Insure or Unsure?

A Case of the Basis Risk Dilemma in the Developing World

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April 2020

2020 Cambridge - McKinsey Risk Prize

Bio-sketch and Photo Page

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Title of Submission: Insure or Unsure? A Case of the Basis Risk Dilemma in the Developing World.

I am a candidate for the degree:

PhD Land Economy

Bio-sketch:

I am a PhD candidate at the Department of Land Economy and researcher at the Cambridge Centre for Environment, Energy and Natural Resource Governance (C-EENRG). My core research area is in the field of environmental and development economics, exploring issues of climate related risk and microfinance in Africa. I am at present working on a larger project which aims to remotely track changing risk preferences of 20,000 Kenyan farmers over an entire agricultural season and across an extensive geography.

Previously, I have completed a bachelor's degree in Economics, Mathematics and Environmental Science, in South Africa, as well as an MPhil in Environmental Policy at Cambridge. I have also worked as an environmental consultant in South Africa, advising on issues of environmental risk (emissions and energy) for both industry and government.

Broadly I am interested in how we as individuals, businesses and governments aim to navigate uncertainty and direct development amidst the imminent climate challenges.

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Number of words of submission: 3967

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[1] If the Risk Summit is a virtual event, I will join live online

This essay presents one of the first case studies to shed light on the significant impact that basis risk can have on the uptake of index insurances. Here I explore these dynamics of adoption for an active micro-insurance product at an unprecedentedly large scale. This case study considers a novel index insurance to manage agricultural crop losses which has seen near 200 000 adoptions by smallholder farmers across southern Kenya. The findings have important implications for tackling challenges of poverty and food security by also for the proliferation of index insurance to other development agendas, such as energy and health.

1. The Context: Risk and Development Challenges

Risk is foundational to all economic decision making where there is some level of unavoidable uncertainty. Smallholder farmers in developing countries are amongst some of the most exposed in terms of their production risks, and among the best documented in terms of how risk shapes their choices. Smallholders are exposed to constant production risks from extreme weather phenomena and, as a consequence of climate change, are expected to become significantly more vulnerable in the near future [1,2]. Risk of crop failure is cited as a major factor inhibiting adoption rates of more productive (but higher risk) technologies and practices [3–7]. Shocks to production present dramatic financial challenges to smallholder farmers which can lead to cycles of income and asset loss and result in poverty traps [8–12]. As such, these dynamics of risk directly relate to food security concerns all around the world.

Microfinance initiatives, such as micro-credit and micro-insurance, have emerged as important tools to help manage these dynamics and protect farmers from shock-induced poverty traps. It has also been expressed that they may stimulate behaviour changes toward more innovative and productive practices. As such, these initiatives are believed to have potentially large developmental returns [13–15]. Research and development of these instruments has proliferated since Muhammad Yunus' work in this area earned him the Nobel Peace Prize in 2006. With the emergence of machine learning, artificial intelligence and the increasing adoption of smartphones among the rural poor it is likely that many new versions of these products will continue to evolve with unique characteristics depending on the market setting.

Informational challenges in micro-insurance contracts makes complete insurance contracts hard to provide. Partial insurance products, such as index insurance and limited liability credit, have been suggested as alternatives with fewer informational problems for areas where physical assessments of claims may prove difficult [5]. Under an index-based insurance contract, a conditional metric (index) is set on some remotely observable state of the world. Thus, removing the need for a physical assessment, as well as any moral hazard concerns. Depending on whether this state is observed to be above or below this index then the purchaser of the insurance will automatically receive the contracted compensation. While projects providing index insurance have been observed in a number of countries they frequently report very low adoption rates [3,5,6,16,17].

It has been shown, somewhat counterintuitively, that demand for these insurance contracts is particularly low from the most risk averse individuals [16,18]. The most established theory of how risk aversion diminishes partial insurance demand is attributed to the presence of ‘basis risk’ in these contracts. Basis risk is defined as the difference between the losses insured under the contract and the actual losses incurred by the policyholder [19–21]. Consider a farmer with a weather based index insurance policy who experiences a localised drought but does not receive a pay-out because the weather recorded at the contractual weather station was deemed to be good [19]. In this case the farmer experiences a double loss (negative basis risk). The opposite is also possible: a farmer may receive a pay-out even though localised weather conditions and yield wouldn’t necessitate it (positive basis risk). Agricultural micro-insurance providers have also stated that, for farmers deciding to purchase this form of crop insurance, the topmost questions on their minds are; “does the insurance really work?” and “in the event of a catastrophe, will insurance really pay me?” Essentially their concerns are two fold, what is the likelihood that the remote assessment identifies the catastrophe (probability) and will the pay-out be the correct size (magnitude).

To date, only a very limited amount of research has explored the prevalence of basis risk in active index insurance products, let alone what role exposure to basis risk has had on product adoption. The absence of substantial research in this area is concerning as inaccuracies in index products can present users with a potentially costly, risk-increasing gamble as opposed to the marketed risk-reducing insurance. It is important for proponents of these products (both policy makers and practitioners) to be aware of their magnitude and distribution of basis risk or else they may “inadvertently peddle lottery tickets under an insurance label” [22]. Fostering a better understanding of these products and the drivers of their uptake will be essential if they are to make a significant contribution towards improving food security and reducing poverty. In light of the mounting global climate risks, this research has never been more necessary or timely.

2. The Product: An Innovative Replanting Guarantee

This case study explores a novel weather index insurance product which has been pioneered in Kenya, the replanting guarantee (RPG). The product was specifically developed as an alternative solution to manage poor and unpredictable rains at the start of the rainy seasons. The product works by indemnifying a bag of drought resistant hybrid maize seed over the crop's germination period. In the event of adverse germination conditions (lack of rain), the farmer will be reimbursed the cost of the seeds. This, reimbursement allows the farmer to then purchase more seeds and replant in the same season, or alternatively balance some other expenditure.

The product has been cleverly designed for deployment in a low-tech environment. Following the purchase of a bag of insured seed, farmers activate the replanting guarantee using their mobile phone. Each bag contains a unique identification number which they must send via a USSD (Unstructured Supplementary Service Data) code at the time of planting (no smartphone required). The location from where the farmer dials the code is triangulated using the local mobile network towers and this location is used as the point of assessment for the germination conditions. Germination conditions are assessed solely on the rainfall measured at the location of activation. Rainfall measures are taken from an advanced open source daily weather map modelled from satellite and weather station data. A complex 'trigger' to determine conditions for germination is calculated based on historical weather data and yield records across the various regions of the country. If rainfall is observed to be below this trigger level for the specified 'germination period' then the farmer is automatically reimbursed via mobile money transfer in M-Pesa credit (a popular mobile money transfer system available in Kenya). This process is represented in the graphic below.

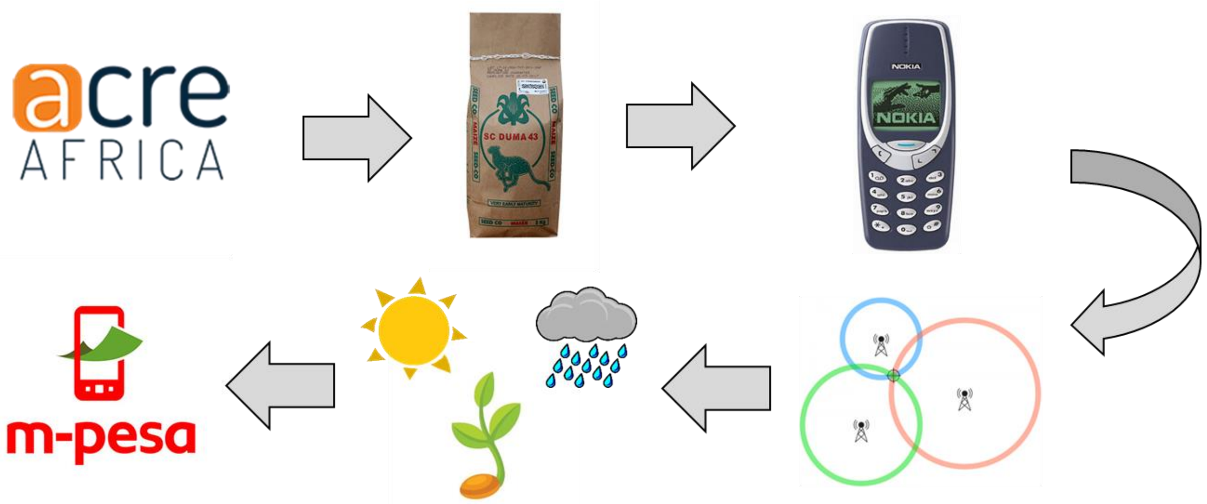

Figure 1: Diagram of the activation process for the RPG product.

Each bag of insured seed costs Ksh 460 (approximately USD 4.6), equivalent to two days wages as an unskilled agricultural worker in the region. The product is typically available to purchase at local agricultural stores or agrovets and is primarily marketed towards small scale subsistence farmers. These farmers may plant between one and twenty bags per season on small plots of a few acres. Interestingly, adoption of the product by these farmers increased over the first few seasons before tailing off in the latter seasons, Figure 2. Spatially, these activations did cover a vast region of southern Kenya with particular agricultural 'hotspots' featuring dominantly, Figure 3. The dynamics driving the patterns of uptake in time and space can be uncovered by taking a more granular view of the localised happenings, the primary focus of this case study.

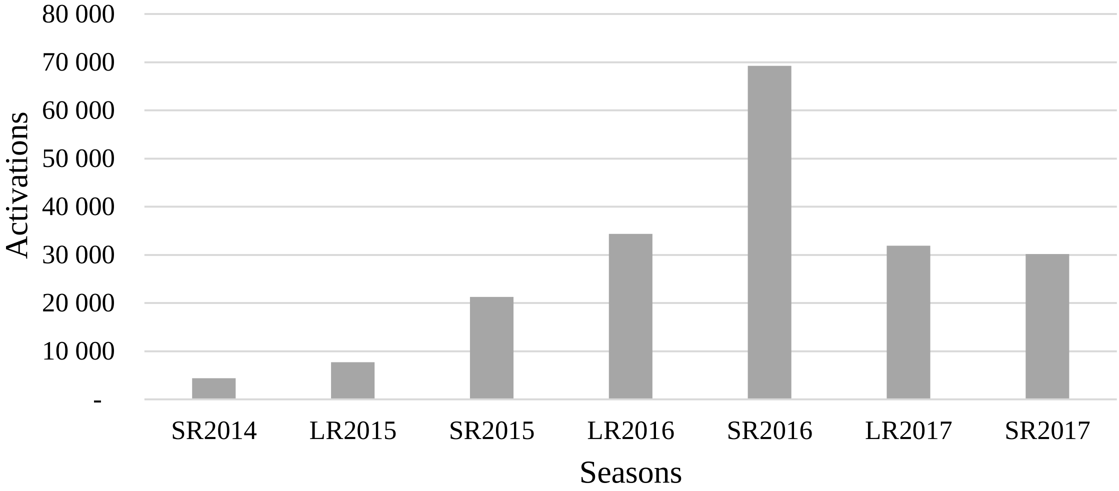

Figure 2: Total RPG activations across the short rain (SR) and long rain (LR) seasons.

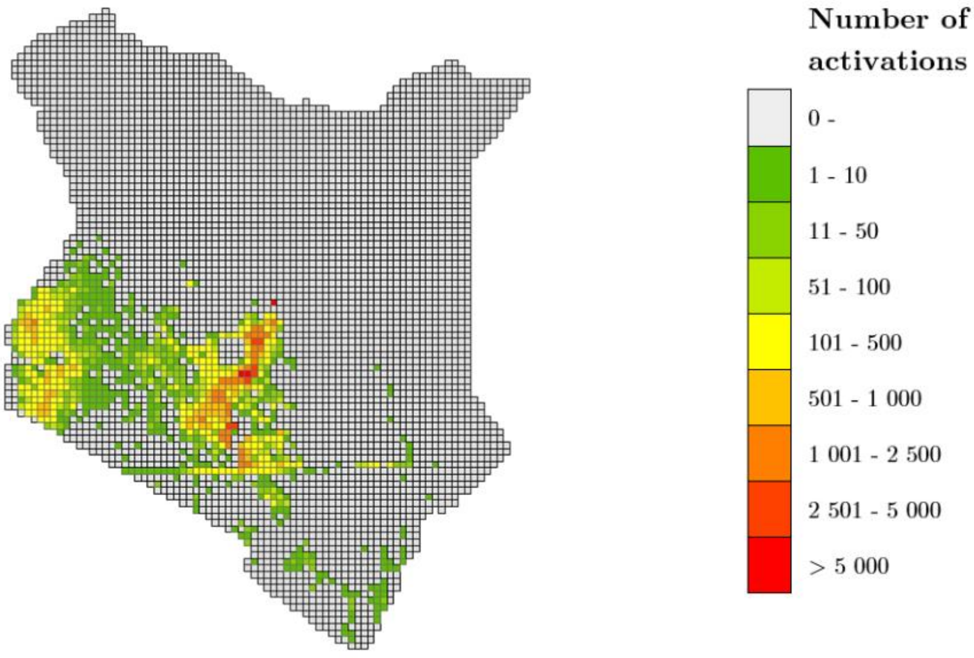

Figure 3: Spatial distribution of RPG uptake within an 11km by 11km grid across Kenya

3. The Dynamics: Adoption, Rainfall and Basis Risk

Zooming in, it is interesting to consider both the measures of rainfall recorded for the germination period (28 days post planting considered here) and whether or not an activation received an insurance pay-out. By exploring this relationship one can begin to develop a better understanding of how the product has 'performed'. This information is collected in the figure below for all the insured farmers across their distinct planting days and locations, and over all seasons.

It is evident that the majority of activations receiving pay-outs recorded 0mm of rainfall in the germination period with another group collecting below the 25mm threshold before pay-outs become sparse. This distribution of pay-out is partly explained by the complexity of trigger value and also possibly by some degree of measurement and allocation error in the product. In any case, these disparities in pay-outs received by farmers recording the same rainfall in their respective germination periods, does ring alarm bells for perceived basis risk.

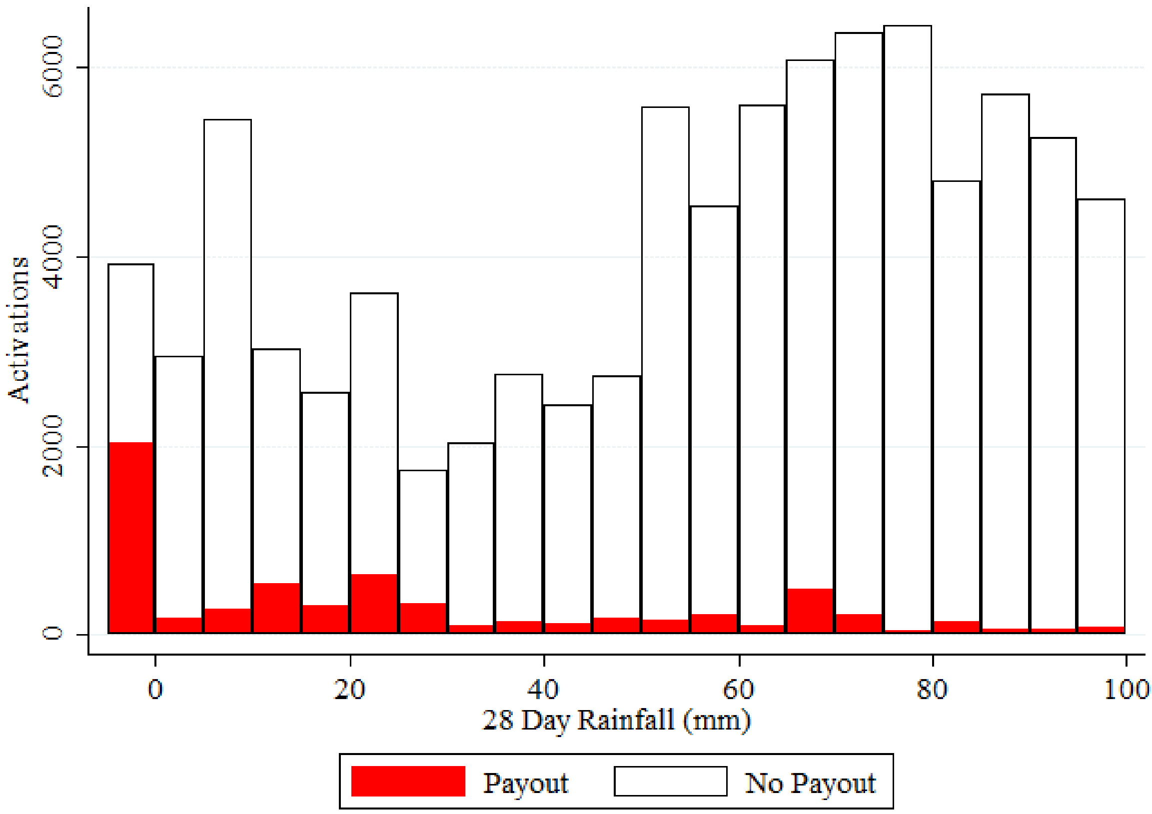

Figure 4: Distribution of the 28 day cumulative rainfall (mm) post-planting for the activations that received pay-outs and those that did not receive pay-outs[1].

[1] Note that this figure excludes the 110 787 activations which received more than 100mm of rainfall where only a tiny fraction (0.5%) received a pay-out.

Using this same data, as well as information about the costs of the insurance and its values of pay-out, it is also possible to explore the performance more technically. Calculating an index called the catastrophic performance ratio (CPR), which aims to estimate the 'average' expected pay-out to a farmer under given 'catastrophic' conditions, provides an indication of insurance reliability [23]. For the RPG product the overall CPR is in the range of 0.71 to 0.35. This implies that the product would be likely to only return on average $0.35 - $0.71 for each $1 spent on the premium. If the contract is designed to fully cover catastrophic losses (as is the case with RPG) the ratio should tend to towards 1 [24].

The CPR can also be calculated to show how the levels of expected return change at different rainfall thresholds (levels of 'catastrophe'), Figure 5. Predictably, the expected return is higher at the lower rainfall levels which suggests a reasonable distribution of insurance return, even if the overall expected return is below what might be considered "actuarially fair". Obviously, this detailed aggregate information is not readily observable to potential users when making their decision to invest in the insurance. However, one can imagine that any localised non-performance (basis risk) of the product observed by farmers may lead toward an unease of the product and its future adoption.

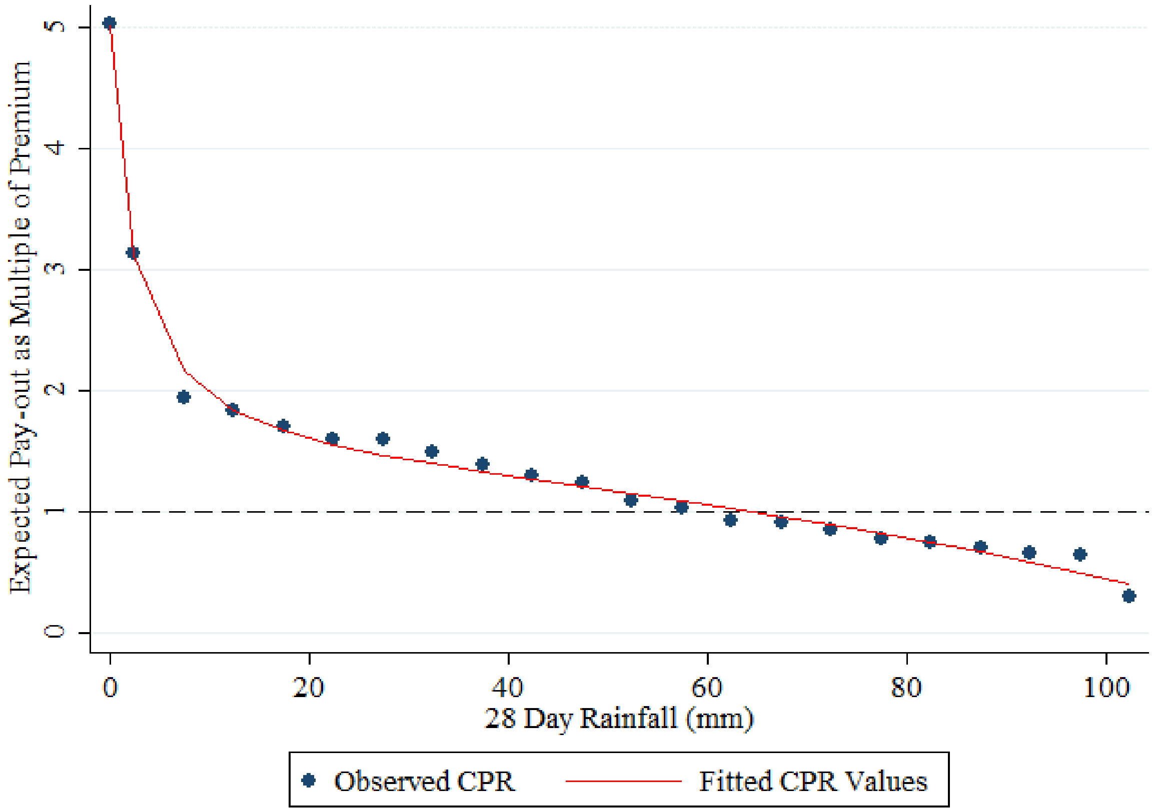

Figure 5: Catastrophic performance ratio for the RPG product at different rainfall thresholds.

Further delving into an individual level, it is possible to get a real sense of how exposure to basis risk has impacted the uptake of the RPG product within small localities. Using a threshold of germination rainfall and the pay-out received by each farmer it is possible to classify each adoption into one of four distinct outcomes relating to basis risk[2]. These outcomes are; 1) sufficient rainfall and no pay-out received, 2) insufficient rainfall and pay-out received, 3) sufficient rainfall and pay-out received (positive basis risk) and 4) insufficient rainfall and no pay-out received (negative basis risk). The key relationships of interest are how the prevalence of these different adoption outcomes in a prior season impact upon the number of future adoptions, within the same locality.

Using some more advanced statistical methods it is possible to estimate these relationships and determine elasticities of uptake based on prior localised experience[3]. For the RPG product, much like many field experiments on micro-insurances, it was found that; localities where pay-outs were made in a given season had an increased uptake of the product in the following season [25]. Specifically, a doubling of the number of correct pay-outs (made when rainfall was insufficient) increased the number of next season adoptions by 13.3% on average. Similarly, a doubling of the remaining adoptions where the product performed as expected, with no pay-out under sufficient rainfall, led to a comparable 7.3% local increase seasonally.

However, when the product did not perform as expected the consequences were quite different. A doubling in the rate of prevalence of negative basis risk instead reduced total future adoptions by approximately 8.4%. Equally importantly, adoptions experiencing positive basis risk have a very similar effect. A doubling in the rate of prevalence of positive basis risk further reduces total future adoptions by approximately 7%. This may be the very first attempt to estimate an elasticity of adoption for both positive and negative basis risk in the context of a weather index insurance. While the observed effects do not appear to be large they can in fact have substantial consequences for the expansion of uptake of the weather index insurance over time. This highlights the ‘cost’ of basis risk instances in terms of lost future adoptions.

[2] Importantly these classifications consider famers’ ‘perceived’ levels of basis risk. This refers to situations where a farmer may imagine that they are owed a pay-out due to their expectations of adverse rainfall for germination. For this reason a simple rainfall threshold of less than 10mm of rainfall in the 28 day germination period as the adverse weather level which a farmer may easily identify as insufficient. While well informed, this threshold is different to the actual trigger mechanism used by the insurance company which is not observable to the farmer.
3 The approach used involves Quasi–Maximum Likelihood Estimation (QMLE) on fixed effects regressions.

To demonstrate this point it is also valuable to consider the actual magnitudes of some hypothetical changes in basis risk in addition to the discussed elasticities. In this case, the number of negative basis risk observations and fair pay-out observations is relatively small within the whole pool of adoptions. Therefore, smaller magnitude changes in these outcomes can effect relatively large magnitude changes in the overall adoption for a given level of elasticity. Assuming that the perceived basis risk activations are distributed evenly within the sample, (which they are not) one can produce a rough estimation of the effect that correctly identifying a portion of these adoptions would have had on uptake. Consider the situation whereby half of the observed negative basis risk adoptions instead received a pay-out following insufficient rainfall. This halving of the negative basis risk activations (reducing nearly 5000 cases) would also increase the activations receiving a fair pay-out by three fold. The combined effect of correcting these near 5 000 perceived negative basis risk cases would have resulted in increasing the future uptake of the product by approximately 60 000 users. Although this is a rough estimation, it presents an interesting insight in to the size of the impact that just the negative basis risk can have on adoption.

4. The Discussion and Conclusions: Why & What to do?

While some fascinating 'new' evidence on the dynamics of basis risk has been uncovered, it is useful to try to disentangle what is driving these dynamics. As mentioned earlier, an individual's base risk preferences may dictate their demand for products such as partial index insurances. In particular, the most risk averse finding the products the least desirable due to the presence of basis risk [16,18–21]. However, another significant component driving demand is the 'perception of risk' (in this case basis risk) attached to the product, as the 'true risk profile' is not known. In the event that the perceived basis risk is considered negligible then demand may rise and vice versa. It is well established that perceptions of risk are not static and can be updated by observation and experience. This may happen by considering all the gathered information rationally (Bayesian updating) or by weighting more salient and recently occurring experiences more heavily (availability heuristics) [26–29]. It is expected that farmers' observations and experiences of the RPG product outcomes update their perceptions of basis risk via either process (although the availability heuristic is favoured here). These updated perceptions of basis risk in turn defined the farmers' decision to hedge their own production risk each season.

An important avenue for informing and applying this belief updating would be 'social learning'. This is the process whereby individuals gather information about the uncertain elements of a product, from both their own experimentation and the experiences of their ‘peer group’ or ‘neighbours’, before deciding to adopt [30]. The finding of the seminal ‘diffusion’ study by Ryan and Gross (1943) suggested that farmer-to-farmer exchange of personal experiences with the use of hybrid seed seemed to lie at the heart of uptake. Once enough positive experiences were accumulated by farmers and exchanged within the community, the rate of adoption accelerated. In the case of the RPG product, it is likely that the same social learning dynamics served to update prior perceptions of basis risk via ‘positive’ or ‘negative’ experiences with the product.

Furthermore, it is also worth discussing the role that income effects may have in addition to risk perception updating. In the event that a farmer experiences negative basis risk outcomes they may well be worse off financially and less able to purchase guaranteed seed again, even if they still desired it. In this situation it is not possible to fully disentangle the income effect from the increased negative basis risk perceptions. While following this same income rationale, one would then expect manifestations of ‘positive basis risk’ to inspire uptake in the following season with farmers having ‘wind fall’ returns to spend. However, the opposite is true. This suggests that any income effect (although not quantified here) is dominated by risk perceptions. Furthermore, these positive basis risk outcomes lead to updated perceptions of increased uncertainty in product performance (positive failures imply possible negative failures too) rather than confidence in a potential upside lottery.

In conclusion, this study proposes with relative confidence that that positive and negative basis risk may not cancel out each other in the eyes of those looking to insure. Rather the two sides of basis risks seem to compound a perception of uncertain risk and hence a distaste for the index insurance product. On the other hand, adoptions where the product performed ‘as expected’ appear to promote localised confidence in product reliability, and inspire further uptake in the future. It is important for policy makers and practitioners to observe that there are genuine sensitivities to basis risk and that there is a necessity for high levels of product accuracy in order to generate sustained uptake. While it may not be possible to eliminate basis risk entirely from index insurances, additional data collection on user perceptions of outcomes (risks and losses) may go a long way toward calibrating future products. The merits of this large scale case study are obvious for agricultural products addressing the developmental objectives of food security and poverty. However, the findings may also be pertinent more widely as index insurance proliferates with remote monitoring and machine learning increasingly being applied in the fields of transport, energy and health.

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