Several reasons have been cited and remedies have been given for this low uptake of a potential useful risk management tool (Carter et al, 2014). However, a comprehensive solution to the problem may require a strategy that comes up with a workable model that is attractive enough to bring on board the players on the risk demand side (small scale farmers) and some of the major players on supply side (commercial banks and the government) in an effective manner that it is viewed as beneficial to all the parties. This forms the aim of our study.

In particular, the role banks can play in providing an enabling environment that eliminates or minimizes the impact of risk factors like climate/weather change and then enable more financial credit to be extended to small scale farmers who have pooled their resources together, under a favourable risk environment. We highlight approaches and procedures for agribusiness lending in Kenya and review the reasons for low levels of agricultural credit supply and uptake. We demonstrate that the uptake of index-based crop insurance can be increased by combining it with other credit products. We also demonstrate how the private sector (commercial banks) in partnership with the public sector (the Government) can combine forces to extend more credit to farmers that are beneficial to all parties in an effectively managed low-risk (default) environment. Figure 1 shows the general framework of how farmers would benefit from proposed products.

The rest of the paper is organized as follows: In Section 2, we give the general development of agricultural credit and index-based risk management products in Kenya. We analyze some of the financial institutions that offer agribusiness credit and their conditions. We also discuss the financial institutions that offer index-based weather insurance in Kenya. In Section 3, we review examples of index-based insurance initiative projects in other developing countries, reasons for low uptakes and recommended strategies for scalability. In Section 4, 5 and 6, we develop an index model for weather process, price a derivative written on the dynamics weather events and discuss how to securitize insurance risks. Also, we derive a suitable Bellman equation for an agent who holds both derivative and insurance in his/her portfolio. In section 7, the conclusion section, we discuss major achievements in our study and open problems for further research.

Figure 1: The general framework of how farmers would benefit from the proposed product.



Agricultural Credit and Index-Based Risk Management Products in Kenya

Currently, the major players in the efforts to mitigate agricultural risk and the extension of credit to agribusiness in Kenya are insurance companies, commercial banks, the Government parastatals such as the Agricultural Finance Corporation, the farmers, and donor-sponsored organizations such as Syngenta Foundation and Financial Sector Deepening (FSD) which explore the application of index-based insurance products. A number of these collaborate or work together; such as Syngenta and several insurance firms and commercial banks have collaborated to explore, build and provide index-based agricultural insurance products and extend credit to agribusiness (ACCI, 2012).

2.1. Management of Agricultural Risk by Farmers in Kenya

Kenyan farmers use various strategies to manage the weather risks that they face. These risk management strategies can be classified as ex ante and ex post: ex ante are those undertaken before the risk occurs while ex post are those undertaken after the risk has occurred. Ex ante risk management strategies include risk avoidance, e.g. planting early maturing and drought resistant varieties to mitigate against drought; risk retention e.g. accumulating savings to use in the periods of scarcity; risk reduction e.g. reducing the investment committed to agricultural farming or practicing conservation agriculture and risk transfer e.g. purchasing insurance to cover themselves against impact of risk occurring have been used by farmers.

Ex post risk management strategies enable farmers to cope with the risks after it has occurred. Ex post risk management approaches include selling of productive assets (land, livestock etc); seeking temporary employments either within or outside their localities; adopting informal risk sharing arrangements with neighbors, friends, families (e.g. if the household suffers an adverse shock, there may be increase in remittance income sent by family members working in major towns) or getting government or donor support in form of relief food.

Clearly, such measures that are taken by farmers alone to mitigate against agricultural risk are far from adequate and some ways of encouraging financial institutions to extend more credit to farmers is required. The objective of our research is to design such an index linked credit or insurance products for the banks that will enhance the extension of agricultural credit extended by the banks and increase the take-up of the insurance product by the farmers.

2.2. The Extension of Credit to Agribusiness by Commercial Banks

The extension of agricultural credit by commercial banks will clearly be affected because of the demand-side's (especially small-scale or rural farmers) inability to meet the product's credit policies or its structure. Examples of such products are discussed below.

Kilimo Biashara Loan: An agricultural credit product which is offered by Equity Bank. The target beneficiaries of this product are the small scale commercial food crops farmers and its purpose is to finance purchase of farm inputs such as certified seeds, fertilizers, chemicals, machinery hiring, labor and harvesting costs. However, to be eligible for this credit facility, the applicant should fulfill the following conditions: Be active account holders with Equity Bank, submit their loan applications within a reasonable time (preferably one month) before the setting in of planting season, demonstrate ability to repay, be ready to attend group meetings on weekly basis as per agriculture group lending policy (for borrowers under this category) an be in commercial farming with farming experience of at least one successful season.

In addition, be able to clearly demonstrate existence of other sources of income that could be utilized for loan payment in case of crop failure, loss of harvest and/or poor marketing due to adverse weather and/or any other factors; Provide documentary evidence of ownership of the farm to be used for the production or a valid lease agreement covering at least two future seasons; the same must be signed and witnessed by a lawyer; Identify inputs suppliers, negotiate the inputs prices and obtain quotations/pro-forma invoices for the inputs to be financed; Be able to demonstrate understanding of the market for the commodity being financed. The amount of loan extended for this credit product is in the range of KSh. 5,000 -100,000 and the repayment period is a maximum of one year or crop production period/cycle whichever is shorter. Collateral/Security for the loan is any or a combination of: Chattels mortgage over farm and household assets and livestock; Conventional securities in form of motor vehicle log books, land title deeds etc; At least two guarantors who are active accountholders in the bank; Group guarantees may also be applied as per the agriculture group lending policy

Clearly, these policies, some of which mirror the policies of many other commercial banks that lend to small-scale agribusiness in Kenya, while understandably are designed to minimize the risk of default by the borrower, are also prohibitive to many small-scale farmers in terms of accessing bank credit. The partnership of commercial banks in extending credit needs to be reworked out by building credit/ insurance products that will encourage both partners to come on board with a clear vision of how the product will be administered to benefit parties. This research is aimed at building and explaining the workings of such credit products for commercial banks to implement.

Jamii Bora Agribusiness loan: An example of another agricultural lending bank, smaller than Equity Bank discussed above, but which has almost similar credit policies and structure, is the Jamii Bora Bank. The credit product; Agribusiness Loan, is specially designed to cater for Agri- entrepreneurs and farmers involved in agricultural related production and agribusiness activities. These includes but not limited to horticulture, floriculture, and livestock farming such as poultry, piggery, beef farming, apiculture and aquaculture. It extends a credit amount in the range Kshs. 50,000 to kshs. 3,000,000 whose loan requirements are: An account holder with Jamii Bora Bank; Owner of an Agri-enterprise for at least one year; Small holder farmer should be a land or lease owner with one successful crop cycle; Credit/Insurance required on Loan. The benefits of these credit facilities are mentioned as low interest rates, flexible Collateral requirements and a loan upto 24 Months.

2.3. Extension of Agricultural credit by the Agricultural Finance Corporation (AFC) – Government Parastatal

The Agricultural Finance Corporation (AFC), a wholly owned Government Development Finance Institution (DFI), was established primarily to provide credit facilities for the sole purpose of developing agriculture. It was established in 1963 initially as a subsidiary of the Land and Agricultural Bank. In 1969, it was incorporated as a full – fledged financial institution under the Agricultural Finance Corporation Act, Cap 323 of the laws of Kenya. Its agricultural credit product policy and structure somehow mirror those of commercial banks and given the overwhelming need for the credit, this corporation has fallen short of discharging its mandate effectively.

Among the agricultural loan products that it offers is the Cash Crop Loan that is designed for cash crop production and improvement. This loan covers the cash crops such as tea, coffee, sugarcane, pyrethrum, cashew nuts, citrus, mango tress, and bananas, among others. The loan finances crop establishment, crop maintenance, processing equipment, and operating costs. Among the features of this loan is repayment of 2 – 5 years with installments and is designed for individuals and groups. Eligibility for the loan requires tangible security for the loan, appropriate and approved crop varieties, and availability of processing facilities within reasonable distances. Some of the requirements of this loan, such as tangible security and proximity to processing facilities will exclude many farmers, and especially small scale ones.

Despite its noble objective and the role that it has played in enhancing agricultural activities in Kenya, since its inception in 1963, AFC has longed for and still requires partnership from the commercial bank in order to meet the overwhelming demand for agricultural credit in Kenya. Innovative credit insurance products, such as those proposed by our research can contribute to increased number of players in the agricultural credit- extension field and encompass more small scale credit-seekers.

Another agricultural credit product offered by AFC is the Horticulture and Floriculture loan which is aimed and financing horticultural and floricultural crops. The items financed include production costs, green houses and equipment, water and electricity supply system, harvesting and packaging equipment, and labour and other operational costs. Eligibility for this loan requires tangible security for the loan, relevant experience in horticulture and floricultural productions, complaint with market requirement, and adequate availability of water.

AFC also offers the Agribusiness Credit product but which starters may find the requirements of the loan limiting. The loans are designed to benefit agribusiness traders. It is meant to provide start-up capital for those seeking to start, or are engaged in agricultural microenterprises. Eligibility for the loan includes viability of the business, tangible security, and 20% equity contribution towards the project. This product is designed for individual and groups with a repayment period of up to 3 years, with an interest rate of 15% per annum.

2.4. Index-Based Weather Insurance Initiatives in Kenya – Syngenta and Financial Sector Deepening (FSD)

According to Financial Sector Deepening, FSD-Kenya (2013), Index insurance has shown significant promise in addressing the weather-related risks of small-scale farmers. Theoretically it removes some of the high costs and moral hazard involved in traditional, multi-peril crop insurance. It can also enable access to inputs and credit for farmers otherwise deemed too "risky" for lenders. However, index insurance also suffers from 'pilot-itis': products have been extensively piloted, but generate little evidence that they can become commercially sustainable and scalable. Although some scale has been achieved in India and Mexico – these positive examples are still subject to high subsidies (India – IFAD 2010) and arguments that the societal cost (in the form of government subsidy) outweighs the benefits (Mexico - Fuchs and Wolf, 2011). There is therefore considerable interest in understanding what it would take to make index insurance sustainable, scalable, and efficient in terms of the allocation of scarce resources.

The first index-based weather insurance, launched in Kenya in 2009, was developed to cover, not crops, but livestock mortality due to drought for the larger Marsabit District (Chantarat et al, 2009). The product indemnified the pastoralists in the event their animals died due to drought. The Index Based Livestock Insurance (IBLI) was designed to allow the pastoralists take care of 15% of the herd loss while the insurance company underwriting the product was to compensate farmers for any loss above 15%.

The project was implemented by the International Livestock Research Institute (ILRI) which designed the product and negotiated with reinsurers. Financial Sector Deepening (FSD17) - Kenya provided part of the funding and coordinated donors (DFID) interested in the project; UAP Insurance underwrote the product; Equity Bank Ltd distributed the product to the potential pastoralists and Swiss Re-provided reinsurance.

In the year 2009 Syngenta Foundation and Syngenta East Africa Ltd started working together in Kenya to promote agricultural development by supporting modern agriculture and access to market. With the target group were rural poor farmers. Syngenta Foundation supported training and extension services for smallholder farmers in Laikipia (ACCI, 2012). In the same year (2009), Syngenta Foundation partnered with UAP Insurance, the agribusiness MEA Limited and the non-governmental organization AGMARK and launched their first index-based insurance product, Kilimo Salama. The product covered loss of inputs and targeted small scale farmers in Laikipia district. Approximately 200 maize farmers insured their farm inputs against drought in the long rains of 2009. This index-based weather insurance product was offered through agro-dealers who acted as distribution and sale agents. The region experienced drought and low rainfall captured in the reference weather stations required payout. This was the first pilot of index based insurance for crops in Kenya.

The initial success of the Kilimo Salama product led to the expansion of index-based insurance products. A new product - "Kilimo Salama Plus" was introduced and developed "Kilimo Salama" further. Kilimo Salama Plus retains the innovative approach of the first product while expanding from the initial focus to go beyond just inputs to giving farmers opportunity to insure the value of their harvest. In addition farmers were now able to insure a wider array of crops including maize, wheat, beans, and sorghum. Kilimo Salama Plus focused more on commercially oriented farmers with a wider range of farming activities and has no inbuilt subsidy. With these two products, the UAP/Syngenta partnership has managed to reach out over 47,000 smallholder farmers, proving that with the right product and approach the potential to reach scale exist. Syngenta Foundation and UAP were able to secure additional support24 by the Global Index Insurance Facility (GIIF) for the expansion process in Kenya. In collaboration with their various partners the Syngenta Foundation/UAP partnership has expanded provision of index based insurance to seven regions in Kenya. To date the UAP/Syngenta insurance products are the most widely known products in Kenya and the only ones which have managed to attract a larger number of small and large-scale farmers (ACCI, 2012). Despite the noble efforts of Syngenta and its partners the uptake of index-based credit insurance in Kenya is still below expectation and the pilot schemes need to be looked at and perhaps the credit model should be improved or modified to effectively incorporate potentially major players such as banks and the government.

The Kenya Financial Sector Deepening (FSD) program was established in early 2005 to support the development of financial markets in Kenya as a means to stimulate wealth creation and reduce poverty. Working in partnership with the financial services industry, the programme's goal is to expand access to financial services among lower income households and smaller enterprises. It operates as an independent trust under the supervision of professional trustees, KPMG Kenya, with policy guidance from a Programme Investment Committee (PIC). In addition to the Government of Kenya, funders include the UK's Department for International Development (DFID), the World Bank, the Swedish International Development Agency (SIDA), Agence Française de Développement (AFD) and the Bill and Melinda Gates Foundation.

In 2005, FSD Kenya began sector-wide support for the development of index-based agricultural insurance (FSD Report, 2013). The aim was to determine whether viable indexed products could be offered which would reduce the impact of weather-related losses. The idea is that effective insurance makes smallholder farmers and pastoralists less vulnerable to crises caused by weather, allowing greater access to credit and increased investment in agricultural production. FSD's engagement began by supporting the development of insurance products covering maize crops. Dry runs were conducted in three areas of Kenya. Since 2008, a number of live pilot studies have been conducted with the aim of developing a market for index insurance in collaboration with Kenya's insurance sector. FSD worked with a wide range of organisations and individuals in both private and public sector, together with the World Bank's Agricultural Risk Management Team (ARMT) and the International Livestock Research Institute (ILRI) as technical partners. Thirty-five insurance products were designed covering six types of agricultural products. These led to five separate payouts to insurance buyers.

APA Insurance was the first insurance company to take up the index-based insurance under the support of FSD-Kenya. APA has piloted index based weather insurance products for crops like maize, bananas, wheat and coffee in different regions in Kenya since 2009. The company has piloted maize index-based insurance in Embu and Muthetheni in Eastern Province, coffee in Meru, Eastern Province, and bananas in Central Province and wheat in Narok in Rift Valley Province. CIC Insurance was the second insurance company to try index-based insurance under FSD assistance and has piloted this type of insurance for bananas in Central Province; while Jubilee was the third company to start piloting the products and had developed and piloted insurance product for sorghum in Kibwezi in Eastern Province and Maize in Embu in Eastern Province.

Examples of Index-Based Insurance Initiative Projects in the Developing World, Reasons for Low Uptake and Recommended Strategies for Scalability

3.1. Index-Based Insurance Projects

There are a number of developing countries where index insurance has been implemented. This has been both at the individual farmer level and at the regional, national, or institutional level. In Table 1, we reviews the impact evaluations of some of these experiences (Carter et al., 2014, Barrett et al., 2008).

Table 1: The impact value of index insurance implemented in Africa

Country	Year	Policy-holder	Project name/ Insurer	Instrument	Scale	Notes
Ethiopia	2005	World-Food Program	AXA Re	Drought-indexed insurance	62,000 households	Premium paid by donors; not renewed
Ethiopia	2007	Teff and bean farmers	HARITA	Rainfall index	300	Ongoing
Kenya	2009	Smallholders	Rockefeller	Rainfall index	500	Pilot stage
Kenya	2009	Maize and wheat smallholders	Kilimo Salama	Rainfall index	200	Pilot stage
Malawi	2008	Maize, tobacco farmers	MicroEnsure, others	Rainfall index	2500	Initially maize, moved to tobacco; ongoing
Malawi	2009	Government of Malawi	World Bank	Weather derivative on rainfall index	Country level	Intend to transition to private insurer
Millennium Villages (Kenya, Ethiopia, Mali)	2007	Smallholders	Millennium Villages	Rainfall and satellite-based greenness index	1000	Premiums paid by MVP; not continued
Rwanda	2009	Smallholders	MicroEnsure	Rainfall index	500	Ongoing
Tanzania	2009	Smallholders	MicroEnsure	Rainfall index	400	Ongoing

3.2. Reasons for Low Insurance Uptake

A number of factors have been cited as contributing to the low uptake of index-based insurance products in Kenya and other developing countries. Carter et al (2014) cite the following as reasons for low uptake of indexed-based insurance products among small scale farmers in the developing countries:

Weather risk may not be the largest risk the farmer perceives and he may need more comprehensive insurance: Farmers are generally interested in income and wealth losses and not particularly about hedging rainfall shortages. Hence what would be of value to them is a contract that has a negative correlation with their actual negative income shocks.

Basis Risk: The main drawback of index insurance is existence of basis risk. This arises from the discrepancy between measured risks at the meteorological station level and the occurrence of weather shocks at the location of the farm of the insured. It may rain more than the trigger level for drought insurance at the meteorological station, while the farmer suffers from drought. In this case, no indemnities are offered when the farmer had incurred the cost of the insurance, and additionally had his crop devastated by drought. The opposite can occur, with drought at the station level, but normal rain at the farmer level, providing the double bonanza of a good harvest and an indemnity payment. If weather stations are few, and microclimates more locally differentiated, basis risk increases correspondingly, making index insurance into a cheap and expedient but low quality product.

Quality of contract design: The demand for indexed-insurance products depends crucially on how well designed the contract is. It is not easy to design a contract that captures well the different ranges in the rainfall distribution that are crucial for crop growth. This aspect of the product is compounded by the fact that a proper contract may need to be complicated for accuracy, and hence more difficult to explain to farmers.

Insurance not desirable if not related to credit or other investment mechanism: Standalone indexed-insurance products may not be desirable. The product may be deemed more useful if the insurance is combined for instance with credit, that may make the cash flow constraint much less onerous.

Limited flexibility in terms of payment of premium or indemnity: It has been observed that credit is much more desirable for low income farmers when the terms of repayment are flexible in the sense that if there is an unexpected income loss to the farmer, then the payment schedule can be adjusted accordingly. The great expansion of microfinance, owes a lot to this aspect of micro-lending. Similarly most local moneylenders owe their success to such flexibility, usually acquired at the cost of a high interest rate. Insurance contracts normally require fixed payment and in advance of the farmer's income realization. If the insurance premium payments can be adjusted to the farmer's current circumstances then demand will be higher.

Limited of trust in the insurance provider: Trust in the insurance provider is a major issue in contracting insurance, especially in the developing country context where there is little legal recourse in reclaiming insurance payments. For index insurance, the expected payout is more difficult to know because the relationship between weather and loss is not precisely known. If there is asymmetric information where the provider is better informed on risk, farmers must rely on the insurance company in setting a fair price. Relations of trust with the insurance provider are thus very important for uptake.

Technology and institutional setup are difficult to explain and understand: This is a well-known practical problem in introducing a relatively complex and state contingent insurance product in an environment where farmers have low education, as is the case in most developing countries. Index insurance is particularly difficult to understand because, with presence of basis risk, payments are not linked to the individual farmer's losses.

Cost and price: A recognized advantage of index-based insurance is lower implementation costs compared to traditional loss adjustment-based insurance as it avoids the administrative costs of loss assessment and moral hazard, as well as the actuarial cost of adverse selection. Price however remains an issue for uptake. In spite of lower costs, risks may initially be poorly informed with existing data, translating into high insurance company loadings. Several studies have shown that demand for index insurance is very price sensitive.

Among the challenges facing index-based crop insurance in Kenya according to the FSD Report (2013) include basis risk, bank commitment and concern (the appetite for agri-lending is questionable due conservative lending criteria despite showing some commitment to agri-lending), data availability, and high cost of location of some areas that are remote such as Marsabit.

3.3. Remedies for Low Insurance Uptake

A number of remedies have been put forward in dealing with the causes of low uptake insurance. For example, Clark and Liam (2013) provide a three-pronged attack to the problem of basis risk: Technological solutions—indices that are intrinsically better predictors of farmer losses either because the index (e.g., area yield) is an intrinsically better predictor (e.g., area yield versus rainfall-based indices), or because the scale or resolution of the index is more fine-grained and more closely related to farmer losses (e.g., satellite-based yield predictions at a resolution of 5 hectares) versus indices based on a terrestrial weather station where a single measure must predict the losses of all farmers within a 25 km radius of the weather station (approximately 2,000 hectares); Contractual solutions—complement the primary index-based contract with a secondary contract that can be index-based over a broader area or damage assessment-based; Institutional solutions—contracts that rely on a secondary index, audit rule, or within group redistribution. Also advocated by Clarke and Liam (2013) and which our study is also emphasizing is the Public role in private index insurance markets or public-private partnerships for insurance take-up. Realizing the development potential of agricultural index insurance may require a unique public-private partnership, with the public sector playing an important regulatory role in certifying contract quality and also in providing well-designed subsidies that will cost-effectively help the market reach scale and sustainability.

Among the principles advocated by FSD-Kenya Report (2013) for upscale and sustainability of Index-based crop insurance in Kenya are: Creating a proposition for real value for the insured, and offering insurance as part of a wider package of issues; Increasing client awareness of index insurance product; Building capacity and ownership of implementation of stakeholders; Graft onto existing efficiency delivery channels; Engaging the private sector from the beginning; Accessing international risk transfer markets; Improving the infrastructure and quality of weather data.

Index linked insurance/ derivatives contract modeling and pricing

4.1. Modeling of rainfall process

We assume that the rainfall is the key determinant of crops yield in Kenya and that lack of rainfall is the main source of risk. In order to take into account that different growth stages have different water needs, we not only assume the simple cumulative rainfall but track the rainfall-yield relationship by assigning specific weights to the different growth phases.

Specifically the rainfall can be aggregated in ten-day periods. Also, we improve the quality of the rainfall index by 'capping' procedure taking into account the fact that water in excess of storage capacity is lost and do not contribute to plant growth. Therefore the effective rainfall in period i is defined as

$$r_i = \max[r_i^*, CAP_i]$$

where r_i^* is actual rainfall in period i, and CAP_i is the amount of rainfall in period i beyond which additional rainfall does not contribute to increased yield.

The rainfall index for year t is defined as weighted average effective rainfall:

$$R_i = \sum_{i=1}^{m} \omega_i r_{it}$$

where m is the total number of 10-day periods in the growing season, ω is the weight assigned to period i of the growing season and r_{it} is the effective rainfall in period i of year t. The weights are chosen to maximize the sample correlation between the rainfall index and yield using data on rainfall and yield, that is, by the regression of the farm yields.

An alternative probabilistic model is described in section 4.2.

4.2. Derivative Contract pricing

Contract Payout Structures

The rainfall index derivatives for crop in Kenya are structured to pay out when in rainfall

(R_i) in the crop year is below a specified threshold (K). The payout received by the contract buyer is described by the following equation.

$$Payout\ (R)=H(R)=Max(K-R,0)\ x\ A,$$

Where

R = Value of the index evaluated on the last day of the contract period.

A = Slope of the payout function or 'tick payment' or liability

K = Value of index at which payments are initiated or 'strike'.

Contract Pricing

Consider an index based on the cumulative rainfall for a place in Kenya, where precipitation index based risk transfer products (IBRTPs) are currently offered. Suppose we classify risks into several layers: Risk retention layer, Market-risk transfer layer and Market failure layer. The risk retention layer is characterized by high probability but low magnitude loss event which can be handled through informal insurance mechanisms.

The market failure layer is characterized by very low probability but high magnitude loss events. It results to situation where there is too much or too low rainfall. The density exists in the tail of the distribution, therefore when calculating premium, and due to sparse data the insurer may add an ambiguous load. This layer could be financed subsidies by the government or the international donor community.

The market insurance layer includes loss event that are insurable using IBRTPs. The insurance premium can therefore be computed using expected premium rule.

$$\text{Premium, } p(x) = D(0,T) \sum_{x \geq 0} x \times F^*(x)$$

Where

$F^*(x)$ = risk adjusted probability density function (pdf) of payouts

$x = Payout\ (R)$

$D\ (s,t)$ The discount factor between times s and t

The risk adjusted pdf can be computed using Esscher transformation (Cabrera et al., 2013) or by various parametric and non-parametric statistical approaches (Hess et al., 2005).

Moreover, the price for the Index-linked weather derivatives can be computed using the principle of arbitrage pricing model. Weather index-linked assets are not traded at the Nairobi Security Exchange, therefore the standard no arbitrage pricing method may not be applied directly. The pricing can thus be done in line with Leobacher and Ngare (2011). Specifically, assuming the market is incomplete; we can construct a suitable model for the weather index process. We then identify the correlated asset traded at the Nairobi Security Exchange (NSE), whose dynamics depends on precipitation index, and then use the concept of utility maximization to derive suitable measure and price the derivatives (using utility indifference pricing).

Index-Linked Credit product

A major problem for banks and other financial institutions with geographically limited loan portfolios is the threat of correlated risks that hinders the provision of credit. Specifically, a disaster event implies the potential for much higher default rates and liquidity problems since clients simultaneously draw down savings and increases demand for borrowing to cope with disaster (Skees and Barnett 2006).

We note that when farmers have access to variety of financial services, they are able to make productivity-enhancing investments (Skees and Barnett 2006). For instance, when insurance services are available to transfer non-diversifiable risks, farmers are compensated should insured event occur without need to sell productive assets for consumption smoothing. The presence of insurance services also increases accuracy in pricing risk, hence increases efficiency of credit markets (USAID 2006). Banks too benefit from the index based risk transfer products, perhaps more than individual agricultural producers. Specifically, an index that measures systematic agricultural production shocks in a bank's geographical scope should inform banks of the possible cash shortfall. Thus enabling banks to make some diversifying strategies earlier than the borrowers (Miranda et al., 2010).

However, the challenge is in the event of correlated risk, the traditional risk pooling is ineffective (Harwood et al. 1999). A risk transfer mechanism for the correlated weather risks blended with government effort to facilitate market development can remove major constraint to rural financial markets (Skees and Barnett 1999; Skees and Hartell 2006). Moreover, the lender can be allowed to pass on the benefits of the large indemnity payment from the IBRTP, can be another efficient way of dealing with the large transaction costs associated with providing more complete financial services to small households (Skees et al., 2007).

5.1. Agent's investment decision problem

Consider a group of small scale farmers (agent) who may borrow a fixed amount G, provided they have not defaulted before. If the group does not repay the loan within T periods they will be permanently barred from borrowing. Assume the repayments are in the form C_i, $i=1,2\ldots,T$ That is at the start of any period the group observes their wealth W and decide whether to repay or not. If they repay the loan, their utility will be $U(W_i\text{-}C_i)$ where U a utility function is satisfying the usual properties. We assume the agent's portfolio is self-financing, that is, the agent's wealth at the beginning of period $i+1$ depends on: The accumulative amount of loan capital to be repaid (which can be calculated retrospectively);

$$G(1+r)^{i+1} - \sum_{J=1}^{i} C_j \left(\frac{1}{1+r}\right)^{i\text{-}j},\ 1 \leq j < i \leq T$$

where r is the rate of interest. The exogenous random shocks, R_{i+1}, shared by all agents and the yield amount, y_{i+1};

$$W=f(C,h(R),y(R))=\{w_i\}_{i\in[1,T]}$$

We normalize our monetary unit of measure such that expected income without loan is exactly 1 and indicate $g>1$ the agent's expected income with a loan. That is, if the agent does not take out a loan in period i, then $w_{i+1}=y(R_{i+1})$; if the agent takes out loan in period i then $w_{i+1}=gy(R_{i+1})$

Suppose that the agent who take loan, purchases an index insurance contract at a premium The agent's optimal value problem (Bellman equation) can therefore be stated as

$$V_i(w)=max\{U(w\text{-}c_i\text{-}p) + \delta EV_i[gy(R) + h(R)],\ U(w) + \delta EV_{i+1}[y(R)] \quad \text{............ (1)}$$

Subject to the boundary conditions

$$V_{T+1}(w)=U(w)+ \frac{\delta}{1-\delta}E[y(R)]$$

Where $\delta = \frac{\delta}{1-\delta},\ \varrho>0,$

denotes the per period subjective discount factor; $V_i(w)$ is the maximum expected present value of current future consumption, given that the agent possesses disposable wealth w and a loan of age $i\leq T;\ V_{T+1}(w)$ denotes the expected present value of current and future consumption, given that the agent wealth and has been permanently barred from borrowing.

Define

$$X_i = \begin{cases} EV_i[gy(R)+h(R)] & \text{if } i\leq T \\ \delta = \frac{\delta}{1-\delta},EU[y(R)] & \text{if } i=T+1 \end{cases} \quad \text{....(2)}$$

Substituting equation (2) into equation (1) yields;

$$V_i(w) = E[max\{U(w\text{-}c_i\text{-}p) + \delta X,\ U(w) + \delta X\} \quad \text{...................... (3)}$$

Let , if this value is positive the agent repays, otherwise the agent defaults. The optimal borrowing strategy can be obtained by taking the first order derivative of with respect to and equating the results to zero. For instance, if the agent is risk averse and has utility function is given by then continuous and strictly decreasing. The optimal borrowing strategy, This is the level of wealth at which the agent is indifferent between repaying and defaulting. Equation (3) can be solved numerically for optimal investment strategies with results indicating that index-linked insurance have influence on loan repayment strategies (see e.g. Miranda and Gonzalez-Vega, 2010).

Securitization of weather index-linked insurance

In this section we explore the possibility of trading index-linked weather insurance in a financial market. The concept used is similar to that of the collateralized debt obligation. Consider an insurance company that offers weather index-linked insurance to several parts of the country. Suppose the total risk is tranched to reflect seniority of losses. The tranche investors pay an initial amount, PV that is held as collateral in the special purpose vehicle (SPV). If no losses are incurred on the tranches, a value of PV is returned to the investors at maturity.

At the beginning of each period, investors receive a premium payment, p, from the issue via SPV. In exchange, a fraction of PV is transferred from the SPV to the issuer, in the event that the unfavorable weather event has occurred. This provides a protection in case the insurer has to pay more that expected number of claims. After a loss has occurred, premiums are then calculated as a percentage of the reduced notional principal. The price of each tranche is determined by equating the expected present values of premiums and losses under an equivalent risk adjusted probability measure for weather process.

6.1. Tranching by percentage cumulative loss

Suppose there are M tranches which are characterized by attachment and detachment points denoted by $L_{A,m}$ and $L_{B,m}$ for $m=1,....M$ respectively. So that the total pool has unitary notional. The expected loss in each tranche determines the appropriate premium. As losses are incurred on the underlying annuity portfolio, they are allocated to a tranche when the cumulative loss falls between its attachment and detachment points.

The loss on the portfolio is defined as the amount by which the index-linked payouts at time exceed the expected payouts on the index-linked insurance:

$$L(t)=\sum[H(R)_{it} - E(H(R)_{it})]^{+}$$

The portfolio cumulative loss,

$$CL(t)=\frac{\sum_{i\geq 1}^{i} L(s)l}{PV}$$

The cumulative loss on the tranche at time t is given by

$$CL_m(t)=[(CL(t) - L_{A,m})1_{\{L_{A,m}<L(t)\leq L_{B,m}\}} + (L_{B,m} - L_{A,m})1_{\{L(t)\geq LB,m\}}]$$

The portfolio cumulative loss on the at time is

$$ECLm(t) = \frac{E[CL_m(t)]}{L_{B,m} - L_{A,m}}$$

6.2. Pricing tranched weather risk

The price of tranched weather risk, $S_0^{A,B}$, is defined as a percentage of the principal at risk. This percentage is paid to the investor each period as the tranche premium. As mentioned before the fair price, $\bar{S}_0^{A,B}$, is set so that the expected present value of the premium and claim payment legs of the tranche are equal. Each leg is a function of the expected percentage cumulative loss on the tranche at time under a risk adjusted probability measure, $ECL^*_m(t)$.

Assuming that premium payments occur at the beginning of each time period $t=0,.......T$. The value of tranche $m's$ premium leg is equal to the risk adjusted expected present value of all premium payments to the investor:

$$PL_m=\sum_{i=1}^{T} S_0^{A,B}D(0,t\text{-}1)[1\text{-}ECL^*_m(t\text{-}1)].$$

Where $D(0, t\text{-}1)$ is the present value of a risk-free zero-coupon bond that pays \$1 at time $(t–1)$. $ECL^*_m(t\text{-}1)$ is the risk adjusted value of the expected percentage cumulative loss on the tranche at the time at which the premium is paid, so $[1\text{-}ECL^*_m(t\text{-}1)]$ determines the proportional value of the notional face value of the tranche on which the premium is calculated. At the beginning of the contract, the premium is paid on 100% of the notional face value. This reduces over time to zero when the tranche is exhausted and the premium payments ceases.

The value of the claim payment leg is the risk adjusted expected present value of the loss payments, which occur at the end of each period.

$$LL_m=\sum_{i=1}^{T} S_0^{A,B}D(0,t)[ECL^*_m(t) - ECL^*_m(t\text{-}1].$$

The fair price of the tranche is then defined as the premium $\bar{S}_0^{A,B}$ such that

$$PL_m=(\bar{S}_0^{A,B}) - LL_m(\bar{S}_0^{A,B})=0$$

Resulting to .

$$CL(t)=\frac{\sum_{i=1}^{T} D(0,t)[ECL^{*}_{m}(t)-ECL^{*}_{m}(t\text{-}1)]}{\sum_{i=1}^{T} D(0,t)[ECL^{*}_{m}(t)-ECL^{*}_{m}(t\text{-}1)]} \qquad \text{.. (4)}$$

The numerical implementations of equation (4) can be found in Wills and Sherris (2010).

07
SEVEN

Discussion and Further research

The foregoing study gives evidence that a would-be potentially major player in extending agricultural credit, the commercial bank, has not substantially embraced this role. Therefore if the agricultural index-linked insurance uptake is to be scaled-up, the product needs to be redesigned and re-modeled. We have reviewed agricultural financing strategies in developing economies in light of the risks that agricultural businesses face due to variations in weather conditions among other challenges.

We have discussed the application of index-based agricultural insurance and credit products. We analyze reasons for low uptake of the product and propose an innovative credit-insurance model. Our model aims at persuading the commercial banks that, there is more business to tap in the agribusiness credit for small scale farmers with reduced exposure to the risk of default. Our study concludes that, in order to scale-up the uptake, in Kenya, banks should consider funding small-scale farming through credit linked to weather index insurance products. We place a great emphasis on the role of public sector or government's in a successful implementation. We explored the use of pooled resources by small scale farmers, together with government extension of credit to groups of small scale farmers and where the credit is managed by commercial banks. We therefore suggest a further study to analyze, links between stocks and commodity market volatility, supply chain management and extension of weather model to incorporate more than one weather process. This would reduce the basis risk experienced by insurance companies when paying out weather related claims.

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Kenya Bankers Association
13th Floor, International House, Mama Ngina Street
P.O. Box 73100– 00200 NAIROBI
Telephone: 254 20 2221704/2217757/2224014/5
Cell: 0733 812770/0711 562910
Fax: 254 20 2221792
Email: research@kba.co.ke
Website: www.kba.co.ke

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