# Risk and Development: An Experimental Study of Insurance Demand and Risky Decision Making in Rural Uganda


Borja Pérez-Viana Martínez

MSc MA BA


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School of International Development
University of East Anglia


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# Introduction

From the dawn of life, humans have faced risks to their survival and often succumb to them, yet our continued existence is testament to the success of our ancestors in managing risk. Early efforts, like developing weaponry and gathering in large groups, focused on making life safer and defending against threats. They were followed by the accumulation of resources to ensure continuous sustenance, starting with the domestication of animals and the cultivation of land. Humans also began trading to take advantage of specialisation, increasing the availability of goods.

The advent of commerce led to the development of new technologies to deal with risk, most notably the invention of money and the legal system—originating in Babylonia 3000 years before Christ. These innovations also extended to the management of risk. Precisely, the Babylonians provide one of the first examples. Under the auspices of the Great Code of Hammurabi (1800 BC), a trader whose goods were lost to bandits was relieved of any debts—contracted for the purchase of the stolen goods—owned to the money lender. A particularly fruitful endeavour for the emergence of risk management methods was sea trade. Phoenician, Greek and Roman sea merchants who borrowed sums to fund their activities, pledging their ship or cargo as collateral, were offered an option whereby, for a higher interest rate, the lender agreed to forego the debt if the cargo was lost at sea. This additional interest rate on the loan was referred to as 'praemium', precursor of the modern term premium (Vaughan, 2012).

Many examples of this type of mechanisms abounded in antiquity, and during the Middle Ages and later periods; some of them are of great historical importance, like the Venetian *commenda*, which was one of the pillars of the Republic's prosperity (Acemoglu and Robinson, 2012).[1] Despite the multiplicity of examples, risk management and insurance were not widespread and did not play a vital role in economic activity, even at the end of the 18th century; an aspect that Adam Smith (1776) highlighted in his monumental work.[2]

[1] In the *commenda*, the wealthiest of two partners assumed the lion's share of the losses if the cargo was lost at sea, he also profited the most from the business if the ship completed the journey successfully.

[2] Smith (1776:105) stated "That the chance of loss is frequently under-valued, and scarce ever valued more than it is worth, we may learn this from the very moderate profits of insurers (...) Taking the whole kingdom at an average, nineteen houses in twenty (...) are not insured from fire. Sea risk is more alarming to the greater part of people, and the proportion of ships insured to those not insured is much greater."

This state of affairs changed dramatically during the 19th century, with the enormous extension of the insurance system in parallel to the Industrial Revolution. Nevertheless, modern risk management, based on a systematic and mathematically rigorous methods of risk analysis, only emerged after World War II (Zachmann, 2014). Insurance expanded then beyond the coverage of losses associated with accidents and new risk management instruments appeared. The 1970s saw the introduction of derivatives to manage insurable and uninsurable risks, and financial risk became a key priority for companies during the 80s. Within the same decade, international regulation of risk began to be issued. However, all these rules did not suffice to prevent the financial crisis in 2007, due to their lack of application and enforcement (Dionne, 2013).

The concept of risk developed throughout history in conjunction with the efforts to deal with it. The origin of the word can be traced all the way back to the middle ages in many European languages and Arabic (Aven, 2012). The proto-modern notions of risk embedded in these terms emerged in a context that considered future uncertainties as an opportunity to make a fortune and therefore worth the wager (*e.g.* gambling and aleatory contracts). These uncertain events inspired mathematicians to develop methods to predict the probable outcome of future events; thus, beginning to quantify uncertainty as probability.[3] The great political, social and economic transformation in Western societies during the Industrial Revolution ushered a new era in which risks were no longer seen as a sign of lucrative opportunities, but as something to be avoided or at least managed. However, it was not until the end of WWII and the advent of risk management as an established activity that the modern approach to risk was consolidated. This modern understanding was based on mathematically rigorous methods that encouraged the statistical understanding and probability assessment of risks in diverse fields (Zachmann, 2014).

Despite its rise to prominence in our contemporaneous society, there is still no single definition of risk, which varies radically depending on the context and discipline (Aven, 2012). Throughout this thesis we adhere to the Knightian definition, prevalent in economics, formulated at the beginning of the 20th century. Knight (1921) defines risk as an objective and measurable uncertainty of an event, as opposed to a subjective uncertainty that cannot be measured. Yet this description is eminently impractical in most cases with the exception of controlled conditions, coincidentally, of great importance in the present work—which relies heavily on experimental designs, justifying the adoption of Knight's definition. Unlike in our experiments, where objective probabilities are an essential and enlightening simplification, in real life, risk can rarely be quantified accurately, being, at best, possible to uncertainly estimate it in some cases. For this reason and in line with common parlance, we typically refer to risk as the possibility of an unfortunate occurrence

[3] A prime example being Bernulli's (1738, cited in Starmer, 2000) so-called St. Petersburg paradox, which we will encounter later.

in contexts other than the experimental conditions (Aven, 2012).[4]

In spite of the relative success of humanity managing it, risk has been and likely remains one of the main deterrents of development. Diseases, natural catastrophes, political strife, all lead to a state of uncertainty about the future and the distinct chance of a negative outcome. In their historical reflection on the success and failure of nations, Acemoglu and Robinson (2012) provide a plethora of detailed accounts of how the unabated risk of losing any production surplus thwarted innovation and improvements in productivity, even when more efficient technologies were known and readily available.

Although modern societies, as noted earlier, have developed strategies to deal with risk, in developing countries these modern institutions exist alongside traditional ways of coping with risk. This dichotomy is part of a wider set of differences at the heart of poor economies, neatly captured by Arthur Lewis (1954) in his seminal theory of dualism. According to this paradigm, the economies of less-developed countries have a dual structure and are roughly divided into a modern productive sector—associated with urban life, industry and advance technology—and a traditional unproductive one—broadly characterised by rural life, traditional agriculture and use of 'backward' technologies (Acemoglu and Robinson, 2012). Even though this is a blunt distinction, which is blurred at the micro level, it remains a powerful tool for describing the existing gaps in productivity still observed nowadays (Gollin, 2014).

In few other sectors these differences in productivity are as stark and consequential as in agriculture. Three out of four poor people in developing countries live in rural areas, with the majority of them relying on agriculture for their livelihoods; making it the sector from whose growth the poorest benefit the most (FAO, 2003; World Bank, 2007). Improving agricultural productivity is also a growing need for achieving food security in the face of a rising population, which increasingly concentrates, precisely, in the regions lagging technologically behind (UN, 2017).

As a result of the pressing need of closing the technological gap, interventions aimed at improving productivity in agriculture are commonplace in developing countries (World Bank, 2002; IMF, 2010). Many of them focus on increasing the use of inputs, which are credited to account for very large differences in yields (Morris *et al.*, 2007). Despite the prospect of large returns (Duflo *et al.*, 2008), investment in agricultural technology, and in inputs specifically, has been much lower than the level required to close the productivity gap (Foster and Rosenzweig, 2010).

A major obstacle for technology adoption is the pervasive presence of risk in rural areas of developing countries. For a myriad of reasons risk is higher for the inhabitants of these places than in almost any other part of the world. First off, they are subjected to a much

[4] However, we occasionally refer to risk somehow in the opposite sense, as the possibility of a positive occurrence; like in risk taking (*i.e.* investing), which can also fail and end up in losses.

higher incidence of diseases and environmental hazards. Sub-Saharan Africa, where half the countries are affected by a drought every seven years and by a flood every three, exemplifies this well (Carter *et al.*, 2014). In addition, business risk plays a major role in people's lives since the majority of them run at least one business, typically, their own farms. Not only is this by itself a much riskier way of making a living than, for example, having a waged employment, but also these enterprises are usually small, undercapitalised, underequipped and very vulnerable to shocks. Furthermore, safety nets are practically non-existent in least-developed countries since they cannot be appropriately funded. In addition, the provision of many social services (*e.g.* healthcare) is problematic, especially, in rural areas. Lastly, low levels of contractual compliance, and the isolation of rural communities due to poor infrastructure also increase the degree of risk sustained in these areas (Fafchamps, 2003).

Rural peoples exposed to these risks have developed many systems for coping with them. Most of these strategies have an ancient lineage, like settling in relative safe areas and breeding resilient plants and animals species, as well as diversifying the sources of income. These coping techniques can be classified as aimed at reducing the exposure to risk (*ibid.*). Among them, it is also risk avoidance, which involves engaging in low risk traditional activities at the expense of higher expected returns—obtainable through more innovative, albeit riskier—methods (Carter et al., 2014).

Another set of strategies, as per Fafchamps's (2003) classification, involve the accumulation of assets, like gathering precautionary savings or seeking wage employment. When a shock occurs, these assets are liquidated or consumption has to be reduced. Both of these events can entail long lasting impacts, not only on the household's welfare but also on its capacity to produce, as in some cases the assets cleared are used for production or the ability to work is impaired due to reduced consumption. These effects are more severe the larger the shock is and the higher the initial level of deprivation. To the extent, that a negative shock can lead to a poverty trap, in which the capacity to earn future income becomes lower than the current level of income (Banerjee and Duflo, 2011).

Given the magnitude of these perils, poor people in rural areas also resort to share risk with others. Solidarity bonds often tie together members of the same family, kinship group or village. Those bonds manifest themselves in a variety of ways, such as manpower assistance or land and livestock loans. Most commonly though, they take the form of transfers (*e.g.* gifts, food transfers or interest-free credit) from one household to another (Fafchamps, 2003). These transfers enable consumption smoothing when households suffer from shocks which do not affect the average income of the community, *i.e.* individual risk, leaving mostly common risk, which afflicts the whole community (Ravallion and Dearden, 1988; Udry, 1994; D'Exelle and Verschoor, 2015). The extent of their coverage is limited though, and shocks are still felt. Moreover, covariate shocks remain a major source of risk (Banerjee and Duflo, 2011).

Due to the capital role of risk in the lives of the rural poor, the main goal of this thesis is to contribute to the study of how risk—avoiding or pursuing it, sharing it informally, or taking up formal insurance against it—influences their livelihood decisions.

As it emerges from the earlier discussion, risk leaves poor households vulnerable to serious negative shocks hard to cope with, and forces them to engage in costly risk management strategies to hedge against their occurrence. Mutual support networks offer limited coverage and are, as noted, ill-suited to protect against covariate or catastrophic risks. Even though modern forms of risk management, like formal insurance, have the potential to mitigate these shocks by offering a compensation when they occur, they have so far failed to fulfil its potential, plagued by serious informational and enforcement problems. First, insurance is highly vulnerable to adverse selection, as it may attract individuals involved in riskier activities on average, who are difficult to detect due to lack of information on risk profiles. Second, insurance also suffers from moral hazard because it encourages beneficiaries to take more risks. More importantly, the difficulty and cost of verifying certain insured events can be substantial, especially in rural settings where many small farmers operate (Morduch, 2006; Dercon *et al.*, 2009).

Nevertheless, in recent years a new form of index-based insurance has arisen as a promising instrument to deliver formal coverage, overcoming the mentioned issues through its particular design. Index insurance determines indemnity payments not on the basis of individual losses but on the value of an index correlated with them. Such index can be based, for instance, on rainfall, temperatures or the humidity levels in the area where the farmer operates. In this way, index insurance covers against some of the main risks affecting agricultural production in rural areas, especially those related to adverse weather events, over which policyholders have no direct influence. This feature effectively eliminates the perils of moral hazard and adverse selection (Barnett and Mahul, 2007). Moreover, once established, index insurance is less expensive to administer than other types of insurance, since it does not require on-site inspections or individual loss-assessments, facilitating the development of an insurance market (Hazell *et al.*, 2010). Yet index insurance is not without problems, its key limitation is basis risk—the imperfect correlation between index and losses; an issue that partially explains the low demand it has been met with (Dercon *et al.*, 2014; Mobarak and Rosenzweig, 2013).

Some recent papers argue that informal risk sharing can complement the coverage of index insurance, by partially absorbing basis risk (Dercon *et al.*, 2014; Mobarak and Rosenzweig, 2013). However, the possibility that pre-existing risk-sharing arrangements hamper formal insurance uptake cannot be dismissed (Arnott and Stiglitz, 1991; De Janvry *et al.*, 2014). To shed light on this relationship and the future of index insurance, we investigate how the provision of formal insurance interacts with pre-existing risk-sharing arrangements, employing experimental evidence from a rural area in eastern Uganda. We contribute by, for the first time, varying exogenously actual risk sharing—to study its effect on insurance demand—and insurance characteristics—to test whether this effect varies depending on the type of insurance. In addition, we investigate the influence that the provision of formal insurance exerts on risk sharing behaviour. We find that anticipated informal risk sharing crowds out demand for index insurance, but does not affect indemnity insurance take up. This result is partly explained by the risk sharing behaviour observed. Although being insured is neutral for receiving informal support, among those who are insured, the type of insurance still matters for seeking help from peers. Being index insured draws a significantly higher amount of transfers than having the protection of an indemnity cover.

We turn the focus next to the study of the relationship between insurance and investment, mediated by informal risk sharing; a largely unexplored area in the literature, but crucial for the success of insurance, which is yet to prove its worth in the context of agriculture (Dercon *et al.*, 2009; Cole *et al.*, 2012; Carter *et al.*, 2014). This achievement could make of insurance an important tool in the quest to improve agricultural productivity, a key political and economic goal in the developing world, as highlighted earlier. Our main contribution to the literature is precisely to investigate the impact that both formal and informal insurance exert on investment, separately and, especially, in combination. To this end, we conduct a framed field experiment in eastern Uganda, where insurance status and the availability of risk sharing are varied exogenously to examine their influence over investment behaviour. We find that being formally insured, in any of its forms, does not influence investment decisions. By contrast, risk sharing appears to increase investment to some extent, yet only when the investor is not insured or insured by a fallible cover (*i.e.* indexed). Additionally, the paper investigates whether being insured matters for the level of informal support that investors receive. We employ random variation in insurance status to study the risk-sharing behaviour towards risk takers. Our findings show that being insured crowds out informal risk sharing towards investors, but that this effect is more pronounced when the cover is perfectly compliant (*i.e.* of the indemnity type).

Finally, the thesis puts an old, but highly influential, narrative in development economics under the microscope: the notion that poverty perpetuates itself due to the influence it wields on the attitudes of those who suffer from it towards risk. In a recent review article in *Science*, Haushofer and Fehr (2014) claim that risk aversion is part of the psychology of those in poverty. They argue that material hardship increases the stress levels of the poor, instilling in them a sense of short-sightedness and aversion to risk in the decisions they take, and that, in turn, this chain of events leads to deprivation. With the aim of examining how cogent this account of poverty is, we investigate whether, and to what extent, risk preferences matter for investment in agricultural technology adoption by a representative sample of 1,803 households. This exercise was carried out through the study of the main correlates of investing in two meaningful examples of this phenomenon—purchasing fertiliser and growing cash crops with the recommended inputs. Risk preferences were elicited experimentally and comprise aversion to risk and the heterogeneous weighting of probabilities. The main lesson from the analysis is that risk aversion plays a non-trivial role in investment decisions. However, its importance pales in comparison to that of having the means to invest, which calls into question the validity of the prevailing narrative and points to the risk environment rather than preferences towards it as the main barrier for investment.

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# Risk Sharing and Demand for Insurance: An Experimental Analysis

**Abstract**

Uninsured risk leaves poor households in developing countries vulnerable to serious negative shocks hard to cope with, and forces them to engage in costly risk management strategies to hedge against their occurrence. Although mutual support networks have long existed, they are ill-suited to protect against covariate or catastrophic risks. Grounded in a strong rationale, insurance has however failed to fulfil its potential, plagued by serious informational and enforcement problems. Nevertheless, in recent years a new form of index-based insurance has arisen as a promising instrument to deliver formal coverage, overcoming the mentioned issues through its particular design. Yet index insurance is not without problems, its key limitation is the imperfect correlation between index and losses (*i.e.* basis risk), a problem that partially explains the low demand it has been met with. Some recent papers argue that informal risk sharing can complement the coverage of index insurance, by partially absorbing basis risk. However, the possibility that pre-existing risk-sharing arrangements hamper formal insurance uptake cannot be dismissed. To shed light on this relationship and the future of index insurance, the paper investigates how the provision of formal insurance interacts with pre-existing risk-sharing arrangements, employing experimental evidence from a rural area in eastern Uganda. We contribute by varying exogenously actual risk sharing—to study its effect on insurance demand—and insurance characteristics—to test whether this effect varies depending on the type of insurance. In addition, we investigate the influence that the provision of formal insurance exerts on risk sharing behaviour. We find that anticipated informal risk sharing crowds out demand for index insurance, but does not affect indemnity insurance uptake. This result is partly explained by the risk sharing behaviour observed.

# I Introduction

Rural inhabitants in developing countries are especially exposed to the pervasive presence of risk. First off, they are subjected to a much higher incidence of diseases and environmental hazards. Sub-Saharan Africa, where half the countries are affected by a drought every seven years and by a flood every three, exemplifies this well (Carter *et al.*, 2014). In addition, business risk plays a major role in people's lives since the majority of them run at least one business, typically, their own farms. Not only is this by itself a much riskier way of making a living than, for example, having a waged employment, but also these enterprises are usually small, undercapitalised, underequipped and very vulnerable to shocks (Fafchamps, 2003).

All these risks go largely uninsured, leaving poor households vulnerable to serious negative shocks hard to cope with, and also forcing them to engage in costly risk management strategies to hedge against their occurrence (Dercon *et al.*, 2009). To cope with shocks, households typically need to reduce consumption expenditures to achieve asset smoothing, or must smooth consumption by selling assets. Reducing consumption can have hefty welfare costs, leading for example to irreversible consequences in health (*e.g.* stunting) and education (*e.g.* dropping out of school at an early age). On the other hand, selling productive assets undermines income-generating activities and can push household into poverty traps. The negative welfare effects of these *ex-post* coping decisions come in addition to the harmful consequences of some of the risk management strategies the poor need to resort to. One of them is risk avoidance, which involves engaging in low risk activities at the expense of higher expected returns (Carter *et al.*, 2014). Consequently, welfare costs due to shocks and forgone profitable opportunities can be substantial, contributing to persistent poverty and its perpetuation across generations.

Insurance has the potential to reduce these costs by offering compensation when a negative shock occurs. This mechanism avoids the need of some costly risk coping strategies and can facilitate the pursuit of profitable activities (Dercon *et al.*, 2009).

To a large extent the virtues of insurance are already known to most communities across the world, where there have long existed networks of mutual support to cope with crises. However, due to their very nature, these networks are often only suited to protect against idiosyncratic risks affecting a few of their members, but not covariate or catastrophic shocks, hitting whole communities (Dercon, 2009).

Although its rationale is strong, insurance is affected by serious informational and enforcement problems. First, it is highly vulnerable to adverse selection, as it may attract individuals involved in riskier activities on average, who are difficult to detect due to lack of information on risk profiles. Insurance also suffers from moral hazard because it encourages beneficiaries to take more risks. More importantly, the difficulty and cost of verifying certain insured events can be substantial, especially in rural settings where many small farmers operate. As a result, considerable incentives exist to research and experiment with innovative forms of insurance that deal with these problems (*ibid.*; Morduch, 2006).

Index insurance is one of the most promising instruments in the search to feasibly deliver insurance to smallholder farmers in the developing world, since it can seemingly overcome the three issues mentioned above through its particular design. Index insurance determines indemnity payments not on the basis of individual losses but on the value of an index correlated with them. Such index can be based, for instance, on rainfall, temperatures or the humidity levels in the area where the farmer operates. In this way, index insurance covers against some of the main risks affecting agricultural production in rural areas, especially those related to adverse weather events, over which policyholders have no direct influence. This feature effectively eliminates the perils of moral hazard and adverse selection (Barnett and Mahul, 2007). Moreover, the low risk of manipulation of the index allows for the reinsurance of indexed products, allowing that insurers transfer part of their risk to international markets. Lastly and most importantly, once established, index insurance is less expensive to administer than other types of insurance, since it does not require on-site inspections or individual loss assessments, facilitating the development of an insurance market (Hazell *et al.*, 2010).

Promising as it is, index insurance is not without problems. Its key limitation is that beneficiaries are still exposed to basis risk, which refers to the imperfect correlation between the index—and, thereby, the transfers triggered by it—and the losses experienced by the beneficiary. As a result, it is possible for the policyholder to experience a loss and yet not receive any insurance indemnity (Barnett and Mahul, 2007).[5]

Recent research has made considerable progress in linking basis risk to the surprisingly low demand registered for index insurance. Some of these studies have hinted at a solution, arguing that informal risk sharing can complement the coverage of index insurance, by partially absorbing basis risk (Dercon *et al.*, 2014; Mobarak and Rosenzweig, 2012, 2013b,a, 2014).

However, the possibility that pre-existing risk-sharing arrangements hamper formal insurance uptake cannot be dismissed (Arnott and Stiglitz, 1991; De Janvry *et al.*, 2014). Moreover, the availability of formal protection can also crowd out informal support (Attanasio and Rıos-Rull, 2000; Lin *et al.*, 2014; Boucher and Delpierre, 2014), undermining further the case for complementarity.

To shed light on the relationship between formal and informal protection, and the future of index insurance, this paper investigates how the provision of formal coverage interacts

[5] This type of basis risk is known as downside basis risk, which translates into heavier losses for the policyholder than without insurance. In contrast, upside basis risk refers to the opposite scenario, where the individual can make a profit out of purchasing insurance, by receiving a payout without suffering any losses (Jensen *et al.*, 2016).

with pre-existing risk-sharing arrangements. We do so by conducting a framed field experiment in a rural area of eastern Uganda, complemented with extensive survey data. We contribute by, for the first time, varying exogenously actual risk sharing—to study its effect on insurance demand—and insurance characteristics—to test whether this effect varies depending on the type of insurance. In addition, we investigate the influence that the provision of formal insurance exerts on risk sharing behaviour.

Our findings indicate that anticipated informal risk sharing crowds out demand for index insurance, but does not affect indemnity insurance take-up. This result is partly explained by the risk sharing behaviour observed. Although being insured is neutral for receiving informal support, among those who are insured, the type of insurance still matters for seeking help from peers. Those who are index insured receive a significantly higher amount of transfers than individuals under the protection of an indemnity cover.

The next section reviews the literature, highlights its shortcomings and elaborates on our contribution. Section III, presents our theoretical framework. The fourth section describes our experimental design and the area of study. The analysis of the results is shown in Section V. Finally, a discussion of our results in the context of the related literature follows in the next section, which concludes the paper.

# II Literature Review and Contribution

Despite its seemingly large potential benefits, demand for unsubsidised index insurance has been discouragingly low, especially among the poor (Cole *et al.*, 2012; Carter *et al.*, 2014). This observation has been deemed a puzzle by some development economists (Karlan and Morduch, 2010; Cole *et al.*, 2013; Clarke, 2016), who attribute this outcome to a variety of reasons, such as: credit constraints faced by low-income farmers (Binswanger-Mkhize, 2012), inadequate decision making on their part influenced by negative perceptions about the product (Karlan and Morduch, 2010; Cole *et al.*, 2013), interaction between formal and informal insurance (Boucher and Delpierre, 2014; De Janvry *et al.*, 2014) or simply due to the deficient design of many index insurance policies (Clarke, 2011, 2016).

Researchers relied initially on willingness-to-pay (WTP) questions about hypothetical contracts to elicit information about prospective index insurance uptake (Sarris *et al.*, 2006; Turvey and Kong, 2010; Hill *et al.*, 2013; McIntosh *et al.*, 2013). The studies conducted employing this kind of methodology show considerable interest in the indexed cover among farmers, yet not high enough to sustain unsubsidised markets. Using a large panel sample of Ethiopian farmers, Hill *et al.* (2013) find that those educated, rich and showing more proactive traits are likely to be the first entrants into the market. Their results reveal that individuals facing higher rainfall risk and who are less risk-averse (as measured by a Binswanger-style lottery [Binswanger, 1980]) are more inclined to purchase insurance. The latter finding, in combination with the importance of education and being proactive, is taken by the authors as indicative that the purchase of insurance is close conceptually to the adoption of a new technology (*i.e.* a novel financial instrument). These conclusions are however undermined by the hypothetical nature of the product offered, which may not lead to responses representing actual behaviour. As shown by McIntosh *et al.* (2013), who implemented a randomised field experiment after their willingness-to-pay survey, the relationship can be tenuous; in particular, these authors find almost no correlation between stated and actual demand.

One of the first studies on the demand for actual index insurance policies in a developing country context was conducted by Giné *et al.* (2008) in rural India. Using a non-experimental design, they investigate the determinants of household insurance demand and evaluate the take-up patterns against the predictions of a neoclassical model of insurance participation. The model is a simple representation of prevailing economic theory about households' willingness to pay for an insurance policy in a scenario without informational asymmetries. The results of the empirical analysis conform to the predictions of the benchmark model in that demand is decreasing in basis risk (imperfectly proxied by the portfolio of crops grown), and increasing in the size of the insured risk. However, the rest of their main findings are difficult to reconcile with the benchmark. They report that familiarity with the vendor, membership in the local council and connection to other village networks are among the most important determinants of take-up. More importantly, risk-averse households are less likely to purchase rainfall insurance, contradicting the benchmark prediction. The lack of predictive power of the authors' model symbolises the inadequacy of classical models of indemnity insurance to characterise the demand mechanism for its indexed counterpart, stressing the differences between these two kinds of covers. The corollary of which is that new forms of conceptualising index insurance are needed in order to understand demand and design better products.

In one of the most influential early papers on the demand for index insurance, Cole *et al.* (2013) employ a series of randomised experiments in rural India to assess the importance of price and non-price factors in determining the purchase of rainfall insurance. The authors' results show that demand for the product is pointedly price sensitive, suggesting that the high insurance prices which providers usually need to charge in order to operate in rural areas contribute significantly to low demand. Nevertheless, this sensitivity to price factors cannot fully explain low uptake. In their search for additional determinants of demand, the authors investigate the role played by trust, which they consider crucial given the uncertain nature of any insurance product and, especially, of index insurance, finding that indeed efforts to instil confidence in the product significantly increase take-up. This result leads the authors to conclude that farmers do not completely trust or understand the product, which consequently shifts demand significantly downwards.

Building on this research, Cole *et al.* (2014) examine the development of a new rainfall insurance market using a seven-year panel of purchasing decisions made by rural farming households in the Indian state of Gujarat. The article investigates the dynamic effects that payout experiences exert on the demand for the product, which appear to change over time. In the short term, demand is highly sensitive to payouts being made in the household's village, however, this effect seems to fade over time in favour of the household's own payout experience, which influences uptake several years on.

Karlan *et al.*'s (2014) study is at the forefront of the scarce research exploring the impact of insurance on technology adoption in developing countries. The paper investigates how relaxing risk constraints through the provision of insurance affects agricultural investment, employing an experimental design in northern Ghana.[6] As part of their investigation, the authors also attempt to shed light on the drivers of demand for index insurance products. Like several papers studying the demand for indexed products (Cole *et al.*, 2013, 2014), they highlight the importance of trust for uptake. They explain that farmers do not seem to trust that payments will be made when the trigger event occurs, and, as a consequence, demand for the product increases significantly with farmer's own receipt or someone in the network receiving payouts. In addition, they find that farmers display

[6] Full commentary on this paper in regard to the impact of insurance on investment, as well as a review of the related literature, can be found in Chapter 2 (Pérez-Viana, 2019a).

heuristic tools that make them overweight recent experiences in forming and updating beliefs about insurance which, in turn, influence their demand. In particular, farmers' behaviour seems to be consistent with recency bias, in that those who experienced a payout in the previous year overestimate the probability of its recurrence in the current year and *vice versa*. Unlike some of the studies reviewed (Giné *et al.*, 2008; Cole *et al.*, 2013), wealth does not appear to determine demand for insurance. The authors show that demand, conditional on insurance price, is not related with baseline household non-land wealth. In accordance with the lessons from Cole *et al.* (2013) above and Mobarak and Rosenzweig (2012, 2013a), commented below, price emerges as a key driving factor of demand, with steep elasticities at prices above the actuarially fair. However, demand is sizeable for policies offered at the latter prices or lower, with 40% to 50% of farmers demanding insurance at fair prices, and over 67% of them purchasing insurance with an additional discount. Moreover, those purchasing policies at actually fair costs, insured more than 60% of their cultivated acreage.

Notwithstanding the resounding marketing success of this project, which provides strong evidence for the existence of sufficient demand to sustain a market for index insurance, it is an exception to the results obtained by most of the literature. Further support would be needed in order to justify the commitment of the sizeable resources required to scale up the indexed securities sector.

Cai *et al.* (2014, 2015) conduct a study of the causal effects of financial education and social learning on insurance uptake in rural China, employing a randomised design. They report that financial education about insurance and its benefits improves adoption by a large proportion (from a 35 percent take-up rate to 50 percent). Furthermore, the intervention has large and positive spillover effects on uptake by other members of the social network. The authors argue that these effects are driven by knowledge diffusion rather than imitation among peers. They back their claim by means of an ingenious, albeit fairly complex, identification strategy, involving several randomly-assigned subtreatments, IV estimation and restricting the size of the network (to the five closest friends). First, they show that having more well-informed friends significantly increases take-up.[7] Yet as it turns out, when they vary the information about the peers' decision among the subsamples, being more aware of these decisions does not have a significant effect on demand. By contrast, listening to statistics about other villagers' decisions, had a surprisingly strong effect on take-up choices. Similarly to previous studies, beneficiaries who receive payouts or those who have more friends in the network receiving payouts are more likely to purchase insurance in the following period. Grounded on their careful research of the influence of networks on take-up rates, the authors advocate for their use for the marketing of weather index insurance in combination with subsidies, which are common-

[7] Meaning having more friends taking part in the intensive sessions, where further information about the product was provided than in the regular ones.

place. Particularly, they suggest making use of individuals central to village networks to achieve a rapid diffusion of information about the product and its benefits.

In a similar vein, Giné *et al.* (2013) highlight the importance of social networks for the demand of index insurance. They conduct a randomised field experiment measuring the direct impact and social network spillovers of providing financial education and discount vouchers in Kenya. Their results show that receiving financial literacy materials increases the probability that a farmer takes up insurance, but only when more than half of the farmers' neighbours also obtain them.

While the early paper by Cole *et al.* (2013), and those of the other studies following a similar methodology (Giné *et al.*, 2013; Cai *et al.*, 2014; Cole *et al.*, 2014; Cai *et al.*, 2015), provide useful empirical insights about elements that are practically very relevant for the uptake of actual index insurance products, their research lacks the theoretical foundations to rule out competing explanations about what drives the take-up of the product, and, ultimately, build a theory of index insurance demand. Their findings are often presented as evidence that standard economic theory systematically fails in predicting the main determinants of demand for index insurance; however, no alternative behavioural model is put forward to represent how these factors affect purchasing decisions.

As suggested, the previous literature suffers from the absence of solid theoretical foundations to explore the demand for index insurance. It was not until Clarke (2011, 2016) developed, for the first time, a utility-maximising model of index insurance demand that the void was partially mitigated (Binswanger-Mkhize, 2012). Clarke sets out to tackle two of the main puzzles about demand for this type of insurance: first, the low uptake registered despite the seemingly large benefits of agricultural insurance for farmers (Cole *et al.*, 2012; Carter *et al.*, 2014); second, the negative relationship between risk aversion and demand for the insurance product (Giné *et al.*, 2008; Cole *et al.*, 2013). Clarke notes that intuitions from models of indemnity insurance have led some to attribute the former problem to cash and credit constraints typically afflicting poor households (Binswanger-Mkhize, 2012; Cole *et al.*, 2013). The second counter-intuitive finding had been ascribed to irrational decision making caused by the uncertainty about the product (Karlan and Morduch, 2010). The author moves away from these explanations and takes a novel approach to conceptualising index insurance, considering it more akin to a derivative product than to indemnity insurance, due to the presence of basis risk. The rationale is that the payout triggered by the product is derived from an index, very much like any derivative product derives its value from an underlying asset. The dependency from the index introduces basis risk, arising from the imperfect correlation between index insurance transfers and consumer's losses. The presence of basis risk entails that the purchase of index insurance both worsens the worst possible outcome and improves the best one. Assuming that agents are well-informed, price-taking and risk-averse utility maximisers, the author characterises insurance demand by generalising a model of insurance contracting by Doherty and Schlesinger (1990), where there is a non-zero probability that the insurer defaults on the contract.[8] He shows that rational demand for index insurance is then decreasing in basis risk, decreasing in the loading factor, increasing with risk aversion, but decreasing when the loading factor is greater than one, and ambiguous with respect to wealth (Hill *et al.*, 2013).[9]

Aside from crafting a fully-fledged framework to understand the behaviour of demand for indexed securities, perhaps Clarke's most important achievement is to demonstrate that a rational decision maker may rightly choose not to take up index insurance.

The author conducts in Clarke and Kalani (2011) probably the first framed field experiment on index insurance, with the purpose of testing the predictions bore by his groundbreaking model, namely, that demand for index insurance is increasing in risk aversion up to a point due to basis risk. The experiment consisted in a game in which participants had to choose the extent of their hedge both in the case of indemnity insurance, where payouts were a function of incurred losses, and index insurance, where payments were correlated but not a function of the losses. By considering both products, Clarke and Kalani are able to determine whether demand for the indexed cover is affected by the presence of basis risk. The analysis of the experimental data partly validates the hypothesis of a hump-shaped index insurance demand, although they do not control for risk preferences, despite its importance in the theory, casting some doubts about the results obtained.

For all its virtues, Clarke's (2011, 2016) theory does not account for pre-existing mutual support networks which, owing to their widespread presence and important role in coping with shocks (Fafchamps, 2003, 2008), are key to evaluate the future of any new risk management tool in poor rural economies. These networks are what most closely resemble insurance in this context. They enable consumption smoothing when households suffer from income fluctuations uncorrelated with variation in the average income of the community, *i.e.* idiosyncratic risk, leaving mostly collective risk (Ravallion and Dearden, 1988; Udry, 1994; D'Exelle and Verschoor, 2015). Informal networks appear to be fairly successful at performing this smoothing task, leading to substantial, albeit incomplete, reduction in the sensitivity of consumption to idiosyncratic risk (Townsend, 1994). Consequently, a fundamental aspect in understanding how uptake for formal insurance would turn out is to study the way it interacts with the risk-sharing arrangements already in place. This mantle has been taken by some of the most innovative research published to date in the field.

[8] We refer here to the predictions of the model derived assuming Constant Relative Risk Aversion (CRRA) utility.

[9] The loading factor of an insurance product is the ratio of the price (or premium) to the actuarially fair price of the insurance contract, which, in turn, is equal to the expected value of the payouts.

Dercon *et al.* (2014) is one of these studies; they investigate the complementarity between risk-sharing and index insurance in Ethiopia. Their main argument is that selling index insurance to those already sharing risk can overcome or, at least, attenuate several of the difficulties associated with marketing the product. Informal risk-sharing groups can help to deal with problems of understanding and are better positioned to enforce insurance contracts, addressing the issue of trust. More importantly, they are an effective way of dealing with basis risk, insofar as not all basis risk is perfectly correlated among its members. If individuals within a group are part of an arrangement of mutual support against idiosyncratic shocks, then index insurance will complement the coverage provided by this informal sharing of risk, which, in turn, can partially absorb basis risk. The authors devise a model to make this point, and show that, under reasonable assumptions, within-group risk sharing and index insurance are complements. The model implies that index insurance crowds in risk sharing and, therefore, demand will be higher among groups of individuals who can share risk. Subsequently, they test this prediction empirically by marketing weather insurance to well-established informal (funeral) risk-sharing groups, *iddirs*, in Ethiopia. Dercon *et al.* (2014) employ an experimental design, in which they randomised the content of the training provided to group leaders, with some sessions specifically focusing on the benefits of informally sharing idiosyncratic basis risk. Consistent with the theoretical model, they find that members of groups whose leaders receive training emphasising risk sharing have considerably higher uptake than groups in which leaders are trained in the individual benefits of insurance. The authors admit that their experiment does not allow them to fully disentangle whether the risk-sharing message works primarily through a selection effect or directly through its content.[10] Despite not being able to prove that selling insurance to risk-sharing groups is superior to selling it to individuals, the authors contend that it can make index insurance more attractive to these entities than to individual farmers.

*Iddirs* were also employed by Belissa *et al.* (2018) to market index insurance more effectively in another randomised field experiment with farmers in Ethiopia. Their interest in *iddirs* stems not so much from their ability to share risk informality, but from the potential they exhibit to inspire trust and, thereby, draw greater interest in the cover. This effort to tackle a problem frequently stressed in the literature is complemented by an intervention aimed at alleviating liquidity constraints which may be pulling demand downwards—the focus of much less attention in previous work. In particular, the authors allowed one of the groups in their experiment to pay the premium after the harvest season rather than before it, when farmers are seemingly too strapped for cash to afford that cost. Due to the possibility of default by the beneciaries of this arrangement, in a different sub-treatment, Belissa *et al.* (2018) attach to the delayed premium payment a contract that stipulated

[10] Group leaders trained on sharing may have invited participants to join who were more likely to purchase insurance, for instance, because they were already sharing risk beyond funeral insurance.

severe penalties in the event of default. By contrast, the trust intervention worked by building confidence in the insurance product through the endorsement of *iddir* leaders, a marketing strategy designed to prove the trustworthiness of the cover to the members of the association. All these interventions were combined resulting in six experimental arms assigned randomly each to a group of *iddirs*, including a control group which was simply sold the standard insurance product. Based on a theoretical model that predicts that risk averse farmers will always prefer postponing paying the premium and that the lack of trust erodes the gains associated with the cover, the authors hypothesise that both core interventions would increase take-up. The results from the experiment do not fully back these predictions. While delaying the payment of the premium increases the demand for insurance substantially, up 17 percentage points, marketing the product with the endorsement of the group leader does not lead to any significant change in uptake. Nevertheless, the combination of both initiatives results in a staggering increase of 540% in demand, to the point that almost half of the population becomes insured. Despite the remarkable success of the intervention, tested among several thousands of farmers, questions remain about the sustainability of such marketing method because of the 17% default rates registered for the delayed premium.[11] In order to break even, the insurance company would need to increase the mark-up of the indexed cover 26%, which may discourage farmers from buying, offsetting the rise in demand. The authors argue that the addition of contractual penalties could provide a solution, however, this feature did not manage to bring down default in the experiment.

Mobarak and Rosenzweig (2012, 2013a,b, 2014) series of studies are at the forefront of current research on the demand for index insurance. Building on previous literature, they confront the issue of low demand rates from the perspective of the interaction between informal and formal insurance. They scrutinise a long-standing argument justifying the absence of insurance markets in poor countries, namely, that pre-existing informal arrangements to share risk diminish the demand for formal insurance, to the extent of preventing markets from being established altogether.

Arnott and Stiglitz (1991) provide theoretical support for this notion and show that if both formal insurance providers and informal risk-sharing groups are not able to monitor risk taking, then the latter type of protection will drive out formal contracts in the presence of moral hazard. The agent lacks the incentives to avoid risk when she is not observed, and enjoying informal support further reduces her effort to prevent risk. By contrast, if informal groups are more capable of monitoring risky behaviour, then both forms of insurance provision can coexist. In this case, the reduction in risk avoidance is countered by the ability of the group to observe and punish excessive risk taking.

[11] Furthermore, these default rates are likely underestimated since those who received an insurance payout were automatically deducted the premium and, thus, did not have the chance of defaulting. More importantly, widespread default would indicate that participants were attracted to the 'virtually' free offering of the product and did not see insurance as useful tool in the long term.

Since index insurance is devoid of moral hazard yet suffers from basis risk, it calls for a different conceptual framework to explain its demand and interplay with informal arrangements. Mobarak and Rosenzweig (2012) develop such a model, combining the cooperative risk-sharing framework of Arnott and Stiglitz (1991) with Clarke's (2011, 2016) model of index insurance with basis risk. It borrows from the former the basic setting where two individuals are members of a group of mutual assistance, and it takes from the latter the representation of basis risk. The model shows that risk sharing is limited, specifically to half the losses of a group member, and that welfare can be improved through further coverage against losses. In fact, agents would demand complete coverage of fairly priced insurance against covariate shocks free of basis risk, regardless of the capacity of the informal risk-sharing arrangements to hedge against idiosyncratic shocks. However, when the insurance policy suffers from basis risk, risk sharing exerts an ambiguous effect on demand. The benefits of informal support when basis risk materialises are offset by the reduction in the utility of the contract when an informal transfer is received in addition to an insurance payout, especially when no common shock has taken place. Nevertheless, as basis risk increases the positive terms become greater, while the negative ones see their size reduced.[12]

Mobarak and Rosenzweig (2012, 2013a) test their predictions about the demand behaviour for index insurance conducting a randomised field experiment in rural India. In the experiment, the insurance policies are sold to sub-caste groups or *jatis*, identified as the most relevant risk-sharing group in their area of study. The authors vary the degree of basis risk *jatis* are subjected to, by randomising the distance from the weather station. They indeed find that when the insurance contract carries no basis risk, there is no difference in index insurance demand between groups who do not compensate idiosyncratic risk and groups at the median level of indemnification. However, as basis risk increases, members of groups who share idiosyncratic risk become more likely to purchase index insurance, albeit not significantly so in statistical terms. On the other hand, members of *jatis* which substantially indemnify losses from adverse common events, affecting the whole village, demand significantly less of the indexed cover. The study also randomised the distribution of vouchers for the purchase of index insurance, which are shown to increase demand significantly. Weather risk, proxied by the coefficient of variation of annual rainfall in the village during a seven-year period, also appears to increase uptake.

De Janvry *et al.* (2014) enter the debate about the complementarity between formal and informal insurance with a theoretical contribution. They consider a situation where farmers are members of a group with common interests, represented by the production of a common public good, resembling the organisation of producer cooperatives. The authors show that in this setting, demand for the indexed cover can be hampered by

[12] A version of this model provides the theoretical foundations for the present study, and it is fully developed in the next section.

two factors. The first is a free-rider problem, which may occur when the purchase of the insurance product has a positive spillover effect over the rest of the group, rendering the need to purchase insurance of other group members less pressing. Secondly, the utility value of insurance against an aggregate shock in their model can be positive or negative depending on the insurance decisions of other members in the group, which may lead to a situation in which individuals do not take up formal insurance due to lack of coordination even if it is the Pareto dominant outcome. The main lesson of the model is that the sum of the individual willingness to pay for insurance may be lower than that of the group as a whole. Not surprisingly, the authors recommend marketing index insurance to entire risk-sharing groups rather than to individuals. A suggestion not based just on the boost for demand predicted by their model, but also in the additional advantages of this design in terms of transaction costs and scalability.

To some extent, Mobarak and Rosenzweig (2012, 2013a,b, 2014) and, especially, Dercon *et al.* (2014) assume that index insurance may crowd in informal support when basis risk is imperfectly correlated among members of informal risk-sharing arrangements. This assumption relies on the existence of an effective mechanism for sharing basis risk. However, in many circumstances, basis risk sharing will be limited because of weak enforcement mechanisms, as inferred from the literature on risk sharing in developing countries (*inter alia* Coate and Ravallion, 1993; Kocherlakota, 1996; Ligon, 1998; Ligon *et al.*, 2002; Cox and Fafchamps, 2008; Delpierre *et al.*, 2016). In fact, some studies argue that the sudden availability of formal insurance may crowd out pre-existing informal arrangements, once again undermining the case for complementarity between these two forms of insurance. The main mechanism put forward is that formal insurance improves a position of autarky, in which the individual can avoid helping others by attenuating the consequences of not participating in informal arrangements (Attanasio and Rıos-Rull, 2000; Lin *et al.*, 2014). Specifically for the case of index insurance, Boucher and Delpierre (2014) formally argue that the presence of moral hazard due to risk taking within an informal group reverts the complementarity between the indexed cover and risk sharing, leading to the crowding out of the latter. The reason is that index insurance reduces the marginal cost of risk taking, exacerbating the moral hazard problem faced by the informal arrangement. This forces the group to reduce the amount of idiosyncratic risk sharing, which could lead, for high levels of the insurance premium, to a fall in farmer's welfare compared to a situation without the cover.

The contested status of index insurance and informal risk sharing as either complements or substitutes calls for further research on how these two types of protection interact. Firstly, to establish the circumstances under which pre-existing informal arrangements can crowd in or out index insurance. Secondly, to ascertain whether the availability of index insurance deters or encourages risk sharing.

A few unpublished studies have attempted to shed light on these issues. Vasilaky *et al.* (2014) and Munro (2015) investigate experimentally the effect on demand of offering index insurance to groups rather than individuals, finding evidence of crowding out of the formal cover. Nevertheless, in both experimental designs the source of exogenous variation in risk sharing is not fully convincing. In the case of the former paper, participants could actually self-select into buying individual insurance even if the were allocated to the group treatment, as they could opt out of the group contract and simply purchase individual insurance. It therefore follows that, as the authors admit, the experiment cannot be considered a direct comparison of the choice between individual and group demand (Vasilaky *et al.*, 2014).

As for Munro's (2015) contribution, her elaborated design does not appear to limit the source of variation to the possibity of receiving informal support exclusively. In her experiment participants were allocated to groups of three individuals and could either make transfers to one another ("Transfer" treatment) or not ("No Transfer" treatment). In the treatment where transfers were allowed, members of the group could negotiate, to discuss the transfers or devise a strategy for the successive rounds of the game. In addition, their insurance decisions were not only affected by the possibility of transfers, but also by the decisions taken by the other partners (*e.g.* if one partner did not insure, she would vie for more support than a member purchasing insurance). It therefore becomes hard to determine which of multiple elements in which the treatments differ was ultimately responsible for changes in the demand for insurance.[13]

In contrast to the previous papers, Berg *et al.* (2017) craft a sound framework to study how risk sharing interacts with insurance take-up. In the footsteps of Dercon *et al.* (2014), they develop a model in which risk sharing is shown to be a substitute of indemnity insurance, yet a complement to the indexed type. They test their predictions in an experimental setting with four treatment arms, resulting from the combination of two dimensions: type of insurance (index or indemnity), and existence of informal transfers or lack of thereof. The results presented strongly validate their theoretical predictions. Despite the merits of their intellectual effort, their experiment can hardly be considered a test of the effects of informal risk sharing, since this takes the form of a forced transfer from one player to another, a far cry from the functioning of actual informal support mechanisms, characterised by lack of enforceability as is well-established in the risk-sharing literature mentioned above.

In light of the shortcomings of the existing literature, the present paper continues to investigate how the provision of formal insurance interacts with risk-sharing arrangements.

[13] In Munro's (2015) experiment demand is represented by the valuation of participants of the insurance product as measured by Becker-DeGroot-Marschk (BDM) mechanism (Becker *et al.*, 1964).

We set out to study the influence of risk sharing on demand for formal insurance. In order to address this question, we employ a framed field experiment (Harrison and List, 2004).[14] As argued by Falk and Heckman (2009), this methodology allows for the evaluation of precise predictions about complex phenomena by giving the researcher control over the source of variation in the study, essential for drawing causal inferences reliably. Specifically in our case, it allows to limit the source of exogeneity to the risk-sharing technology available and study its effect on the demand for formal insurance.

In addition to this, our methodological approach possesses another important advantage in research involving insurance. Only in a controlled environment, such as the one devised, both researcher and consumer can have a precise idea of the joint probability distribution of the losses and payouts. Instilling such an objective and unambiguous belief about the joint distribution in a study involving real products is extremely difficult to do, given the informational requirements (*i.e.* decades of reliable time-series losses and indemnities data) and the additional factors involved (Clarke and Kalani, 2011).

Our main contribution is to vary exogenously, for the first time, actual risk sharing—to study its effect on insurance demand—and insurance characteristics—to test whether this effect varies depending on the type of insurance. In our experimental design, risk sharing takes the form of unconstrained transfers from one player to another, much like in real-life sharing arrangements.

The current study also seeks to investigate whether risk sharing is affected by the availability of formal insurance. Risk sharing within informal groups is commonplace in rural areas of developing countries, where, as pointed out earlier, people rely on informal transfers to smooth consumption in the face of large income fluctuations (Barr and Genicot, 2008). A large literature has explored in depth the motivation behind these arrangements and how they are formed (aptly reviewed in Fafchamps [2008]), and the way they are held together (Barr and Genicot, 2008; Cox and Fafchamps, 2008; Fafchamps, 2008). Among the factors found to influence the propensity to share risk in empirical research are group selection (Barr *et al.*, 2012) and operational rules (*e.g.* in-built enforcement mechanisms [Barr and Genicot, 2008]), congenial risk preferences and social networks (Attanasio *et al.*, 2012), and reciprocity in repeated interactions (Charness and Genicot, 2009).

Recent research has investigated whether perceived control over risk exposure also affects willingness to help. Cettolin and Tausch (2015) posit that when individuals do not have full control over the risk sustained and are unlucky, they may be perceived as more worthy of help than those making losses but who could have taken action to minimise risks. A scenario akin to introducing formal insurance in communities where residents rely on informal sharing arrangements. Insurance allows individuals to reduce their exposure to

[14] As defined by Harrison and List (2004), ours is a field experiment with a defined set of rules, field context in the task and conducted with a non-standard subject pool.

risk and may alter individuals' perceptions about who is deserving of help. A recent framed field experiment in Cambodia conducted by Lenel and Steiner (2017) provides support for these conjectures. The authors report that solidarity transfers towards participants who turn down the chance to insure are significantly lower than the assistance received by those not given the possibility to hedge themselves.

However, the sensitivity of informal risk sharing to formal insurance may also depend on the actual ability of the product to control the exposure to risk. This feature differs between indemnity and index insurance. Whereas an indemnity cover allows the policy-holder to effectively hedge against losses by buying insurance, an indexed security cannot guarantee protection against losses due to basis risk.

We add to the empirical literature on risk sharing by studying the influence that formal insurance and its characteristics exert on informal transfers, with special attention to how they are affected by basis risk.

# III Theoretical Framework

The theoretical framework for this paper draws upon the seminal work of Arnott and Stiglitz (1991) on the relation between market and non-market insurance, and on Clarke's (2016, 2011) theory of rational index insurance demand. Both theoretical explanations were combined by Mobarak and Rosenzweig (2012) into a unified framework characterising the interaction between formal insurance and informal risk sharing, which we adopt with some minor modifications.

## III.1 Basic Setting: Informal risk sharing

The aim of this first part is to formally describe the inner workings of group-based informal arrangements, and assess their ability to share risk given how they are characterised.

The informal arrangement consists of two partners who support each other against the negative income shocks they are subjected to.

Each partner displays strictly risk-averse preferences over wealth, with a von Neummann-Morgensten utility function $u$ satisfying $u'>0$ and $u''<0$. They are endowed with wealth $w$, and face the possibility of losing $l$ of it, with a probability $p$ drawn from a common distribution for both partners, even though the realisation of the idiosyncratic shock may differ between them.

The group of two partners behaves cooperatively, when a member incurs in a loss, she receives a transfer $t$ from the partner, as long as she does not suffer a loss too. The other partner behaves identically. The probabilities for every state of the world are described in the following table:

**Table I.1: Probabilities States**

| State $s$ | Description | Probabilities |
|---|---|---|
| $NN$ | Neither partner makes a loss | $(1-p)(1-p)$ |
| $LL$ | Both partners make losses | $p * p = p^2$ |
| $NL$ | First partner does not make a loss but second does | $(1-p)p$ |
| $LN$ | First partner makes a loss but not second | $p(1-p)$ |

Each individual partner therefore needs to chose $t$ to maximise:

$$E(U) = (1-p)^2 U_0 + p^2 U_1 + (1-p)p(U_2 + U_3) \tag{1}$$

where the utilities are:

$U_0 = U(w)$
$U_1 = U(w - l)$
$U_2 = U(w - t)$
$U_3 = U(w - l + t)$

The first order condition (FOC) for risk sharing $t$ is:[15]

$$\frac{\partial E(U)}{\partial t} = (1-p)p(-U_2' + U_3') = 0 \tag{2}$$

The optimal $t$ to solve (2), denoted $t^*$, for a positive $p$ is $l/2$. $\partial E(U)/\partial t = 0$ if and only if $U_2' = U_3'$, which can happen iff $t = t^* \equiv l/2$, in this way:

$$-U_2' + U_3' = -U'(w-t) + U'(w-l+t) = -U'(w-\frac{l}{2}) + U'(w-l+\frac{l}{2}) = 0$$

Consequently, we can conclude that the best that the pair can do is indemnifying half of the losses. The protection provided by the group is therefore limited and welfare is below the level that could be reached with full insurance because transfers are stochastic.

## III.2 Model with Index Insurance

Within this basic setting formal insurance is now introduced and becomes available to the members of the group.

The risk environment is now divided into two components: aggregate and idiosyncratic risk. Aggregate risk affects in equal measure all members of the group, very much like adverse weather leads to losses for all farmers in an area; as such, the partners cannot hedge against the aggregate shock as they both suffer it to the same extent. The probability that the weather shock occurs is given by $v$. When it happens, both partners experience a loss $L$; covariate losses are 0 otherwise.

Aggregate risk is assumed to be independent of the idiosyncratic type, which is still represented by $p$, and follows the same structure as described in the basic setting.

Index insurance becomes available in this context, providing the partners with a cover against losses caused by adverse weather. The product is tied to an index $\tilde{I}$, which is equal to $I$ with probability $q$ and 0 with a likelihood of 1-$q$. An important characteristic of the index $\tilde{I}$ is that it is not perfectly correlated with losses $\tilde{L}$, resulting in four possible states of the world; the outcome of combining the two possible realisations of the index (denoted $I$ or 0, second digit) and the two losses states ($L$ or 0, first digit).

[15] See the Kuhn-Tucker conditions in Appendix A.

$$r \in R = 00, 0I, L0, LI \tag{3}$$

In a similar fashion to Clarke (2011, 2016), parameter $\gamma$ denotes basis risk explicitly, which represents the joint distribution of losses and the index, holding their respective marginal distribution, $v$ and $q$, fixed. In particular, $\gamma$ is the joint probability that the index is 0 and the loss is $L$. An increase in $\gamma$, without any change in $v$ or $q$, can be interpreted as a rise in basis risk or an increase in the probability that an individual incurs in a loss but the index is zero. The resulting joint probability structure is the following:

**Table I.2: Joint Probability Structure**

| | **Index = 0** | **Index = *I*** | |
|---|---|---|---|
| **Loss = 0** | $1 - q - \gamma$ | $q + \gamma - v$ | **1-*v*** |
| **Loss = *L*** | $\gamma$ | $v - \gamma$ | ***v*** |
| | **1-*q*** | ***q*** | |

Denoting each state $r$ by $\pi_r$ Table I.2 can be summarised as $\{\pi_{00}, \pi_{0I}, \pi_{L0}, \pi_{LI}\} = \{1 - q - \gamma, q + \gamma - v, \gamma, v - \gamma\}$.

For an index realisation of $I$ to be a valid indicator that the loss has been $L$, it is required that $\frac{\pi_{LI}}{\pi_{0I}} > \frac{\pi_{L0}}{\pi_{00}}$, implying that:[16]

$$\gamma < v(1 - q) \tag{4}$$

It is also assumed that basis risk $\gamma$ is strictly positive and that all states have a non-negative probability of occurrence, which implies that:

$$\pi_{L0} > 0 \Rightarrow \gamma > 0$$
$$\pi_{LI} \geq 0 \Rightarrow v - \gamma \geq 0 \Rightarrow \gamma \leq v$$
$$\pi_{00} \geq 0 \Rightarrow 1 - q - \gamma \geq 0 \Rightarrow \gamma \leq 1 - q$$
$$\pi_{0I} \geq 0 \Rightarrow q + \gamma - v \geq 0 \Rightarrow \gamma \geq v - q$$

Which can be summarised in:

$$0 < \gamma < v(1 - q) \text{ and } \gamma \geq v - q \tag{5}$$

[16] This condition imposes that for the index to be considered as such, the probability that the index signals a loss when it occurs, with respect to the likelihood of the index being triggered when there are no losses, needs to be be greater than the probability that the index is not triggered when there are losses, with respect to the chance that the index is not triggered when there are no losses.

As noted, the individual has access to index insurance to hedge against the potential loss $L$ due to the aggregate shock, this security pays a proportion $\alpha \geq 0$ of $L$ when the index realisation is *I*. Loss $\tilde{L}$ and index $\tilde{I}$ are imperfectly correlated, therefore the product only offers partial protection against aggregate losses, not paying any indemnity in state *L0*.

In exchange for the indexed security the agent needs to pay a premium of:

$$P = qm\alpha L \tag{6}$$

where $m$ is a multiple applied to the premium which determines its actuarial fairness; for $m > 1, m = 1$ and $m < 1$, the premium is deemed actuarially unfair, fair and favourable, respectively. The payment of $P$ grants a claim of an indemnity $\alpha L$ if the index is *I*, but of zero otherwise.

In the aggregate risk environment described there are four states of the world, depending on the index outcome ($\tilde{I}$) and the occurrence of the aggregate shock ($\tilde{L}$). Yet the realisation of the idiosyncratic shock gives way to four possible outcomes within of each of the aggregate states. The resulting outcome map is a four by four matrix with sixteen different outcomes:

**Table I.3: States Framework**

| **State** | ***r*** | ***L0*** | ***LI*** | ***00*** | ***0I*** |
|---|---|---|---|---|---|
| ***s*** | **Probability $\pi_r$** | $\gamma$ | $v - \gamma$ | $1 - q - \gamma$ | $q + \gamma - v$ |
| | **Probability $\pi_s$** | | **Wealth w/insurance** | | |
| ***NN*** | $(1-p)(1-p)$ | $w - L - P$ | $w - L + \alpha L - P$ | $w - P$ | $w + \alpha L - P$ |
| ***LL*** | $p^2$ | $w - l - L - P$ | $w - l - L + \alpha L - P$ | $w - l - P$ | $w - l + \alpha L - P$ |
| ***NL*** | $p(1-p)$ | $w - t - L - P$ | $w - t - L + \alpha L - P$ | $w - t - P$ | $w - t + \alpha L - P$ |
| ***LN*** | $(1-p)p$ | $w - l + t - L - P$ | $w - l + t - L + \alpha L - P$ | $w - l + t - P$ | $w - l + t + \alpha L - P$ |

Using Table I.3 we can now specify the expected utility maximised by each member of the informal risk-sharing group, facing idiosyncratic, aggregate and basis risk:

$$\begin{aligned} E(U) = (v-\gamma)&\big[(1-p)^2 U_0 + p^2 U_1 + (1-p)p(U_2 + U_3)\big] \\ &+ \gamma\big[(1-p)^2 u_0 + p^2 u_1 + (1-p)p(u_2 + u_3)\big] \\ &+ (q+\gamma-v)\big[(1-p)^2 U_4 + p^2 U_5 + (1-p)p(U_6 + U_7)\big] \\ &+ (1-q-\gamma)\big[(1-p)^2 u_4 + p^2 u_5 + (1-p)p(u_6 + u_7)\big] \end{aligned} \tag{7}$$

where:

$U_0 = U(w - L + (1 - qm)\alpha L)$ **[State *NN-LI*]**
$U_1 = U(w - l - L + (1 - qm)\alpha L)$ **[*LL-LI*]**
$U_2 = U(w - t - L + (1 - qm)\alpha L)$ **[*NL-LI*]**
$U_3 = U(w - l + t - L + (1 - qm)\alpha L)$ **[*LN-LI*]**
$U_4 = U(w + (1 - qm)\alpha L)$ **[*NN-0I*]**
$U_5 = U(w - l + (1 - qm)\alpha L)$ **[*LL-0I]***
$U_6 = U(w - t + (1 - qm)\alpha L)$ **[*NL-0I*]**
$U_7 = U(w - l + t + (1 - qm)\alpha L)$ **[*LN-0I*]**

and:

$u_0 = U(w - (1 + qm\alpha)L)$ **[*NN-L0*]**
$u_1 = U(w - l - (1 + qm\alpha)L)$ **[*LL-L0*]**
$u_2 = U(w - t - (1 + qm\alpha)L)$ **[*NL-L0*]**
$u_3 = U(w - l + t - (1 + qm\alpha)L)$ **[*LN-L0*]**
$u_4 = U(w - qm\alpha L)$ **[*NN-00*]**
$u_5 = U(w - l - qm\alpha L)$ **[*LL-00*]**
$u_6 = U(w - t - qm\alpha L)$ **[*NL-00*]**
$u_7 = U(w - l + t - qm\alpha L)$ **[*LN-00*]**

Because both partners in the group are identical, they will both purchase the insurance or not.

Each member of the group must choose the level of coverage $\alpha$, conditional on the group's ability to hedge against idiosyncratic losses, by maximising equation (7).

The FOC with respect to $\alpha$ of the problem is:[17]

$$\begin{aligned}\frac{\partial E(U)}{\partial \alpha} &= (1 - qm)\Big\{(v - \gamma)\big[(1-p)^2 U_0' + p^2 U_1' + (1-p)p(U_2' + U_3')\big] \\ &\quad + (q + \gamma - v)\big[(1-p)^2 U_4' + p^2 U_5' + (1-p)p(U_6' + U_7')\big]\Big\} \\ &\quad - qm\Big\{\gamma\big[(1-p)^2 u_0' + p^2 u_1' + (1-p)p(u_2' + u_3')\big] \\ &\quad - (1 - q - \gamma)\big[(1-p)^2 u_4' + p^2 u_5' + (1-p)p(u_6' + u_7')\big]\Big\} = 0 \end{aligned} \tag{8}$$

Given that $E(U)$ is a concave function, the second-order condition is trivially satisfied.[18]

[17] See the Kuhn-Tucker conditions in Appendix A
[18] The function consists of the sum of several concave functions $U_i$.

## III.3 Propositions

Clarke (2011, 2016) states that in his model without risk sharing of idiosyncratic risk, for $0 \leq \alpha < 1$, the objective function has strictly decreasing differences in $(\alpha; \gamma)$, *i.e.* $\frac{\partial^2 E(U)}{\partial\alpha\partial\gamma} < 0$. A result which, as argued by Mobarak and Rosenzweig (2012), carries over to the current model with informal, but constrained, risk sharing and can be expressed in the form of a proposition:

**Proposition 1:** *The optimal level of coverage $\alpha^*$ is decreasing in basis risk $\gamma$, and strictly decreasing if $\alpha^* > 0$.*

A second proposition to follow from equation (8) gives us the demand behaviour when insurance does not suffer from basis risk:

**Proposition 2:** *If there is no basis risk and insurance is actuarially fair, the partners will fully insure ($\alpha^* = 1$) and variation in $t$ will have no effect on the demand for insurance.*

With $m = 1$ and no basis risk, $q = v$ and $\gamma = 0$, equation (8) turns into the following expression:[19]

$$(1-p)^2 U_0' + p^2 U_1' + (1-p)p(U_2' + U_3') = (1-p)^2 u_4' + p^2 u_5' + (1-p)p(u_6' + u_7') \quad (9)$$

The only solution for $\alpha$, which equates both sides of the expression, is $\alpha^* = 1$, no matter the value taken by $t$.

This result is very much in line with classical insurance theory which states that a rational risk-averse agent will always chose full coverage of fairly priced insurance to make wealth equal in all states of the world (Zweifel and Eisen, 2012). In terms of our model, the agent will choose to fully insure against the common shock regardless of the transfers received to cope with the idiosyncratic shock.

When there is basis risk, the influence of risk sharing $t$ on optimal coverage can be ascertained by performing a *comparative statics* analysis.

Comparative statics consist on subjecting the optimum condition to an exogenous shock in the parameters of interest.

This will entail an optimal adjustment $\alpha^*$ resulting in the objective function $E(U)$ attaining its maximum somewhere else. Nevertheless, the new maximum must still satisfy the first-order condition $dE(U)/d\alpha = 0$ in equation (8). Consequently, the equality to zero must hold before and after the adjustment (Zweifel and Eisen, 2012).

[19] See the full proof in Appendix A.

Let us perform the analysis for a change in informal transfers, $t$, which can be expressed as follows:

$$\frac{\partial^2 E(U)}{\partial^2 \alpha} d\alpha + \frac{\partial^2 E(U)}{\partial \alpha \partial t} dt = 0 \tag{10}$$

The second therm on the left-hand side shows the impact of the shock on expected utility, and the first term, the impact of the induced adjustment of $\alpha^*$. Equation (10) can be rearranged to obtain:

$$\frac{d\alpha}{dt} = -\frac{\partial^2 E(U)/\partial\alpha\partial t}{\underset{(-)}{\partial^2 E(U)/\partial^2\alpha}} \gtreqless 0 \tag{11}$$

Since $u'' < 0$ follows from the concavity of the utility function of the decision maker, the denominator is negative. Therefore, the sign of the numerator determines the sign of $d\alpha^*/dt$.

Consequently based on the above mathematical logic, when there is basis risk, the insurance is actuarially fair ($m = 1$), and the condition specified in equation (5) is satisfied (*i.e.* the index is informative), risk sharing $t$ influence on optimal coverage is given by the following expression:

$$\begin{aligned}
\frac{d\alpha^*}{dt} &= (1-p)p\Big\{(v-\gamma)(1-q)(U_3'' - U_2'') - \gamma q(u_3'' - u_2'') \\
&\quad + (q+\gamma-v)(1-q)(U_7'' - U_6'') - (1-q-\gamma)q(u_7'' - u_6'')\Big\}/\Theta, \\
\text{where}\quad \Theta = \frac{E(U)}{\partial^2\alpha} &= (1-q)^2\Big\{(v-\gamma)\big[U_0''(1-p)^2 + U_1''p^2 + (1-p)p(U_2'' + U_3'')\big] \\
&\quad + (q+\gamma-v)\big[U_4''(1-p)^2 + U_5''p^2 + (1-p)p(U_6'' + U_7'')\big]\Big\} \\
&\quad + q^2\Big\{\gamma\big[u_0''(1-p)^2 + u_1''p^2 + (1-p)p(u_2'' + u_3'')\big] \\
&\quad + (1-q-\gamma)\big[u_4''(1-p)^2 + u_5''p^2 + (1-p)p(u_6'' + u_7'')\big]\Big\} < 0
\end{aligned} \tag{12}$$

The expression can be both positive or negative, as we discuss below.

A farmer member of a group with a greater ability to share idiosyncratic risk derives greater utility from the indexed cover because it mitigates the utility reduction in the worst state ($u_3$), when the group incurs in an aggregate loss but receives no insurance payment and, in addition, the individual experiences and idiosyncratic loss.[20] If risk sharing is less

[20] This is the worst state in which a transfer is made, the actual worst state is $u_1$, when the farmer experiences the same situation as in $u_3$ but receives no transfer, because the partner has also experienced an idiosyncratic loss.

than optimal ($t < t^* = \frac{l}{2}$), as is likely due to commitment issues and liquidity constraints, the term in equation (12) containing the worst outcome ($-\gamma q(u_3'' - u_2'')/\Theta$) would be **positive**.[21]

Similarly, receiving an informal transfer for an idiosyncratic loss increases overall utility, and makes the cost of the premium, even when the policy does not pay, less taxing. The term $-(1-q-\gamma)q(u_7'' - u_6'')/\Theta$ is **positive**.[22]

By contrast, a greater compensation for the idiosyncratic losses when the aggregate loss is partly indemnified by the insurance payouts lowers the utility gain from the formal insurance: the term $(v-\gamma)(1-q)(U_3'' - U_2'')/\Theta$ in equation (12) is **negative**.[23] The essence of this result is that the higher the level of wealth at which an informal transfer is made, *i.e.* when an insurance payout has been received, the more the utility gain falls. Due to the concavity of the utility function, the gain from receiving a transfer when an idiosyncratic shock occurs is lower the higher the level of wealth, whereas the loss in utility from having to support the partner—when one does not suffer from an idiosyncratic shock—fails to decrease in the same proportion. As a result, utility from informal transfers increases to a lesser extent the higher wealth is, that is, when one has received an insurance payout.

Insurance becomes even more redundant with higher risk sharing when the farmer experiences no aggregate losses but an indemnity payout is received. The term $(q+\gamma-v)(1-q)(U_7'' - U_6'')$ in the equation is also **negative**.[24]

We have therefore established that the level of loss sharing is likely to influence the demand for index insurance, and that the sign of this effect is ambiguous given the offsetting factors at play. We can summarise this result in the following proposition:

**Proposition 3:** *If index insurance is actuarially fair but there is basis risk, the index is informative, and some index insurance is purchased, then a rise in the level of risk sharing will increase optimal coverage ($\alpha^*$) if and only if the gains of utility from the transfers exceeds the losses also associated with an increase in risk sharing.*

In summary, the model predicts that risk sharing does not affect indemnity insurance demand, but will most likely lead to changes in uptake of index insurance, which will be positive or negative depending on whether the complementarities between the two forms of protection offset the redundant aspects.

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[21] The reason for this result is that under the conditions stated ($U'' < 0$ and $t < t^*$), we have: $w - t - (1+qm\alpha)L > w - l + t - (1+qm\alpha)L \Rightarrow U(w-t-(1+qm\alpha)L) > U(w-l+t-(1+qm\alpha)L) \Rightarrow u_2 > u_3$ It follows then: $|u_2''| > |u_3''| \Rightarrow u_3'' - u_2'' > 0 \Rightarrow -\gamma q(u_3'' - u_2'') < 0 \Rightarrow -\gamma q(u_3'' - u_2'')/\Theta > 0$

[22] In a similar fashion to the earlier result, and given that $(1-q-\gamma) > 0$: $|u_6''| > |u_7''| \Rightarrow u_7'' - u_6'' > 0 \Rightarrow -(1-q-\gamma)q(u_7'' - u_6'')/\Theta > 0$

[23] Given that $v-\gamma$, $1-q > 0$: $|U_2''| > |U_3''| \Rightarrow U_3'' - U_2'' > 0 \Rightarrow (v-\gamma)(1-q)(U_3'' - U_2'')/\Theta < 0$

[24] $|U_6''| > |U_7''| \Rightarrow U_7'' - U_6'' > 0 \Rightarrow (q+\gamma-v)(1-q)(U_7'' - U_6'')/\Theta < 0$

# IV Experimental Design and Implementation

## IV.1 Area of Study

We conducted a framed field experiment in a rural region of eastern Uganda. This region, located in the Greater Mbale area, comprises the districts of Sironko and Lower Bulambuli, formerly known as Sironko District.[25] This area is close to the border with Kenya, and benefits from substantial, bimodal rainfall, which determines the two cropping seasons around which farmers organise their activities (Humphrey and Verschoor, 2004). The vagaries of the weather are arguably the most important source of risk with 53% and 76% of communities affected by a drought or a flood, respectively, in the last 12 years, and milder but prolonged dry spells or periods of heavy rain taking place more frequently.[26] The area is estimated to be inhabited by around 300,000 people, with a large majority of the population having a Bagisu ethnical background and professing some form of Christianity (UBOS, 2014; Verschoor *et al.*, 2016).

Table I.4 below shows descriptive statistics from a representative sample of the area.[27]

**Table I.4: General Descriptives$^{\Psi}$**

| **Variable** | **Mean** | **Std. Dev.** | **Min** | **Max** |
|---|---|---|---|---|
| Gender (1=Male) | 0.51 | 0.5 | 0 | 1 |
| Age | 40 | 14 | 18 | 73 |
| Education (years) | 6 | 3 | 0 | 13 |
| Married | 0.8 | 0.4 | 0 | 1 |
| Size Households | 5.85 | 2.73 | 1 | 19 |
| Bagisu Ethnicity | 0.95 | 0.22 | 0 | 1 |
| Christian | 0.91 | 0.28 | 0 | 1 |
| Farmer | 0.82 | 0.39 | 0 | 1 |
| Land holdings | 1.72 | 3.3 | 0 | 75 |

Source: Authors' calculations (2012).
Sample size: 1,802 households.
$^{\Psi}$ Sample weights employed.

Most people are married and scarcely educated, with barely 5 years of formal education. Household size averages almost six members, and half of them are estimated to be dependents. People in this area are primarily farmers of their own land, 98 percent of households cultivate some land and 82 percent report working on the household farm as their primary

[25] A map of the area can be found in Appendix A.

[26] The source of these statistics is a survey conducted in 2012 by Verschoor, D'Exelle and Pérez-Viana (2016). Anecdotal evidence from the time reveals that the impact of these events in a farmer's livelihood can be substantial, for example, reducing a regular harvest of 12 bags of maize to only 3 when a drought sets in.

[27] The descriptives were calculated with data from Verschoor *et al.* (2016) collected in the 2012 survey, containing information from 1,800 households.

activity. The remainder of the population typically grows crops as a secondary activity alongside running their own businesses. However, land holdings are small, at around 1.7 acres on average, with few big farmers living in the area.

## IV.2 Sample Selection and Fieldwork Implementation

In the selection of the sample for the study, we employed the sampling framework of Verschoor, D'Exelle and Pérez-Viana (2016), used to obtained a representative sample from the area in 2012.[28]

We selected purposively two sub-counties from the ten selected in the 2012 study.[29] Subsequently, a random draw gave us the names of the 20 villages which took part in the study.

In each of these villages, a list of all adults (18+) by household was compiled and up to 20 adults were randomly selected from the list, subject to the condition that they belonged to different households and that farming was their primary activity.

Data collection took place between August and October of 2016. First, the enumerator team visited all participants to administer the household survey, then, the experiments were carried out in each sub-county. The author supervised *in situ* the entire data collection operation.

In each sub-county, the experiments were conducted in a central venue (typically, a school), conveniently located for participants. Selected subjects from two different villages came every day and took part in the games for about three hours. One session of each game implemented was run in parallel administered by two different teams of enumerators. Attrition was very low, with more than 95% of the selected participants taking part in the study.

## IV.3 Experiment

### IV.3.1 Participants

Prior to the experiment, participants from each of the selected villages were divided randomly into two groups, differentiated by the treatments they took part in (Game 1 or Game 2). Each group from every village participated in one of the ten experimental sessions, each of which was attended by twenty subjects from two different villages in equal proportion (*i.e.* ten from each village).

[28] Chapter 3 contains a full description of the framework (Pérez-Viana, 2019b).
[29] A sub-county is a smaller administrative unit contained within a district.

**Table I.5: Experimental Sessions**

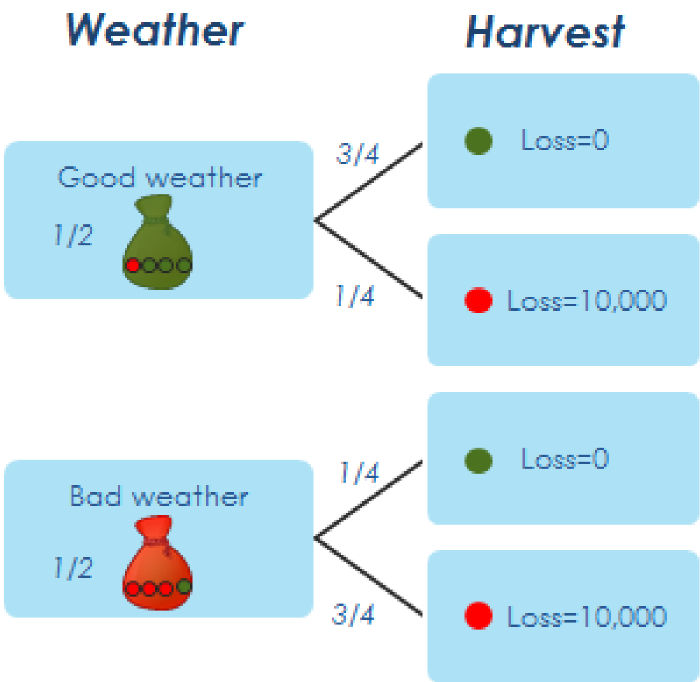
| | Game 1 | Game 2 |
|---|---|---|
| Sessions | 10 | 10 |
| Villages | 20 | 20 |
| Participants | 196 | 196 |

### IV.3.2 Setting

In the experiment, participants were allocated an endowment of 16,000 Ugandan Shillings, and were paired with another individual.[30] One of the members of the pair, Person 1, was then presented a situation with a probability structure, framed as a real-world agricultural context, in which the likelihood of losing a significant fraction (approx. 63%) of the endowment due to a negative (weather) shock was appreciable.[31] The situation is depicted in Figure I.1.

In general, Person 1 faced the loss of her endowment and was offered insurance against this event, which she could decide how much to buy. In contrast, Person 2 had to decide the extent to which she compensated the losses experienced by Person 1 using her own endowment, which was not at risk.[32]

**Figure I.1: Probability Structure Experiment**




[30] 16,000 Shillings are approximately five dollars ($4.73), equivalent to three or four days' wages of an agricultural labourer.

[31] Persons 1 stood to lose 10,000 Shillings, 62.5% of the endowment.

[32] The dichotomy between the roles is inspired in the desing of D'Exelle and Verschoor (2015), who implemented it in a risky-choice experiment.

This probability structure, inspired by Clarke and Kalani (2011), is characterised by two types of shocks. First, a common shock, which determined the weather conditions, that is, the probability distribution determining whether those exposed to losses actually experience them. This shock affected everyone facing losses in the same way and was randomly determined. The second type of shock, of idiosyncratic nature, was the actual realisation of the losses. Contrarily to the weather shock, the idiosyncratic kind affected every person whose endowment was at risk differently, so that not everyone would necessarily experience losses if some other person playing the game suffered them. Although losses were more likely to happen in the event of a common shock, the chances they realised were still determined at random.

The probability structure described above is a representation of the risk environment formalised in the theoretical framework. In a similar fashion to the experimental depiction, there were two types of shocks, a covariate and an idiosyncratic one, in the model. However, in the theory these two shocks led to distinct types of losses when they occurred, rather than to only one kind, as in the experiment. In spite of this difference, losses in the experiment can be thought as deriving also from a common shock and an idiosyncratic one. In fact, this breakdown is readily quantifiable. The change in the expected value of the losses with and without the covariate shock represents the amount of the losses directly attributable to the common shock; with the remainder being the idiosyncratic losses.[33] Additionally, losses in the experiment could not be fully insured by purchasing insurance, meaning that some idiosyncratic losses always remained, as they did in the model.

### IV.3.3 Treatments

Participants were subjected to a number of treatments resulting from the combination of two different dimensions: type of insurance product available to Person 1 and risk sharing technology the partner had at her disposal. The first dimension breaks down into having access to index insurance, to indemnity insurance or to no insurance whatsoever. The second is simply differentiated by whether Person 2 is able to compensate Person 1's losses or not. The combination of the two dimensions gives rise to a grid of treatments which can be summarised in the following table:

[33] The expected value of the losses when the weather is good is:

$$EV(L) = \frac{1}{4} \times 10,000 + \frac{3}{4} \times 0 = 2,500$$

This amount represents idiosyncratic losses.
The corresponding expected value when the weather is bad is:

$$EV(L) = \frac{3}{4} \times 10,000 + \frac{1}{4} \times 0 = 7,500$$

Therefore, there is an increase in expected losses of 5,000 Shillings directly attributable to the common (weather) shock.

**Table I.6: Treatment Matrix**

| | *Insurance* | | |
|---|---|---|---|
| ***Risk Sharing*** | **Index** | **Indemnity** | **No Insurance** |
| **Risk Sharing** | T1 | T3 | T5 |
| **No risk Sharing** | T2 | T4 | |

In the first two treatments, Person 1 had access to index insurance for protection against negative income shocks. Subjects could insure against bad weather purchasing the indexed security, which paid out an indemnity when the shock hit. However, due to basis risk the cover only offered indirect protection against losses, given that insurance payments could fail to be disbursed when Person 1 experienced losses.

Person 2 was allowed, in the first of these treatments (*T1*), to compensate Person 1 for her losses. By contrast, in *T2* Person 2 was not given the chance to make any transfer to Person 1.

Losses included those caused by the shocks, the costs of the insurance, but were net of insurance payouts if they were disbursed. If a shock resulting in 'harvest' losses did not take place, informal transfers were not possible.

The next two treatments (*T3* and *T4*) are characterised by a change in the insurance product Person 1 was offered, now of the indemnity type. This cover allowed Person 1 to directly insure against any losses she may have suffered, regardless of the weather conditions. Same as before, in the first of this type of treatments, *T3*, Person 2 could help Person 1 against any losses she may have experienced by making a transfer, whereas in *T4* no transfers were permitted.

Persons' 2 decisions in *T1* and *T3* correspond to transferred amount $t$ in the theoretical framework, which ensue when only one of the partners experiences idiosyncratic losses, that is, in two out of the four states in the states framework (Table I.3).[34] The remaining states, when risk sharing $t$ does not occur, are represented by the transfer-less treatments (*T2* and *T4*).

Finally, in the fifth treatment (*T5*) Person 1 was not given the right to buy insurance and had to rely solely on the generosity of Person 2 to deal with her losses.

[34] In other words, these two treatments represent the states in which either the first partner makes a loss and the second does not (*LN*), or *vice versa* (state *NL*); the two states when transfers take place.

### IV.3.4 Decisions

In all treatments in which participants were offered insurance they were required to choose the extent of their coverage, expressed in terms of the number of insurance units they wished to purchase, which could range from 0 to 4 units. Each unit of insurance cost 1,500 Shillings and was associated with a payout of 2,250 Shillings. Table I.7 below provides further details about the two types of cover in the game.

**Table I.7: Insurance Characteristics**

| | **Index Insurance** | **Indemnity Insurance** |
|---|---|---|
| Payout per unit | 2,250 | 2,250 |
| Unconditional Probability of Payout | 1/2 | 1/2 |
| Expected Payout (=actuarially fair premium) | 2,250/2=1,125 | 1,125 |
| Premium | 1,500 | 1,500 |
| Loading [35] (mark-up over fair premium) | $33.\overline{3}\%$ | $33.\overline{3}\%$ |

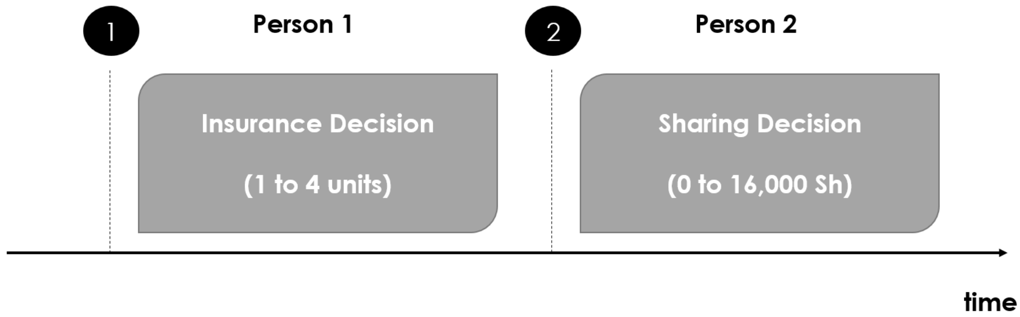
Unlike recent experimental papers (Clarke and Kalani, 2011; Berg *et al.*, 2017) investigating demand for formal insurance, we apply the same loading to both insurance products, which also grant the same probability of receiving a payout, to ensure that the only difference between the two covers is exclusively due to basis risk. This feature allows us to control the source of exogeneity, limiting it to basis risk, which enables us to draw clean comparisons between the relevant treatments, and to claim that the shifts observed in demand are caused by the differences between the covers.

The coverage chosen determined the individual indemnity payable, and therefore the extent of the protection that could be decided by the participant. This hedge could be complemented by an informal transfer in *T1* and *T3*, depending on the decision taken by Person 2, who could share any amount of her endowment, from 0 to 16,000 Shillings, regardless of the losses experienced by Person 1. In order to elicit the sharing decision, we implemented a strategy method by which Person 2 had to decide how much she wished to transfer for every possible level of coverage chosen by Person 1. Before being asked to decide, Person 2 was shown the full array of coverage options and the extent of Person's 1 potential losses for each of these choices. Figure I.2 below shows the timeline for the decisions taken.

The sequence of decisions always followed the pattern described in the figure for all treatments implemented. First, Person 1 took her insurance decision, and subsequently Person 2 decided how much she wished to share, if such option was permitted in the treatment.

Losses included the cost of insurance as well as the uninsured losses, to avoid disincentivising excessively the purchase of insurance due to the (almost) complete vanishment of shareable losses as coverage increased. Nevertheless, shareable losses went down with coverage and the cost of insurance could not be shared when the shock did not take place (*i.e.* without the 10,000 Shillings loss).

**Figure I.2: Timeline Decisions**




### IV.3.5 Other Design Choices

The experimental setup tried to avoid that (anticipated) post-experimental transfers influenced decision-making among participants by making all the pairings anonymous.

However, half of the participants in every session were co-villagers and the other half belonged to a different village. A setup that ensured social distance was kept low among participants, making it likely that risk sharing took place as it would in real life. Transfers of income are frequent and central to financial security in rural communities in the developing world, and in Sub-Saharan Africa in particular (Fafchamps, 2003, 2008). As a result, it is likely to observe transfers when the need arises. Furthermore, in our area of study, D'Exelle and Verschoor (2015) report a sizeable level of loss sharing in an experiment simulating a situation close to the one described here and carried out in the same area.

Even though both partners were not identical in the game as they are represented in the theoretical framework, the design strived to make the partners feel as part of a cooperative arrangement, in which they faced similar circumstances, by having them assume both the role of Person 1 and Person 2 in sequence.[36] Nevertheless, individuals were paired with a different partner for the insurance (as Person 1) and sharing decision (as Person 2) to prevent the imposition of reciprocity and keep focused the exogenous element in the design, as explained next.[37]

One of the main reasons we avoided that participants fulfilled the role of Person 1 and 2 simultaneously was to restrict the source of random variation, so that the coverage

[36] For example, every participant assumed the role of Person 1 first in T1, and later on that of Person 2 in the second round of the treatment.

[37] See the implementation sub-section below for further details.

decision was dependent only on anticipated risk sharing, rather than on the insurance decision of the partner as well. Under simultaneity with the same partner, a decision maker choosing the level of coverage would also have to consider the insurance decision of the partner. If, for instance, the partner chooses not to insure and makes losses, she would vie for a higher degree of support than a decision maker who chooses to buy some insurance. These free-riding considerations may influence the insurance decision aside from the possibility of receiving transfers.

Our intention was also to augment the salience of risk sharing in those treatments where it was allowed. With simultaneous roles, the chance of receiving a transfer would not follow automatically from making losses, it would be conditional on the partner not having made losses too, diminishing the influence of risk sharing.

### IV.3.6 Payoffs

Table I.8 depicts the payoffs for an individual participant in every state of the world determined by the weather, under every possible insurance status.[38] Expected payoffs are calculated by subtracting from the endowment, if applicable, the losses incurred, as well as by adding the insurance payout minus its cost, when insurance is present.

The expected payoffs shown in Table I.8 translate into the experimental payoffs in Table I.9. For every possible level of coverage, the first row shows the pertinent calculation, subtracting and adding the necessary elements, and the second the resulting net payoff.

[38] The payoffs do not include informal transfers, as there is no guarantee that those would take place and their amount is uncertain even if they do.

**Table I.8: Expected Payoffs Person 1**

| | Payoff (UGX) | | | | Expected Payoff |
|---|---|---|---|---|---|
| State: | Losses | | No Losses | | |
| Weather: | Good | Bad | Good | Bad | |
| Loss: | $L$ | $L$ | 0 | 0 | |
| Prob ($\pi_r$): | $\gamma$ | $v-\gamma$ ($^{\psi}$) | $1-q-\gamma$ | $q+\gamma-v$ | |
| No Insurance | $w-L$ ($^*$) | | $w$ | | $v(w-L)+(1-v)w$ |
| Indemnity Ins. | $w-L+\alpha L-P$ | | $w-P$ | | $v(w-L+\alpha L-P)+(1-v)(w-P)$ |
| State: | $L0$ [1] | $LI$ [2] | 00 [3] | $0I$ [4] | |
| Index Ins. | $w-L-P$ | $w-P+\alpha L-L$ | $w-P$ | $w-P+\alpha L$ | $\gamma[1]+(v-\gamma)[2]$ $+(1-q-\gamma)[3]+(q-\gamma-v)[4]$ |

($^{\psi}$) $v$ represents the probability of losses $L$.

$^*$As explained earlier, $L$ comprises both the covariate ($L$) and idiosyncratic losses ($l$), which appear separately in the theoretical framework.

**Table I.9: Experimental Payoffs Person 1**

| State: | Losses | | No Losses | | |
|---|---|---|---|---|---|
| Weather: | Good | Bad | Good | Bad | |
| Loss: | 10,000 | 10,000 | 0 | 0 | |
| Prob: | 1/8 | 3/8 | 3/8 | 1/8 | |
| Insurance Units | Payoff (UGX) | | | | Expected Payoff |
| | **No Insurance** | | | | |
| | 16,000-10,000<br>6,000 | | 16,000<br>16,000 | | 11,000 |
| | **Indemnity Insurance** | | | | |
| 0 | 16,000-10,000<br>6,000 | | 16,000<br>16,000 | | 11,000 |
| 1 | 16,000-10,000-1,500+2,250<br>6,750 | | 16,000-1,500<br>14,500 | | 10,625 |
| 2 | 16,000-10,000-1,500·2+2,250·2<br>7,500 | | 16,000-1,500·2<br>13,000 | | 10,250 |
| 3 | 16,000-10,000-1,500·3+2,250·3<br>8,250 | | 16,000-1,500·3<br>11,500 | | 9,875 |
| 4 | 16,000-10,000-1,500·3+2,250·4<br>9,000 | | 16,000-1,500·4<br>10,000 | | 9,500 |
| | **Index Insurance** | | | | |
| State: | $L0$ | $LI$ | 00 | $0I$ | |
| 0 | 16,000-10,000<br>6,000 | 16,000-10,000<br>6,000 | 16,000<br>16,000 | 16,000<br>16,000 | 11,000 |
| 1 | 16,000-10,000-1,500<br>4,500 | 16,000-10,000-1,500+2,250<br>6,750 | 16,000-1,500<br>14,500 | 16,000-1,500+2,250<br>16,750 | 10,625 |
| 2 | 16,000-10,000-1,500·2<br>3,000 | 16,000-10,000-1,500+2,250·2<br>7,500 | 16,000-1,500·2<br>13,000 | 16,000-1,500·2+2,250·2<br>17,500 | 10,250 |
| 3 | 16,000-10,000-1,500·3<br>1,500 | 16,000-10,000-1,500+2,250·3<br>8,250 | 16,000-1,500·3<br>11,500 | 16,000-1,500·2+2,250·3<br>18,250 | 9,875 |
| 4 | 16,000-10,000-1,500·4<br>0 | 16,000-10,000-1,500+2,250·4<br>9,000 | 16,000-1,500·4<br>10,000 | 16,000-1,500·2+2,250·4<br>19,000 | 9,500 |

### IV.3.7 Time Frame and Implementation

The implementation of the experiment followed a series of defined steps, summarised in the following table:

**Table I.10: Time Frame**

| Time | Event |
|---|---|
| t=1 | Setting up games & pairing |
| t=2 | Explanations Part 1 (later on Part 2 & 3) |
| t=3 | Decisions (back to t=2 for Part 2/3) |
| t=4 | Resolution |
| t=5 | Payment |

For full details about the implementation see Appendix C, which contains the entire experimental script for one of the games implemented.

***Step 1: Setting up the games (t=1)***

Participants arrived at the venue for registration and were allocated to one of two rooms, representing different sets of treatments. Participants allocated to one of these rooms took part in Game 1, which comprised the index insurance treatments (*T1* and *T2*); and those selected to the other room participated in Game 2, featuring the treatments where the cover available was of the indemnity type (*T3* and *T4*). Everyone played *T5*, regardless of which Game they were allocated to.

***Step 2: Pairing (t=1)***

Participants were paired with other individuals taking part in the session. Each partner performed a different role, however, each role was taken by every partner in sequence. For example, every participant assumed the role of Person 1 first in *T1*, and later on that of Person 2 in the second round of the treatment.

As noted, Person 1 faced the loss of her endowment and was offered insurance against this event, which she could decide how much to buy. In contrast, Person 2 had to decide the extent to which she compensated the losses experienced by 1 using her own endowment.

Subjects were paired with a different individual for every role they fulfilled. For example, in *T1*, the participant's partner while playing as Person 1 in the first round of the treatment was different from the one she had in the second, when taking the role of Person 2. This procedure was explained to participants in simple terms through role playing at the explanation stage.

***Step 3: Explanations (t=2)***

Subjects were explained the game.

They were presented with a probability structure common to all treatments (Figure I.1 above), where Person 1 was subjected to the two above-mentioned types of shocks.

The game consisted of three parts, differentiated by the role fulfilled by participants and the existence of risk sharing.

**Part 1**

In the first part, subjects participated in the treatments in which only Person 1 played an active role and loss compensation was not allowed.

Subjects were explained one of these treatments publicly. Whether the type of cover available in the treatments was indexed (*T2*) or not (*T4*) had been randomly determined beforehand, during the selection of participants to Games 1 or 2, respectively.

After the explanations, understanding was tested privately by an enumerator and participants proceeded to the decision stage. During this private time with the enumerator, subjects were informed they would fulfil the role of Person 1. The information was disclosed privately to make more believable the presence of Person 2 in the room.

The game went back to the explanations step for the second part of the experiment.

**Part 2**

Once subjects had made their choices in Part 1, the next one began.

The game came back to the explanations step for the second treatment, *T1* in Game 1 or *T3* in Game 2. In contrast to the previous treatment (*T2* or *T4*), Person 2 was allowed to make a transfer to Person 1.

Given that Person 2 was active, there were two rounds in this part. In the first, all participants took their coverage decisions as Person 1, and in the second, they decided as Person 2. Once again, in order to substantiate the existence of both persons in the pair, participants were informed of the role they were fulfilling in the round privately.

After the explanations, understanding was tested and participants proceeded to the decision stage. In the first round they took the decision as Person 1, and in the second as Person 2.

**Part 3**

After all the decisions in part 2 were made, the final one started with the public explanations once again.

Subjects participated in the treatment where only Person 2 played an active role (*T5*). In this treatment no insurance was available and Person 1 only fulfilled a passive role.

***Step 4: Decisions (t=3)***

After participants had been explained a part (or only a round), they were asked to take a decision. In particular, Person 1 had to decide the number of units of insurance she wished to purchase, ticking the appropriate box in a card like the one below in Figure I.3.

**Figure I.3: Example Decision Card Person 1 (T4)**

| ***Person 1*** | | *ID: ____ Part:__1__ Session:____* | |
|---|---|---|---|
| | | ● - 0 | ● - 10,000 |
| ***Insurance Units*** | ***Insurance Price*** | ***Good Harvest*** | ***Bad Harvest*** |
| 0 ☐ | - 0 | ● + 0 Earnings: 16,000 | ● + 0 Earnings: 6,000 |
| 1 ☐ | - 1,500 | ● + 0 Earnings: 14,500 | ● + 2,250 Earnings: 6,750 |
| 2 ☐ | - 3,000 | ● + 0 Earnings: 13,000 | ● + 4,500 Earnings: 7,500 |
| 3 ☐ | - 4,500 | ● + 0 Earnings: 11,500 | ● + 6,750 Earnings: 8,250 |
| 4 ☐ | - 6,000 | ● + 0 Earnings: 10,000 | ● + 9,000 Earnings: 9,000 |

Person 2 needed to decide how much, if any, of Person 1's losses she wanted to compensate using her endowment and record them.

The decisions of Person 2 were elicited using a strategy method, in which the participant determined how much she wished to transfer in case of losses, for every level of coverage that could be selected by Person 1. An example of the card filled by participants is shown in Figure I.4.

**Figure I.4: Decision Card Person 2 (T3)**

| **Person 2** | | ID: ____ Part: __2__ Session:____ |
|---|---|---|
| ● - 10000 | | |
| **Insurance Units** | **Losses Person 1** | **Sharing** |
| 0 | 10,000 | _________ Shillings |
| 1 | 9,250 | _________ Shillings |
| 2 | 8,500 | _________ Shillings |
| 3 | 7,750 | _________ Shillings |
| 4 | 7,000 | _________ Shillings |

Immediately after the decisions for a given part (or round) were taken, the experiment went back to the explanations step (t=2) so as to continue with the next part (or round).

***Step 5: Resolution (t=4)***

Once subjects had decided about the number of insurance units they wished to buy and, if necessary, how much losses they would compensate in all treatments they participated, a random draw selected which treatment was resolved to determine their gains.

As soon as this was known, the realisation of the covariate shock was randomly determined through a public draw of a green or a red bag.

The selected bag was employed to determine whether losses were realised for Person 1 in the pair. Prior to this, one type of pair was selected, out of the two each participant was involved in every part.

***Step 6: Payments (t=5)***

After the resolution and depending on the decisions made by both members of the pair, payments were calculated for the selected treatment and pair.

Each participant was explained their outcome individually and paid privately.

### IV.3.8 Understanding

Ensuring the understanding of the experiment by participants was one of the key objectives of the design and the implementation went to great lengths in order to achieve it.

The experiment was conducted with small groups of twenty participants in compact classrooms, which however allowed sufficient separation between participants. The setting and decisions were explained thoroughly to all participants by the lead experimenter. Each part (*i.e.* treatment) was explained in full before any decisions were made. At this point, participants were asked to seat individually with one of the enumerators who informed them of the role they were playing (*i.e.* Person 1 or 2) and remind them of the decision to be taken.[39] Once this was done understanding was tested.

The aim of the control questions was not to test the numeracy skills of participants but rather their comprehension of the game employing the decision card—the tool where they would record their choices. All questions were based on their capacity to make use of the card effectively, and they most frequently involved pointing at the part of the card where the exact answer could be found. There were eight questions of this kind, half of them posed after the first stage of the explanations was completed and the rest asked after the remaining parts were explained. The overall percentage of correct answers was very high, above 90%. The precise wording of the questions and all other explanations can be found in Appendix C.

[39] Each experimental session took around three hours to complete.

# V Analysis

In this section, we present the main empirical results, which test the predictions of our theoretical framework regarding the influence of risk sharing on the demand for insurance. In the second subsection we also look at the effect that formal insurance exerts on risk sharing.

## V.1 Descriptives

We begin with a set of descriptive statistics and balancing tests.

**Table I.11: Summary Statistics and Balancing Tests**$^{\Psi}$

| Variable | Mean (Standard Deviation) Total (N=392) | Game 1 (N=196) | Game 2 (N=196) | t-stat | p-value |
|---|---|---|---|---|---|
| Gender (1=Male) | 0.463 | 0.531 | 0.395 | 2.71 | 0.007 |
| | (0.5) | (0.5) | (0.49) | | |
| Age | 38.57 | 39.08 | 38.06 | 0.752 | 0.452 |
| | (13.42) | (13.59) | (13.26) | | |
| Married | 0.788 | 0.765 | 0.811 | -1.112 | 0.267 |
| | (0.409) | (0.425) | (0.395) | | |
| Household size | 5.559 | 5.582 | 5.536 | 0.172 | 0.863 |
| | (2.628) | (2.573) | (2.688) | | |
| Years of Education | 5.703 | 5.842 | 5.536 | 0.841 | 0.401 |
| | (3.246) | (3.307) | (3.185) | | |
| Bagisu Tribe | 0.9693 | 0.9642 | 0.974 | -0.585 | 0.559 |
| | (0.172) | (0.186) | (0.158) | | |
| Protestant | 0.610 | 0.622 | 0.597 | 0.517 | 0.606 |
| | (0.488) | (0.486) | (0.492) | | |
| Land Holdings | 1.262 | 1.274 | 1.251 | 0.199 | 0.842 |
| | (1.156) | (1.186) | (1.129) | | |
| Wealth Index | -0.110 | -0.188 | -0.032 | -0.716 | 0.475 |
| | (2.163) | (2.122) | (2.207) | | |
| Participant's Risk Preferences | 2.217 | 2.189 | 2.245 | -0.38 | 0.704 |
| | (1.461) | (1.443) | (1.482) | | |
| Knowledge of Insurance | 0.235 | 0.25 | 0.219 | 0.714 | 0.476 |
| | (0.424) | (0.434) | (0.415) | | |
| Experience with Shocks | 0.367 | 0.357 | 0.378 | -0.418 | 0.676 |
| | (0.483) | (0.48) | (0.486) | | |

$^{\Psi}$ Details of the variables can be found in Table I.12.

The majority of our farmers are women, although all participants were randomly selected out of the adult members of the household working on the farm. Similarly to the the area statistics, most participants are married, scarcely educated and live in large households. They are overwhelmingly Christian (over 90%), typically following the Protestant faith. Participant farmers are relatively poor, possessing only slightly more than an acre of land. Their knowledge of insurance is very limited, yet a large proportion has experienced severe shocks in the last two years, involving a fall in total and food consumption.

Out of the twelve balanced checks only one, gender, is significantly different among participants in the two games. Given the importance of this characteristic, we conduct sensitivity analyses in D employing gender-balanced subsamples. Our main findings, presented below, remain unaltered.

## V.2 Study Variables

The following is a description of the study variables employed in the analysis below.

**Table I.12: Study Variables**

| Variable | Description |
|---|---|
| Insurance Units Purchased | Insurance units purchased by the Person 1 in the experiment |
| Index Insurance Units Purchased | Index insurance units purchased by Person 1 in Game 1 |
| Indem. Insurance Units Purchased | Index insurance units purchased by Person 1 in Game 2 |
| Index w/ Sharing (*T1*) | Participation in *T1* (where index insurance was offered and risk sharing was permitted) [dummy] |
| Index w/o Sharing (*T2*) | Participation in *T2* (where index insurance was offered and risk sharing was not allowed) [dummy] |
| Indem. w/ Sharing (*T3*) | Participation in *T3* (where indemnity insurance was offered and risk sharing was permitted) [dummy] |
| Indem. w/o Sharing (*T4*) | Participation in *T4* (where indemnity insurance was offered and risk sharing was not allowed) [dummy] |
| Amount Shared | Amount transferred by Person 2 to assist Person 1 with her losses |
| Insured | Whether partner (Person 1) was insured when facing losses (dummy) |
| Type of Insurance: Index | Whether the type of cover the partner (Person 1) was insured under was of the indexed type (dummy) |
| Index Insured (*T1*) | Whether the partner (Person 1) was protected by an indexed cover (dummy) |
| Indemnity Insured (*T3*) | Whether the partner (Person 1) was protected by an indemnity cover (dummy) |
| Not Insured (*T5*) | Whether the partner (Person 1) was not protected by any form of insurance (dummy) |
| Partner's Losses | Amount lost by the partner (Person 1), which changes with the coverage selected by Person 1 |
| Good Weather | Weather conditions under which sharing decision was taken (1=Good) (dummy) |
| Gender (male) | Participant is male (dummy) |
| Age | Participant's age |
| Married | Whether participant was married |
| Household size | Number of members of the participant's household |
| Years of Education | Participant's years of formal education |
| Bagisu Tribe | Whether participant's belongs to the Bagisu tribe |
| Protestant | Whether the participant professes some form of Protestantism |
| Land Holdings | Number of acres owned by the household |
| Wealth Index | First principal component in a PCA of the HH's assets $^{\psi}$ |
| Risk Preferences | Hypothetical willingness to invest (1 least risk averse to 6 most risk averse) |
| Knowledge of Insurance | More than half of the answers correct in a test about insurance |
| Experience with Shocks | Having suffered a serious income shock which led to a reduction in total and food consumption |
| Enumerator Team 2 | Session where decision was taken led by second team of enumerators |

$^{\psi}$ Our overall measure of wealth is calculated through principal components analysis (PCA) of a comprehensive list of household assets reported by the participants in the study. Details can be found in Pérez-Viana (2019b), who employs the same methodology to construct the measure of wealth.

## V.3 *What is the Effect of Risk Sharing on Demand?*

### V.3.1 Comparative Analysis

Before laying down the empirical model to study insurance demand, let us look at how the insurance purchase decision differs across treatments:

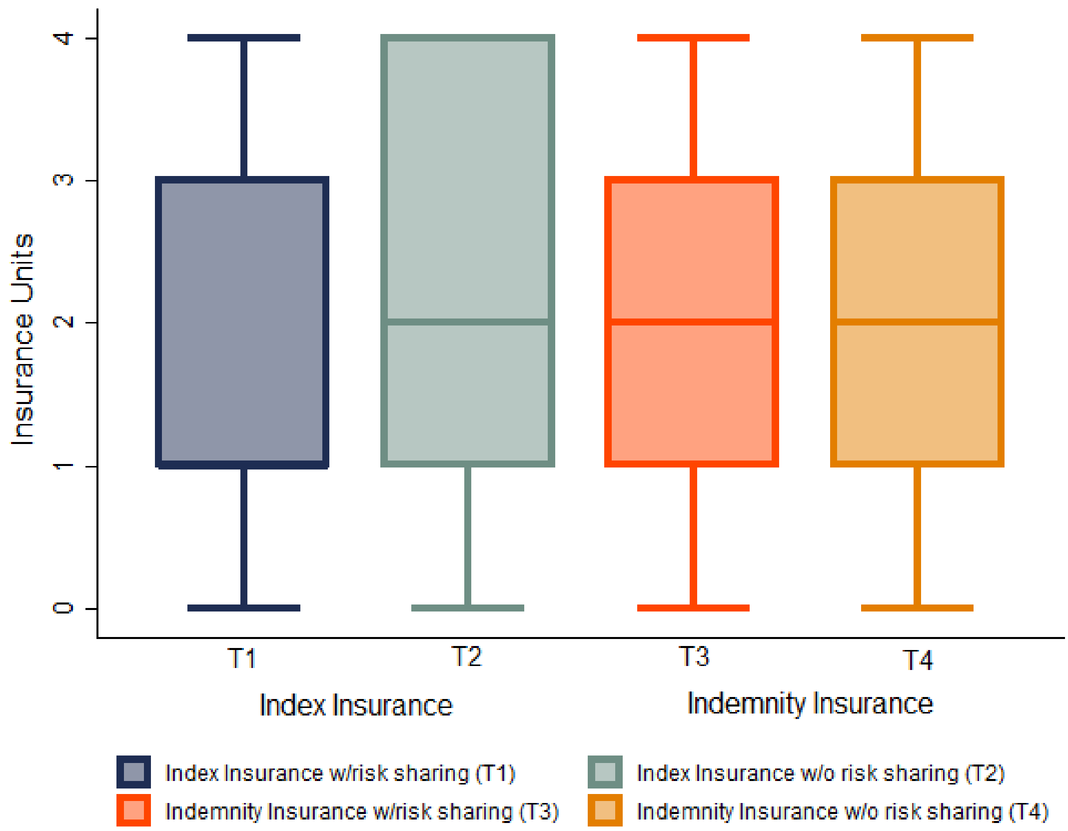
**Table I.13: Insurance Purchased Frequencies$^{\Psi}$**

| | Treatments | | | |
|---|---|---|---|---|
| | Index Insurance | | Indemnity Insurance | |
| Insurance Units | w/ Risk Sharing (*T1*) | w/o Risk Sharing (*T2*) | w/ Risk Sharing (*T3*) | w/o Risk Sharing (*T4*) |
| 0 | 44<br>(22.45) | 33<br>(16.84) | 42<br>(21.21) | 47<br>(23.74) |
| 1 | 68<br>(34.69) | 53<br>(27.04) | 55<br>(27.78) | 48<br>(24.24) |
| 2 | 34<br>(17.35) | 33<br>(16.84) | 40<br>(20.2) | 37<br>(18.69) |
| 3 | 24<br>(12.24) | 26<br>(13.27) | 29<br>(14.65) | 28<br>(14.14) |
| 4 | 26<br>(13.27) | 51<br>(26.02) | 32<br>(16.16) | 38<br>(19.19) |
| Total | 196 | 196 | 198 | 198 |

$^{\Psi}$ Proportion of participants purchasing specific number of units in brackets for every treatment (column).

Despite their lack of familiarity with insurance, most participants purchased some degree of coverage; typically one unit. The results show a large difference in full coverage between the index insurance treatments, which has no equivalent in the indemnity insurance case. To visualise these trends we depict them in a box-plot in Figure I.5.

**Figure I.5: Insurance Purchased by Treatment**




We can appreciate a substantial increase in demand for index insurance when there is no risk sharing, illustrated by the rise of the median from one to two units of insurance purchased. By contrast, the plots for the indemnity treatments are almost identical.

We carry out pairwise comparison of the means to test whether these differences are statistically significant. The comparisons allow us to begin untangling the effect that risk sharing wields on insurance demand. In particular, comparing coverage purchased between *T1* and *T2* gives us the effect of informal transfers on index insurance (column [3] of Table I.14 below), whereas through the comparison of *T3* and *T4* we obtain the change in demand for indemnity insurance attributable to risk sharing (column [6]).[40]

This net variation within type of insurance is then compared to obtain the effect of basis risk sharing on the uptake of insurance in the experiments (column 7). Stripped of the base influence of risk sharing, the only remaining difference among the treatments is that, as opposed to the indemnity cover, index insurance suffers from basis risk, and that this type of risk can be shared.

[40] These are within subject comparisons, given that participants played either Game 1 (*T1*, *T2* and *T5*) or Game 2 (*T3*, *T4* and *T5*).

**Table I.14: Two-sided t-tests**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| | Index Insurance | | Within Diff. | Indemnity Insurance | | Within Diff. | Between Diff. |
| Treatment: | *T1* | *T2* | (*T1*-*T2*) | *T3* | *T4* | (*T3*-*T4*) | (*T1*-*T2*) - (*T3*-*T4*) |
| | (w/ Risk Sharing) | (w/o Risk Sharing) | | ( w/ Risk Sharing) | (w/o Risk Sharing) | | |
| Insurance | 1.59 | 2.05 | -0.454*** | 1.77 | 1.81 | -0.04 | -0.414*** |
| Units | (1.319) | (1.458) | (0.097) | (1.369) | (1.44) | (0.093) | (0.135) |
| N | 196 | 196 | 196 | 198 | 198 | 198 | 196 |

Standard errors in parenthesis, $t-test$ $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

The significant negative difference in the mean units purchased between *T1* and *T2* at the one percent level indicates that risk sharing reduces demand for index insurance.[41] Not only that, the composite comparison in column (7) of Table I.14 indicates that basis risk sharing is also associated with lower uptake of insurance.

### V.3.2 Regression Analysis

In order to control for other factors that may influence take-up of insurance, we turn to regression analysis. This methodology allows us to study the individual's decision employing all the available data and test for non-linear relationships between the key variables.

We deploy an ordered probit estimator to conduct the analysis for the purchase decision. The preference for a non-linear model for ordered outcomes over a linear one stems from the nature of the dependent variable. If one considers the decision to purchase insurance as a discrete choice over five possible outcomes (0, 1, 2, 3 or 4 units purchased), rather than more akin to purchasing an amount of a continuous variable, then the model necessitates of an ordered estimator.

The ordered outcomes are modelled to arise sequentially as a latent variable, $y^*$, crosses progressively higher thresholds $\alpha_j$ (Cameron and Trivedi, 2009). In our case, $y^*$ is an unobserved continuous measure of coverage, which is linear in the independent variables. For an individual $i$ we specify:

$$y_i^* = \boldsymbol{X_i}\boldsymbol{\beta} + u_i \tag{13}$$

where $\boldsymbol{X_i}$ includes the key explanatory and the control variables.

For very low $y^*$, $y^* < \alpha_1$, coverage is lower than that provided by one unit; for $y^* > \alpha_1$, the opposite is true, protection is greater than one unit. The same holds when $y^*$ becomes larger than the remaining thresholds, $y^* > \alpha_j$. These thresholds $\alpha_j$ are unknown parameters to be estimated with $\boldsymbol{\beta}$.

The unknown thresholds $\alpha_j$ of the latent variable $y^*$ are related to the observed values of $y$ (insurance units purchased) in the following way:

[41] An equally significant difference is observed when the distributions of the two groups are compared employing a Wilcoxon matched-pairs signed-ranks test. Equivalent tests were carried out for the other comparisons in Table I.14, leading to the same qualitative conclusions to the parametric tests.

$$
\begin{aligned}
y &= 0 \text{ if } y^* \leq \alpha_0 \\
&= 1 \text{ if } \alpha_0 < y^* \leq \alpha_1 \\
&= 2 \text{ if } \alpha_1 < y^* \leq \alpha_2 \\
&= 3 \text{ if } \alpha_2 < y^* \leq \alpha_3 \\
&= 4 \text{ if } y^* > \alpha_3
\end{aligned}
$$

We assume that the errors $u$ are normally distributed across observations, and normalise its mean and variance to zero and one, respectively. We then have that the probability of the outcomes is given by:

$$
\begin{aligned}
Pr(y_i = 0) &= \Phi(\alpha_0 - \boldsymbol{X_i\beta}) \\
Pr(y_i = 1) &= \Phi(\alpha_1 - \boldsymbol{X_i\beta}) - \Phi(\alpha_0 - \boldsymbol{X_i\beta}) \\
Pr(y_i = 2) &= \Phi(\alpha_2 - \boldsymbol{X_i\beta}) - \Phi(\alpha_1 - \boldsymbol{X_i\beta}) \\
Pr(y_i = 3) &= \Phi(\alpha_3 - \boldsymbol{X_i\beta}) - \Phi(\alpha_2 - \boldsymbol{X_i\beta}) \\
Pr(y_i = 4) &= 1 - \Phi(\alpha_3 - \boldsymbol{X_i\beta})
\end{aligned}
$$

which can be summarised in:

$$
Pr(y_i = j) = \Phi(\alpha_j - \boldsymbol{X_i\beta}) - \Phi(\alpha_{j-1} - \boldsymbol{X_i\beta}) \tag{14}
$$

where $\Phi$ is the cumulative distribution function for the standard normal distribution, given that our errors are standard normally distributed (Cameron and Trivedi, 2009; Greene, 2012).

The regression parameters, $\boldsymbol{\beta}$, and the threshold parameters ($\alpha_1$, ... , $\alpha_4$) are obtained by maximising the log likelihood with $p_{ij} = Pr(y_i = j)$ as defined above (StataCorp, 2013):

$$
\ln L = \sum_{i=1}^{N} \sum_{j=1}^{\alpha} I_j(y_i) \ln p_{ij} \tag{15}
$$

where

$$
I_j(y_i) = \begin{cases} 1, & \text{if } y_i = j \\ 0, & \text{otherwise} \end{cases}
$$

The common linear structure in equation (13) can be expressed as the following empirical model for our preferred specifications in Table I.15 ([2],[4] and [6]):

$$Ins.\,Units_{ijk} = \alpha + \beta Treatment_k + \boldsymbol{\delta X_{ij}} + \eta_j + u_{ijk} \tag{16}$$

where $Ins.Units_{ijk}$ are the units of insurance purchased by participant $i$ (acting as Person 1) in a given treatment, our unit of observation, a decision taken twice by each participant, under different circumstances, during the game. These specific conditions are represented by $Treatment_k$, a categorical variable comprising the four treatments implemented in the experiment where an insurance decision was taken; each category enters the regression as bivariate variable, with the one left out becoming the reference category. $\boldsymbol{X_{ij}}$ includes all the control variables (gender, education, age, wealth, risk preferences, knowledge of insurance, experience with shocks and enumerator team dummies) and $\eta_j$ are location (i.e. village) dummies.

The results Table I.15 shows six different specifications, (1) and (2) utilise the pooled sample, *i.e.* the demand decisions taken in all treatments. By contrast, specifications (3)-(6) employ the sub-sample of decisions where the cover on offer was indexed ([3] and [4]) or of the indemnity type ([5] and [6]). Empirical models (1), (3) and (5) do not include the control variables $\boldsymbol{X_{ij}}$, whereas (2), (4) and (6) features them.

Throughout the analysis, we implement a clustered estimator of the variance-covariance matrix that is robust to the correlation of the errors within experimental sessions.

In light of the regression results in Table I.15, we can safely assert that the main conclusion of the comparative analysis holds strong, namely, that informal loss sharing crowds out demand for index insurance (specifications 1 to 4). There is a significant increase in the uptake of index insurance when loss sharing is not permitted (*T2*) with respect to when is allowed (*T1*).

A significant difference in demand for insurance is also found between the reference category (index insurance with possibility of transfers, *T1*) and the scenario in which the security is of the indemnity type (*T3*).

By contrast, demand for indemnity insurance remains unaltered by the availability of risk sharing, as predicted by theory. Both in the pooled sample (columns [1] and [2]) and in the Game 2 sub-sample, where the cover on offer was of the indemnity type ([5] and [6]).

Interestingly, demand for insurance seems to be higher for men than for women, and for older people. The latter result is somewhat surprising, as in most of the previous scholarship insurance uptake had been negatively associated with age (Giné *et al.*, 2008; Hill *et al.*, 2013; McIntosh *et al.*, 2013; Belissa *et al.*, 2018), although with some exceptions (Cai *et al.*, 2015). In our context, one can speculate that this might be due to the possibility that relatively older individuals may display a more open attitude to innovations

(Feinerman and Finkelshtain, 1996), or that they anticipated fewer transfers from their fellow players, thereby finding a greater use for insurance.[42] Some support for this conjecture comes from the fact that age is only significantly associated with demand for index insurance, where the availability of informal transfers led to changes in uptake.

Additionally, wealth does not appear to matter for take-up, and neither do risk aversion, having experienced severe shocks or knowing about insurance prior to the experiment.

Location dummies at the village level were employed in order to control for village effects, with some of them being highly significant. Similarly, the enumerator team implementing the game appear to have exerted a significant influence on decision making, however, this effect is only noticeable when the estimation is performed separately for the subsample of each game (specifications 4 and 6).

Lastly, we carried out likelihood-ratio tests to evaluate whether the parallel-lines assumption embedded in our ordered probit estimator is violated. This assumption requires that the parameters in the model remain constant for every value of the dependent variable (Williams, 2006). The tests are statistically insignificant for the key variables of interests ($Treatment_k$) and the models without controls (specifications 1, 3 and 5). For this reason, the results for the models estimated without imposing this assumption—deploying a generalised ordered probit estimator—have not been reproduced below.[43,44]

**Result 1.** *Anticipated informal risk sharing crowds out demand for index insurance, but does not affect indemnity insurance take-up.*

[42] In most societies, transfers from older individuals to younger ones exceed the support travelling on the opposite direction; even though in many developing countries, elderly people rely on the generosity of younger adults in the late stages of life (Cox and Fafchamps, 2008).

[43] The parallel-lines assumption was violated only by a few of the control variables (gender and enumerator team most notably) in specifications (2), (4) and (6).

[44] The Stata command *gglogit2* developed by Williams (2006) was employed to carry out the tests and estimate the generalised ordinal models.

**Table I.15: Ordered Probit Regressions: Insurance Demand $^{\Psi}$**

| **Specification** | **(1)** | **(2)$^{\psi}$** | **(3)** | **(4)$^{\psi}$** | **(5)** | **(6)$^{\psi}$** |
|---|---|---|---|---|---|---|
| **Variable** | **Insurance Units purchased** | | **Index Insurance Units Purchased** | | **Indemnity Insurance Units Purchased** | |
| Index w/o Sharing (*T2*) | 0.333*** | 0.364*** | 0.333*** | 0.374*** | | |
| (1=Yes, 0=No) | (0.103) | (0.114) | (0.1) | (0.111) | | |
| Indem. w/ Sharing (*T3*) | 0.121 | 0.177* | | | | |
| (1=Yes, 0=No) | (0.154) | (0.957) | | | | |
| Indem. w/o Sharing (*T4*) | 0.138 | 0.185 | | | 0.02 | 0.01 |
| (1=Yes, 0=No) | (0.148) | (0.115) | | | (0.0811) | (0.101) |
| Gender (1=Male) | | 0.268** | | 0.178 | | 0.448** |
| | | (0.117) | | (0.115) | | (0.225) |
| Age | | 0.011*** | | 0.021*** | | 0.002 |
| | | (0.004) | | (0.005) | | (0.003) |
| Years of Education | | -0.005 | | 0.002 | | -0.009 |
| | | (0.014) | | (0.02) | | (0.025) |
| Wealth Index | | 0.032 | | 0.024 | | 0.044 |
| | | (0.031) | | (0.043) | | (0.053) |
| Participant's Risk Preferences | | -0.033 | | -0.039 | | -0.015 |
| | | (0.028) | | (0.035) | | (0.047) |
| Knowledge of Insurance | | 0.079 | | -0.007 | | 0.115 |
| | | (0.119) | | (0.161) | | (0.202) |
| Experience with Shocks | | -0.101 | | -0.167 | | -0.027 |
| | | (0.104) | | (0.156) | | (0.161) |
| Enumerator Team 2 | | -0.017 | | -0.339*** | | 0.45*** |
| | | (0.085) | | (0.112) | | (0.124) |
| **Reference** | **Index w/ sharing (*T1*)** | **Index w/ sharing (*T1*)** | **Index w/ sharing (*T1*)** | **Index w/ sharing (*T1*)** | **Indem. w/ sharing (*T3*)** | **Indem. w/ sharing (*T3*)** |
| **N** | **788** | **780** | **392** | **392** | **396** | **388** |

Robust standard errors in parenthesis, $^{*}\ p < 0.1$, $^{**}p < 0.05$, $^{***}\ p < 0.01$

$^{\Psi}$ Details of the variables can be found in Table I.12.

$^{\psi}$ Village dummies included in this specification.

## V.4 *What is the Effect of Insurance on Informal Risk Sharing?*

We now turn to the investigation of the decision to share the losses of the partner taken by Person 2. The study of risk sharing behaviour is of great interest on its own, due to the extended reliance on informal arrangements in deprived rural settings like our area of study. Moreover, the analysis of the sharing data can shed light on the patterns of insurance demand observed earlier, as anticipated transfers from the partner may have influenced the coverage decisions of Person 1.

In this analysis we employ the amount transferred by Person 2 to Person 1 as the dependent variable. The helping partner could transfer any amount of her endowment she wished, from zero up to the full amount, regardless of the losses of Person 1. As noted earlier, sharing decisions were elicited through a strategy method, by which Person 2 determined how much of Person 1's losses to compensate for every level of coverage that could be selected by the latter. As a result of this procedure, the number of decisions recorded by treatment varies depending on the coverage choices available to Person 1.[45]

### V.4.1 Comparative Analysis

Prior to proceeding with a more formal analysis, it is useful to visualise the amount of risk sharing that took place in the game. Figure I.6 compares the amount shared by Person 2 when the partner had no access to insurance (*T5*) to the sharing decision when Person 1 decided not to insure despite having the chance in *T1* and *T3*. In turn, Figure I.7 compares the average amount transferred by Person 2 for every possible level of coverage in *T1* and *T3* (*i.e.* from zero to four insurance units).[46]

[45] In *T5*, only one sharing decision is taken by Person 2. Because Person 1 cannot insure, there are only two possible outcomes: either Person 1 does not endure any losses, so no sharing takes place, or she suffers full losses, and Person 2 needs to decide how much to help with. The number of sharing decisions goes up to five in *T3*, because Person 1 can choose any level of coverage between 0 and 4 units, so Person 2 needs to take a sharing decision in each of these instances. Finally, in the first treatment, Person 2 chooses ten times how much of the losses of Person 1 she wishes to share, five in the case of bad weather (one for every possible level of coverage) and likewise five in the event of good weather.

[46] Stars denote significance levels: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

**Figure I.6: Comparison Amount Shared (*T1*/*T3* vs *T5*)**

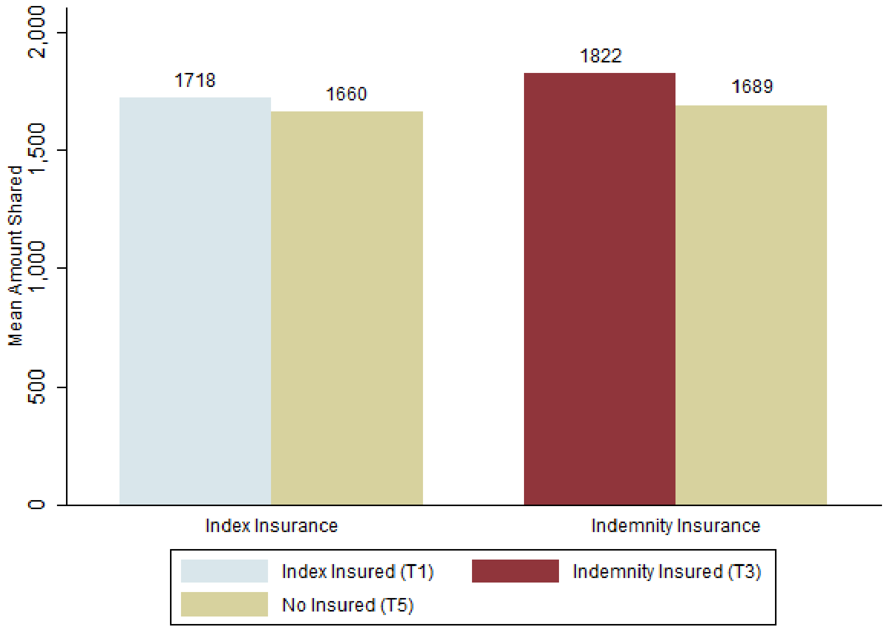
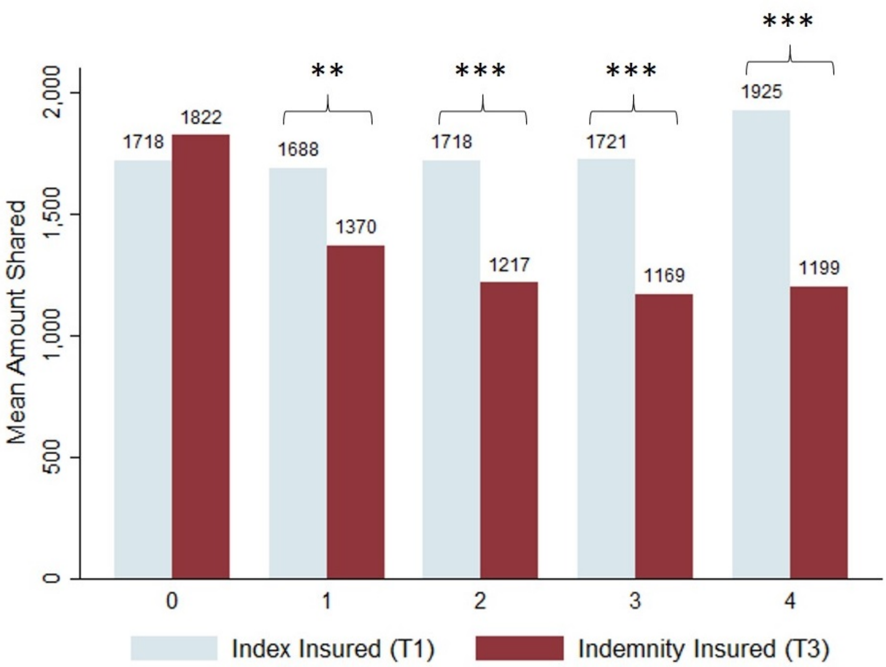



**Figure I.7: Comparison Amount Shared (*T1* vs *T3*)**




No appreciable differences can be observed in the mean transfers towards Person 1 when she cannot insure (*T5*) relative to when she has the opportunity to do so (*T1* or *T3*). In contrast, highly significant differences in sharing arise between the two different covers; transfers towards those who are indemnity insured are much lower than to Persons 1 protected by an indexed cover.

### V.4.2 Regression Analysis

To evaluate the observed patterns formally, we run a series of regressions with the amount shared as the dependent variable. The empirical models estimated through linear least squares follow the structure below:

$$y_i = \boldsymbol{X_i}\boldsymbol{\beta} + u_i \tag{17}$$

where $\boldsymbol{X_i}$ includes the key explanatory variables and the control variables.

We begin investigating the impact that the partner being insured exercises on the amount transferred by Person 2. Table I.16 below presents multiple specifications in which the key explanatory variable is insurance status. First, embodied by a dummy for whether Person 1 is insured or not (*Insured*), regardless of the specific form of insurance (specification [1]). Then, by adding another indicator variable (*Index*) to distinguish the type of cover as indexed ([2]-[3]). Controls are added for the losses sustained by Person 1 (*Losses*), the weather conditions and several other factors included in $\boldsymbol{X_{ij}}$ (gender, education, age, wealth, risk preferences, knowledge of insurance and enumerator team dummies) to avoid them confounding the impact of insurance status.

This latter empirical model takes the following form:

$$Amount\ Shared_{ij} = \alpha + \beta_1 Insured_{ij} + \beta_2 Index_{ij} + \gamma Losses_{ij} + \boldsymbol{\delta X_{ij}} + \eta_j + u_{ij} \tag{18}$$

where $Amount\ Shared_{ij}$ is the amount shared by Person 2 with Person 1 in the event of losses. A decision taken multiple times by each participant, depending on the features of the treatment as described earlier, and $\eta_j$ are the location dummies.

Same as before, we implement a clustered estimator of the variance-covariance matrix that is robust to the correlation of the errors within experimental sessions.

**Table I.16: OLS Regressions: Sharing Decision (Insurance Status)$^{\Psi}$**

| Specification<br>Variable | (1) | (2)<br>Amount Shared | (3)$^{\psi}$ |
|---|---|---|---|
| Insured | -53.31 | -318.9*** | -179 |
| (1=Yes, 0=No) | (109.5) | (106.8) | (120.8) |
| Type of Insurance: Index | | 398.2* | 185.9 |
| (1=Yes, 0=No) | | (206.6) | (171.4) |
| Partner's Losses | | | 0.07** |
| | | | (0.03) |
| Good Weather | | | 19.06 |
| | | | (79.68) |
| Gender | | | 462.2** |
| (1=Male) | | | (198.6) |
| Age | | | 1.551 |
| | | | (7.038) |
| Years of Education | | | 15.39 |
| | | | (14.97) |
| Wealth Index | | | -50.72 |
| | | | (29.91) |
| Enumerator Team 2 | | | 526.1*** |
| | | | (125.4) |
| Participant's Risk Preferences | | | 5.827 |
| | | | (66.93) |
| Knowledge of Insurance | | | -71.65 |
| | | | (194.7) |
| Experience with Shocks | | | -189.7 |
| | | | (139.2) |
| Constant | 1675*** | 1675*** | 472.4 |
| | (115.4) | (115.4) | (394.1) |
| **N** | **3331** | **3331** | **3319** |

Robust standard errors in parenthesis, * $p < 0.1$, **$p < 0.05$,*** $p < 0.01$

$^{\Psi}$ Details of the variables can be found in Table I.12.

$^{\psi}$ Village dummies included in this specification.

The fact that the partner is covered against the negative income shock does not seem to matter much for the amount transferred by Person 2 in case of losses, when examining the decision across all treatments with the pooled dataset. When we do not control for other factors, having access to insurance appears to have a deterrent effect, less so if the cover is indexed. Yet the moment other elements influencing informal transfers are taken into account, only the extent of the partner's losses, regardless of insurance status or type, is shown to determine the sharing decision.

Men are far more generous that women when it comes to provide monetary assistance, and those who were explained the games by the second team tend to donate higher amounts.

Given the lack of conclusive results, yet having found some strong effects of the availability of risk sharing on the demand for index insurance, and also highly significant differences in sharing between insurance types, it seems sensible focusing the analysis on the indexed cover.

We proceed with the analysis by examining the decisions taken by the aiding partner when Person 1 was index insured, and the two other alternative situations separately. In other words, we employ two subsamples in this part of the analysis. The first of them contains sharing decisions made at the time the partner was index insured (*T1*) or not insured at all (*T5*).[47] Secondly, we restrict the sample to transfers made when the partner was either index (*T1*) or indemnity insured (*T3*).[48] The empirical model estimated in the preferred specifications ([5]) is:

$$\begin{aligned} Amount\ Shared_{ijk} = \alpha + \beta Index\ Insured_k + \gamma Losses_{ijk} + \tau Index\ Insured_k \text{ x } Losses_{ijk} \\ + \boldsymbol{\delta X_{ij}} + \eta_j + u_{ijk} \end{aligned} \tag{19}$$

where $Index\ Insured_k$ denotes protection from that type of cover and the remaining covariates are the same as for equation (18).

[47] Specifications (1) and (2).
[48] Specifications (3) to (5).

**Table I.17: OLS Regressions: Sharing Decision (Subsamples)$^{\Psi}$**

| **Specification** | **(1)** | **(2)$^{\psi}$** | **(3)** | **(4)** | **(5)$^{\psi}$** |
|---|---|---|---|---|---|
| **Variable** | **Amount Shared** | | | | |
| Index Insured (*T1*) | 79.34 | 81.36 | 398.2* | 1605.3*** | 1530.2** |
| (1=Yes, 0=No) | (154.2) | (114.5) | (206.6) | (530.3) | (625.5) |
| Partner's Losses | | 0.046 | | 0.193*** | 0.192*** |
| | | (0.031) | | (0.059) | (0.06) |
| Index Insured (*T1*) x | | | | -0.147** | -0.145** |
| Partner's Losses | | | | (0.067) | (0.067) |
| Good Weather | | 127.2** | | 127.2** | 127.2** |
| | | (56.32) | | (56) | (56.25) |
| Gender | | 421* | | | 447.1** |
| (1=Male) | | (224.1) | | | (179.9) |
| Age | | 0.3 | | | 1.34 |
| | | (8.949) | | | (7.256) |
| Years of Education | | 24.79 | | | 17.24 |
| | | (15.39) | | | (14.24) |
| Wealth Index | | -67.07 | | | -54.17* |
| | | (39.87) | | | (30.35) |
| Enumerator Team 2 | | 651*** | | | 495.8*** |
| | | (152) | | | (138.1) |
| Risk Preferences | | 47.28 | | | -6.048 |
| | | (90.76) | | | (67.85) |
| Knowledge of Insurance | | -120.9 | | | -100.5 |
| | | (262.7) | | | (139.5) |
| Experience with Shocks | | -162 | | | -206.1 |
| | | (164.1) | | | (139.5) |
| Constant | 1675*** | 432.4 | 1356*** | -410.7 | -841 |
| | (115.4) | (587.1) | (162.3) | (442.3) | (610.7) |
| **Reference** | **Not insured (*T5*)** | **Not insured (*T5*)** | **Ind. Insured (*T3*)** | **Ind. Insured (*T3*)** | **Ind. Insured (*T3*)** |
| **N** | **2352** | **2350** | **2939** | **2939** | **2929** |

Robust standard errors in parenthesis, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

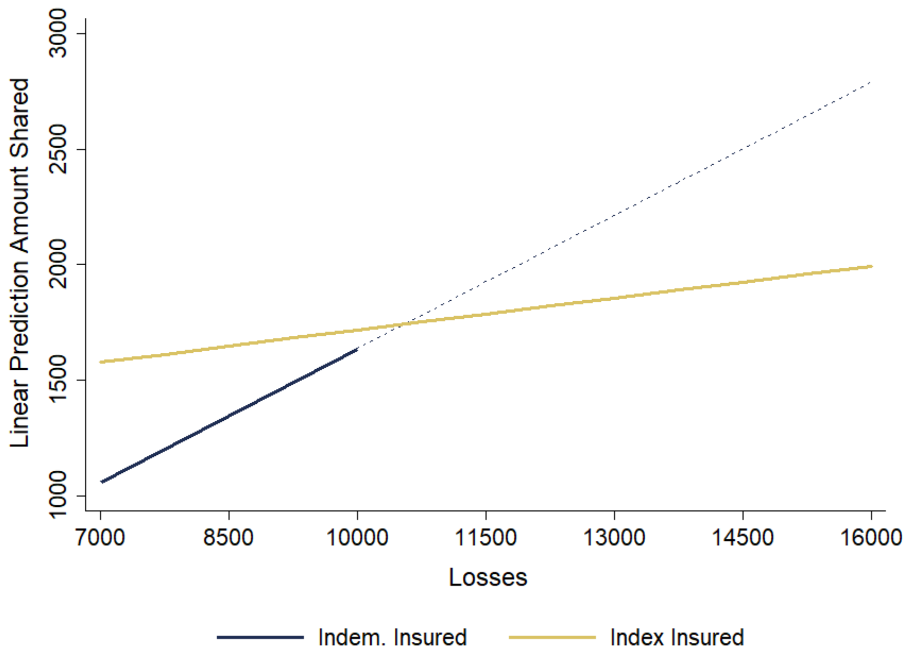
$^{\Psi}$ Details of the variables can be found in Table I.12.

$^{\psi}$ Village dummies included in this specification.

The results from specifications (1) and (2) confirm the previous findings about the neutral effect of being insured for risk sharing, relative to not being protected. However, the second set of specifications ([3] to [5]) show that the type of protection does matter when everyone vying for informal assistance is insured. Under these circumstances, being index insured appears to crowd in informal risk sharing in comparison to being indemnity insured.

As seen earlier, the amount of support increases with the size of the losses, yet those who are index insured seem to receive less transfers as their losses increase. This feature is well-illustrated by the difference in the slope coefficient of losses between those who are indemnity and index insured, seen in Figure I.8.[49]

**Figure I.8: Effect of Losses by Type of Insurance**




Overall, the analysis confirms the trends in the visual representation of Figure I.7 earlier, namely, that informal support is significantly higher when the partner is protected by an indexed cover instead of an indemnity one.

**Result 2.** *Being insured is neutral for receiving informal support, however, among those who are insured, the type of insurance matters for seeking help from peers. Being index insured draws a significantly higher amount of transfers than having the protection of an indemnity cover.*

[49] Nonetheless, it is important to bear in mind that losses in the indemnity case were limited to 10,000 Shillings, whereas for those index insured they could go all the way up to 16,000. The solid lines in Figure I.8 depict the amount shared for the feasible losses in each case.

# VI Discussion & Conclusion

The aim of any behavioural experiment is to create a decision environment in which the source of variation in the situations presented is controlled by the experimenter, who randomly varies it to observe its effect on decision making (Falk and Heckman, 2009). The varied element is usually chosen for its significance for the phenomenon studied. Yet despite its importance, it represents only one aspect among the many that matter for the real-life decision recreated. As a result, the implications of the experimental findings are strictly circumscribed to the behaviour in response to the one element varied, all else equal. Strong qualifications of these conclusions apply when other elements come into play. Even so, the expectation is that the influence of the varied element, as recreated under experimental conditions, should remain unaltered.

Our experiment aimed primarily at studying the effect of anticipated risk sharing on insurance purchase decisions. With this purpose in mind, the exogenous source of variation was restricted to, firstly, the possibility of receiving informal transfers or the lack of thereof, and, secondly, the type of insurance available, which could be of the indexed or indemnity kind.

The results show that anticipated informal risk sharing crowds out demand for index insurance, but it does not affect purchases of indemnity coverage. These findings are at odds with the prevailing narrative in the literature, which backs the complementarity between being index insured and receiving informal help, while maintaining that the latter is incompatible with traditional forms of insurance. These arguments are supported by the important work carried out by Dercon *et al.* (2014) and Mobarak and Rosenzweig (2012, 2013a), yet the evidence provided is at best tentative. Dercon *et al.* (2014) admit their lack of full control over the exogenous variation employed to study this matter—training on the benefits of risk sharing when holding an indexed policy—which could lead to a selection effect in forming sharing groups. Mobarak and Rosenzweig's (2013a) findings are equally inconclusive; they report higher demand among the most active risk-sharing groups, however, the difference is not sufficiently large to become statistically significant. Other sources of evidence do not lend appropriate support for the complementarity thesis, despite being presented as such. As the narrative goes, demand for index insurance in Berg *et al.*'s (2017) framed experiment surges with transfers, whereas uptake of indemnity coverage falls to a lesser extent. Nevertheless, as argued above, their experiment is not a test of how anticipated risk sharing influences demand, given that the element randomised is a fixed and pre-determined transfer between partners in a pair.

To some extent our findings are grounded in a theoretical framework based on two seminal contributions to, first, the relation between formal and informal insurance (Arnott and Stiglitz, 1991) and, second, to the characterisation of rational demand for index insurance (Clarke, 2016, 2011); the two were combined in a single model by Mobarak and Rosenzweig (2012), which was adapted here. The model demonstrates how informal risk sharing is bound to affect demand for index insurance, although the direction of the effect is uncertain, yet it is innocuous for the uptake of indemnity securities. The latter result is explained by the rational goal of the agent to fully hedge against covariate shocks by purchasing fairly-priced insurance, regardless of transfers received to mitigate idiosyncratic losses. In contrast, achieving full protection is unattainable through index insurance due to basis risk. Risk sharing can mitigate its effects by providing assistance, making the indexed cover more attractive. However, informal support also renders index insurance redundant, as it provides further compensation against losses when insurance payouts have already been made, reducing the utility of the formal cover. Our data seems to indicate that negative considerations about the loss of utility of insurance with risk sharing weigh more heavily in the decision to purchase index insurance than the positive ones. Coupled with these perceptions, participants appear to correctly anticipate a sizeable level of risk sharing from their partners, significantly higher than for indemnity insurance, which appears to exacerbate the fall in demand for the indexed cover. Yet these negative aspects appear to go beyond those featured in the theory, namely the ever-increasing reduction in the utility of the indexed cover when informal transfers are received, given that the impact of basis risk sharing is markedly negative too. Theory shows that basis risk mitigation should wield an unambiguously positive effect on demand, as it buffers losses when they are larger; yet we observe the opposite, a fall in demand when the possibility of sharing these losses exists.

It is hard to explain the reasons for this result, but it is safe to assume that other considerations, different to basis risk mitigation, are at play. A plausible explanation comes from behaviour already observed in the area by D'Exelle and Verschoor (2015), which the authors refer to as indebtedness aversion. This behavioural pattern refers to the reluctance of burdening members of the community with the consequences of the risks one takes. This preference stems from a combination of altruism and a wish to avoid potential expectations of reciprocity, which induces in individuals an aversion to become indebted to others.[50] In the example at hand, indebtedness aversion would manifest more strongly the larger basis risk is, as it is then when the decision maker needs to contend with the worst possible outcome (losses from a bad harvest, without an insurance payout, despite paying the cost of the premium), while relying entirely on the partner. Facing such outcome with

[50] This behaviour may arise from what Baumard *et al.* (2013) call 'mutualistic approach' to morality, in which people have internalised norms that sharing needs to be reciprocated: one person insuring another implies an obligation on the latter to provide assistance to the former in the future. In the absence of formal insurance markets—as in most rural areas of developing countries—people attempt to build up their social capital by increasing the network of individuals reciprocally indebted to them and, at the same time, by reducing their reciprocal debts to others (D'Exelle and Verschoor, 2015). The altruistic motivation within indebtedness aversion comes from the preference for avoiding burdening others with one's financial problems unless the need is dire, since assistance would likely be provided if requested as a result of the strong sharing norms in place (Fafchamps, 2003, 2008).

a non-negligible probability, a decision maker seeking to avoid inflicting the consequences of her decision on the partner may withhold buying index insurance, knowing that the call for assistance will likely be answered. This interpretation of the behaviour observed is supported by the extensive experimental literature demonstrating that the two factors giving rise to indebtedness aversion, altruism and reciprocity, can play a very important role in motivating behaviour.[51]

Our results defy some other predictions borne by the theory, both in surprising and expected ways. Although not the main focus of our investigation, basis risk does not appear to exert any effect on the demand for insurance in our experiment. Demand for formal protection differing in the presence of basis risk is roughly the same, which defies our priors about the negative effect of basis risk for coverage, a stylised fact in the literature. Likewise, uptake of indemnity insurance is far from full coverage as predicted by the model, a result that might be explained by the sizeable loading applied over the security offered to emulate real-life market conditions, and the fact that the cover's protection was not circumscribed only to the losses attributable to the common shock. In fact, the average level of indemnity insurance purchased in the experiment—about two units—is just enough to cover the losses derived from the covariate shock. It is precisely this level of coverage which remains constant regardless of the existence of informal transfers, in line with the theoretical prediction.

The present study also investigates how risk sharing decisions are affected by the availability of formal insurance. Of special importance, when formal insurance is introduced where previously only informal arrangements existed, is the change in control over risk exposure—a factor shown to hold sway over the propensity to share (Cettolin and Tausch, 2015; Lenel and Steiner, 2017). Insurance allows individuals to reduce their exposure to risk and may alter perceptions about who is deserving of help. However, the sensitivity of informal risk sharing to formal insurance will also depend on the actual ability of the product to control the exposure to risk.

Based on the lessons from Cettolin and Tausch (2015) and Lenel and Steiner (2017), we hypothesise that the lower the control over the risk sustained, the greater the help received from the partner would be. Our findings conform with this general rule to a limited extent. Contrary to expectation, those without access to insurance (and completely

[51] First, studies featuring dictator games have proven that altruism is a salient behavioural motive (Forsythe *et al.*, 1994; Bohnet and Frey, 1999), with copious experimental evidence of altruistic sharing behaviour found in African societies (Henrich *et al.*, 2001; Gowdy *et al.*, 2003; Ligon and Schechter, 2012). Second, studies employing trust and gift exchange games have shown that any transfer of resources to others is largely driven by (expected) reciprocity (Berg *et al.*, 1995; Fehr *et al.*, 1998; Ostrom and Walker, 2003). Moreover, there is ample experimental evidence on trust and reciprocity in developing countries and in African communities, where these experiments have been implemented (Henrich *et al.*, 2001, 2006; Gowdy *et al.*, 2003; Binzel and Fehr, 2013). Given the abundant evidence on the importance of altruism and reciprocity as drivers of behaviour in a variety of settings involving sharing, one would expect that they also play a role in a situation where losses resulting from a risky choice can be shared.

reliant on informal help to deal with losses) did not receive a higher degree of support on average; neither compared to those index insured or protected by an indemnity cover. However, when comparing support towards those who are insured, we observe a significantly higher level of transfers in favour of those insured under an indexed cover rather than an indemnity one, even when controlling for other factors correlated with sharing. Most importantly among them, the size of the losses, which appears to attract significantly higher levels of informal support, defying standard economic theory. In fact, what the main determinants of sharing (*i.e.* being index insured and amount of losses) have in common is embodying higher loss prospects for the partner, which, rather than deterring sharing, pulls its level up. As noted earlier, these results, in particular the higher level of informal assistance received by those index insured, help explain the patterns in demand, driving indexed coverage markedly down.

Notwithstanding the discrepancies between our findings and those of some of the empirical literature (Mobarak and Rosenzweig, 2013a; Dercon *et al.*, 2014), they demonstrate that risk sharing plays an important role in the demand for index insurance, and that, therefore, pre-existing informal arrangements need to be taken into account in the marketing of the product.

Both proponents of the complemetarity argument (Mobarak and Rosenzweig, 2013a; Dercon *et al.*, 2014) and those warning about issues of incompatibility between informal and formal protection (Boucher and Delpierre, 2014; De Janvry *et al.*, 2014) agree that the best vehicle for achieving synergies between risk sharing and index insurance is insuring sharing groups, rather than individuals not belonging to these arrangements. Nevertheless, the issues raised in our investigation and the related literature (De Janvry *et al.*, 2014)—leading to the crowding out of the formal cover by informal support—would persist unless the insured unit is the group as a whole rather than individuals within the group, as proposed by the critics of complementarity (Boucher and Delpierre, 2014; De Janvry *et al.*, 2014). Despite its advantages, which extend to the administrative domain (De Janvry *et al.*, 2014), marketing index insurance in this way would curtail the ability of farmers to decide in accordance with their own insurance needs and possibly increase spatial basis risk, since weather conditions may vary between the location set for the group and that of the farmers forming it.

An intermediate solution, benefiting from the advantages of both options, would be selling insurance to members of informal groups with an in-built mechanism to deal with basis risk as well as other idiosyncratic shocks; in other words, groups in which risk sharing is to some extent enforced. Suggestive evidence in support for this approach is presented by Berg *et al.* (2017), where a guaranteed transfer from the partner to the person facing losses leads to a substantial rise in index insurance demand.

An example of this kind of arrangement is a village savings and loans association (VSLA), a type of group to which many farmers belong to in our sample area. In VSLAs, members contribute regular savings to a common fund. This fund is used for informal loans to members when idiosyncratic shocks prevent their meeting emergency expenditures (*e.g. food, medical*) or financing planned agricultural investment (*e.g.* fertiliser). However, when covariate shocks occur, the demand for loans is correlated among members, which reduces the likelihood that the common fund is an adequate buffer. Index insurance could be used to boost the common fund at such times. Contracts could be designed that stipulate both individual payouts and a payout to the common fund when the trigger level is met. Provided basis risk is imperfectly correlated among VSLA's members, the already established mechanism for sharing idiosyncratic risk could double as a mechanism for sharing basis risk. At times that the common fund is at risk of being depleted because of excess demand for informal loans (*e.g.* in a situation of a drought), index insurance could top it up to cater for the basis risk not covered by members' individual contracts. Furthermore, thanks to the existence of an established mechanism for both sharing risk and distributing insurance payouts efficiently, concerns related to the redundancy of the formal and informal covers are mitigated significantly. More importantly, channelling informal assistance through a centralised fund prevents farmers seeking help from dealing directly with individual benefactors, which diminishes fears of burdening someone excessively with one's financial plight.

In sum, we find that, contrary to expectations, risk sharing can have a detrimental effect on the demand for index insurance. This result is partly explained by the crowding in of risk sharing towards those protected by an indexed cover, correctly anticipated by them, and the redundancies between formal and informal coverage. However, the extent of the fall in demand goes beyond that predicted by theory, and it was argued that behavioural aspects derived from altruistic and reciprocal motives are at play, given the extensive evidence of their importance in the sharing of risk in similar settings. In particular, the aversion to overly burdening someone in the network with one's debts was held as the likely culprit for the observed crowding out of index-insurance demand when risk sharing was permitted. Further research is needed to identify precisely the causes of this relationship and test mechanisms that could overcome the issues observed, as the one proposed above, in order to fulfil the promise of index insurance as a feasible instrument to deliver insurance to the developing world.

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# Appendix A: Companion Theoretical Framework

## A.1 Kuhn-Tucker Conditions

### A.1.1 Model of informal risk sharing

$$\begin{aligned} \text{Max } E(U) = (1-p)^2U_0 + p^2U_1 + (1-p)p(U_2+U_3) \text{ s.t.} \\ 0 \leq t \\ 0 \leq l - t \\ L(t,\lambda_1) = (1-p)^2U_0 + p^2U_1 + (1-p)p(U_2+U_3) + \lambda_1(l-t) \end{aligned}$$

$$\begin{aligned} &(1)\; t \geq 0 \\ &(2)\; \frac{\partial L}{\partial t} = L_t = (1-p)p(-U_2' + U_3') - \lambda_1 \leq 0 \\ &(3)\; tL_t = 0 \\ &(4)\; \lambda_1 \geq 0 \\ &(5)\; \frac{\partial L}{\partial \lambda_1} = L_{\lambda_1} = l - t \geq 0 \\ &(6)\; \lambda_1 L_{\lambda_1} = 0 \end{aligned}$$

### A.1.2 Model with index insurance

$$\begin{aligned} E(U) = (v-\gamma)&\big[(1-p)^2U_0 + p^2U_1 + (1-p)p(U_2+U_3)\big] \\ &+ \gamma\big[(1-p)^2u_0 + p^2u_1 + (1-p)p(u_2+u_3)\big] \\ &+ (q+\gamma-v)\big[(1-p)^2U_4 + p^2U_5 + (1-p)p(U_6+U_7)\big] \\ &+ (1-q-\gamma)\big[(1-p)^2u_4 + p^2u_5 + (1-p)p(u_6+u_7)\big] \\ &0 \leq \alpha \\ &0 \leq 1-\alpha \\ L(\alpha,\lambda_1) = (v-\gamma)&\big[(1-p)^2U_0 + p^2U_1 + (1-p)p(U_2+U_3)\big] \\ &+ \gamma\big[(1-p)^2u_0 + p^2u_1 + (1-p)p(u_2+u_3)\big] \\ &+ (q+\gamma-v)\big[(1-p)^2U_4 + p^2U_5 + (1-p)p(U_6+U_7)\big] \\ &+ (1-q-\gamma)\big[(1-p)^2u_4 + p^2u_5 + (1-p)p(u_6+u_7)\big] + \lambda_1(1-\alpha) \end{aligned}$$

(1) $t \geq 0$

(2) $\frac{\partial L}{\partial \alpha} = L_\alpha = (1-qm)L\Big\{(v-\gamma)\big[(1-p)^2U_0' + p^2U_1' + (1-p)p(U_2'+U_3')\big] + (q+\gamma-v)\big[(1-p)^2U_4' + p^2U_5' + (1-p)p(U_6'+U_7')\big]\Big\} - qmL\Big\{\gamma\big[(1-p)^2u_0' + p^2u_1' + (1-p)p(u_2'+u_3')\big] - (1-q-\gamma)\big[(1-p)^2u_4' + p^2u_5' + (1-p)p(u_6'+u_7')\big]\Big\} - \lambda_1 \leq 0$

(3) $\alpha L_\alpha = 0$

(4) $\lambda_1 \geq 0$

(5) $\frac{\partial L}{\partial \lambda_1} = L_{\lambda_1} = 1-\alpha \geq 0$

(6) $\lambda_1 L_{\lambda_1} = 0$

## A.2 Result with no basis risk

We begin from the FOC for the model with basis risk (eq. [8]):

$$\begin{aligned}\frac{\partial E(U)}{\partial \alpha} &= (1-qm)\Big\{(v-\gamma)\big[(1-p)^2U_0' + p^2U_1' + (1-p)p(U_2'+U_3')\big] \\ &+ (q+\gamma-v)\big[(1-p)^2U_4' + p^2U_5' + (1-p)p(U_6'+U_7')\big]\Big\} \\ &- qm\Big\{\gamma\big[(1-p)^2u_0' + p^2u_1' + (1-p)p(u_2'+u_3')\big] \\ &- (1-q-\gamma)\big[(1-p)^2u_4' + p^2u_5' + (1-p)p(u_6'+u_7')\big]\Big\} = 0 \end{aligned} \tag{A1}$$

With $m = 1$ and no basis risk, $q = v$ and $\gamma = 0$, equation (8) turns into the following expression:

$$\begin{aligned}\frac{\partial E(U)}{\partial \alpha} &= (1-q)v\big[(1-p)^2U_0' + p^2U_1' + (1-p)p(U_2'+U_3')\big] \\ &- q(1-q)\big[(1-p)^2u_4' + p^2u_5' + (1-p)p(u_6'+u_7')\big] = 0 \end{aligned} \tag{A2}$$

By virtue of $q = v$, this expression can be written as it appeared in equation (9) above:

$$(1-p)^2U_0' + p^2U_1' + (1-p)p(U_2'+U_3') = (1-p)^2u_4' + p^2u_5' + (1-p)p(u_6'+u_7') \tag{A3}$$

If we replace the simplified utilities for their full depiction we get:

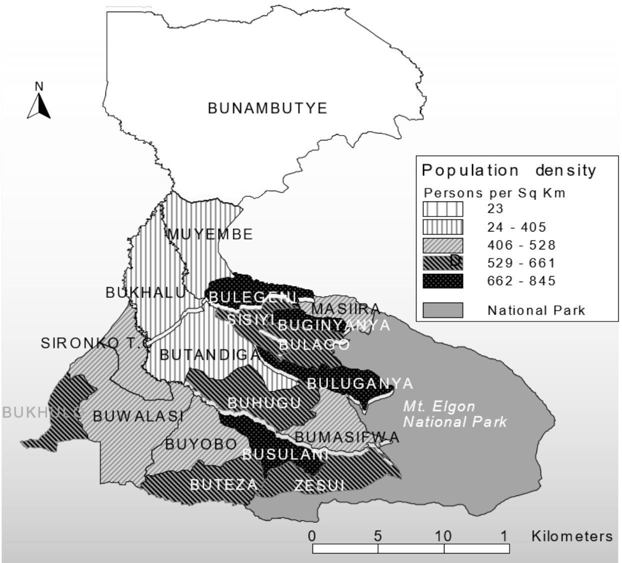
$$\begin{aligned}(1-p)^2U'(w-L+\alpha L-q\alpha L)\ +\ p^2U'(w-l-L+\alpha L-q\alpha L)\\ +(1-p)p\big(U'(w-t-L+\alpha L-q\alpha L)+U'(w-l+t-L+\alpha L-q\alpha L)\big)\ =\\ (1-p)^2U'(w-q\alpha L)\ +\ p^2U'(w-l-q\alpha L)\\ +(1-p)p(U'(w-t-q\alpha L)\ +\ U'(w-l+t-q\alpha L)\end{aligned}\qquad\text{(A4)}$$

In the latter equation it is easy to see that unless $\alpha = 1$, both sides of the equation would never be the same, as only in this case the aggregate loss $L$ would be swept away.

# Appendix B: Maps Area of Study

**Figure I.B1: Location Former Sironko District in Uganda**


**Figure I.B2: Map Area of Study (Former Sironko District)**



# Appendix C: Instructions and Procedures

## C.1 Room Preparation

[When people enter the meeting room, they are asked for their name. We have a list of invited candidates. Their name is marked and they are given a sticker with an identity number, which we ask them to stick on their shirt. It is explained that this identity number is unique and allows us to identify them during the exercise while guaranteeing complete confidentiality. This is important, as they are able to earn real money in the exercise.][52]

[They are asked to take a seat in the experimental room. There are two rows of chairs/benches, placed perpendicular to the instruction table. Participants are seated randomly in each row. Both rows of participants are seated back-to-back. The benches/chairs should be arranged so that no subject can see what another subject is looking at.]

## C.2 Running the Experiment

[The following instructions should be given to all subjects simultaneously while they are seated in the experimental room.]

### C.2.1 Welcome Address

"Welcome. Thank you for taking the time to come today. [Introduce Experimenters and Assistants.] Later, you can ask any of us questions during today's programme. For this raise your hand so that we can come and answer your question in private."

"We have invited you here, today, because we want to learn about how people in this area take decisions. You are going to be asked to take decisions about money. The money that results from your decisions will be yours to keep. The decisions that you take here will not be told to anyone. We will never use your name."

"What you need to do will be explained fully in a few minutes. But first we want to make a couple of things clear."

"First of all, this is not our money. We belong to a university, and this money has been given to us for research."

"Participation is voluntary. You may still choose not to participate in the exercise."

[52] Instructions in square brackets were not read out loud and were directed towards the implementation team. Regular text in quotation marks were the instructions orally explained to participants.

"We also have to make clear that this is research about your decisions. Therefore, you cannot talk with others. This is very important. I'm afraid that if we find you talking with others, we will have to send you home, and you will not be able to earn any money here today. Of course, if you have questions, you can ask one of us. We also ask you to switch off your mobile phones."

"Make sure that you listen carefully to us. You will be able to make a good amount of money here today, and it is important that you follow our instructions."

"During today's programme, you will be asked to make one or more choices, which will be explained to you very clearly. Only one of your choices will be selected to determine the money you will be paid. At the end of the exercise, we will randomly select one of your decisions to be paid out. Any money you earn will be paid out to you privately and confidentially after all parts of the exercise are complete."

"Now, before we explain what you need to do, it is really important to bear one more thing in mind. You will be asked to take decisions that are not a matter of getting it right or wrong; they are about what you prefer. However, it is important to think seriously about your choices because they will affect how much money you can take home."

"Please bear in mind when you take your decisions, no projects are going to come to this area because of the research that we do here today."

"There are three parts to today's programme. In all parts you will be asked to take decisions. Only one of the decisions will be selected. You will be told which decision that is at the end, and that decision determines how much money you take home. However, you will only find out which decision is selected at the end, so with every decision you take, remember: for all you know, this could be the one that determines how much money you take home."

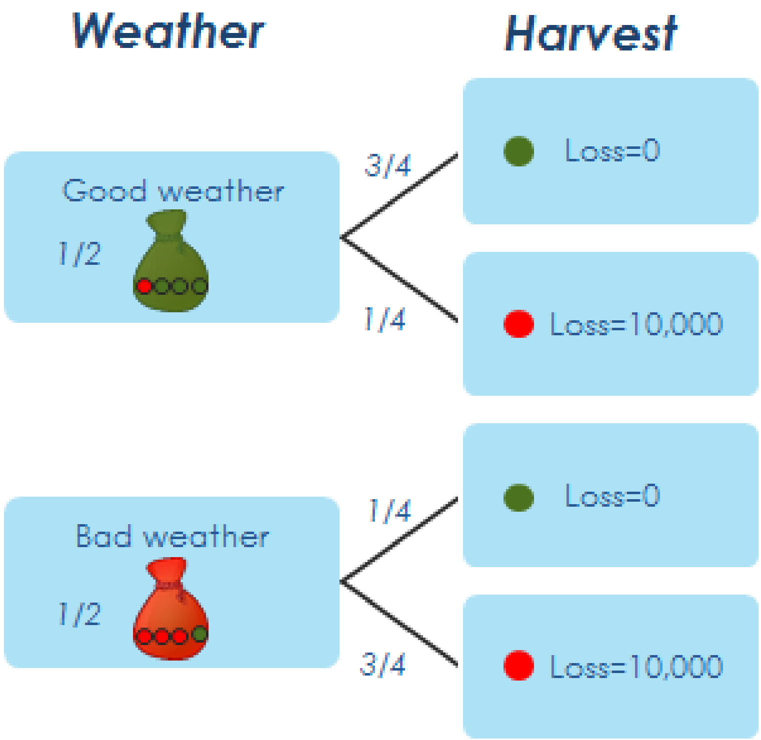
### C.2.2 Part 1 (Treatment 2)

***[The following instructions correspond to the implementation of Game 1, the instructions for Game 2 are identical apart from those modifications required to implement the treatments featured in that game.]***

**Instructions**

[Stick poster for the common event]

"In the first part of the task you will receive 16,000 Shillings and you will be presented with the situation you can see in the poster."




"As you can see there is a chance that you lose part of your endowment, 10,000 Shillings. This is determined by two events: a common event, which affects everyone similarly, and an individual one, which affects everyone differently."

"You can think about the endowment as your harvest and the common event as the weather. If the weather is good, it is more likely that you get a good harvest and you don't make any losses. By contrast, in case of bad weather, there is a higher chance that you lose your harvest. However, the weather alone does not determine your losses. One can be lucky and not make a loss even when the weather is bad, but also be unlucky and lose the harvest with good weather."

"In this task, good weather is represented by a green bag and bad weather by a red bag. If the green bag is drawn everyone gets good weather, in this case there is only 1 in 4 chances that you lose the 10,000 Shillings, and 3 in 4 chances that you go home with the 16,000 Shillings. In contrast, if the red bag is selected the likelihood of losing 10,000 Shillings goes up to 3 out 4 times, while there is 1 in 4 chances that you keep all the endowment. There are equal chances that the green or the red bag are selected, we will put both bags into a larger bag and ask a volunteer to pick one without looking."

"Whether the losses are actually realised depends on the type of token that you draw individually from the green or red bag, if the token is red, you lose the 10,000 Shillings, if it is green, you do not lose that money and you get to keep 16,000 Shillings. There are 3 green tokens in the green bag for only 1 red token, so only 1 out 4 chances of losing the 10,000 Shillings in the green bag for 3 out of 4 chances of keeping the 16,000 Shillings. As opposed to this, in the red bag there are 3 red tokens and only 1 green token, so 3 out of 4 chances of losing 10,000 Shillings and 1 out 4 of keeping the 16,000 Shillings."

*Decision*

"The decision that we will ask you to make is one about insurance. Insurance is an arrangement that pays out some money when a specified bad event happens, like making a loss due to bad harvest, in return for a cost."

"The insurance that you will have access to protects you against bad weather, the more you buy of it, the more you get in case of bad weather. So if you make a loss with bad weather, you would lose less of the 10,000 Shillings the more insurance you buy. However, there is a chance that you lose 10,000 and the insurance does not pay anything in case of good weather." [Go back to the first poster and make this point clear.]

"Every insurance unit costs 1,500 Shillings and pays out 2,250 Shillings when there is bad weather."

*Pairing*

"Throughout this task you will be paired with somebody in this room. You don't know who this person is, but it is somebody who is also here now, participating in this workshop."

"One person in the pair is called Person 1, the other is called Person 2. Both persons have an endowment of 16,000 Shillings each. Person 1 will be at risk of losing her harvest and will need to decide whether she wants to buy insurance and, if so, how many units. By contrast, Person 2 will not be at risk of losing her harvest and won't need to buy insurance."

"Person 2 does not take any decisions in this exercise. They receive their endowment of 16,000 Shillings, but they don't need to decide what to do with it."

"You are paired with two different people in this part. In one pair you are Person 1 and in another pair you are Person 2."

“We will determine at random later on whether you are paid for your decision as Person 1 or as Person 2.”

[Role play to explain pairing by asking two participants to come forward. One of them takes the role of Person 1 and the other that of Person 2. With the volunteers present we explain:

“Both Person 1 and Person 2 have an endowment of 16,000 Shillings each. Person 1 is again at risk of losing 10,000 Shillings due to a bad harvest and will need to decide whether to buy insurance, and if so, how many units. Person 2 is not at risk of losing her harvest, and will not take any decision.”

Subsequently, the participant role-playing as Person 1 becomes Person 2 and another participant comes forward to fulfil the role of Person 1.]

“Because Person 2 cannot take any decision, in this part you will all make a choice as Person 1 only. Person 1 is at risk of losing 10,000 of her endowment and needs to decide whether to buy insurance and, if so, how many units.”

**Questions I**

“Please raise your hand if you have any questions” [The experimenter administrator answers participants’ questions in front of everybody as clearly and accurately as possible. If necessary, clarify the instructions. Refrain from giving any answers that may influence their decisions.]

**Choices**

[Stick the posters of the insurance decision card for part 1 to the wall, and use it to explain the possible outcomes. During the explanations emphasise that there are four different possible outcomes.]

“Person 1 is at risk of losing 10,000 Shilling due to a bad harvest and will need to decide how much insurance she wants to buy. In other words, you as Person 1 are asked to choose among the available insurance options.”

“The choice is between the different options on the table on display here, it represents the decision card where you will record your choice after it is handed in to you. You can choose exactly one of these options.”

| **Person 1** | | ID: ____ Part: __1__ Session: ____ | |
|---|---|---|---|
| | | ● - 10,000 | ● - 0 |
| **Insurance Units** | **Insurance Price** | **Good Weather** | **Bad Weather** |
| 0 ☐ | - 0 | +0<br>● Earnings: 6,000 ● Earnings: 16,000 | +0<br>● Earnings: 6,000 ● Earnings: 16,000 |
| 1 ☐ | - 1,500 | +0<br>● Earnings: 4,500 ● Earnings: 14,500 | +2,250<br>● Earnings: 6,750 ● Earnings: 16,750 |
| 2 ☐ | - 3,000 | +0<br>● Earnings: 3,000 ● Earnings: 13,000 | + 4,500<br>● Earnings: 7,500 ● Earnings: 17,500 |
| 3 ☐ | - 4,500 | +0<br>● Earnings: 1,500 ● Earnings: 11,500 | + 6,750<br>● Earnings: 8,250 ● Earnings: 18,250 |
| 4 ☐ | - 6,000 | +0<br>● Earnings: 0 ● Earnings: 10,000 | +9,000<br>● Earnings: 9,000 ● Earnings: 19,000 |

"If you don't buy any insurance you will not pay anything, and if you draw the green token your earnings will be of 16,000, as you will get to keep your endowment. However, if you draw the red token, you will end up with losses of 10,000 Shillings and earnings of 6,000 Shillings."

"If you buy 1 unit of insurance it will cost you 1,500 Shillings of your endowment, and if you draw the green token your earnings will be of 14,500 Shillings if the weather is good, and of 16,750 Shillings if the weather is bad, since then the insurance will pay you 2,250 Shillings. If instead you draw the red token, you will make a loss of 10,000 Shillings and the insurance will not pay you anything if the weather is good; you will then end up with earnings of 4,500 Shillings. However, if you draw the red token and the weather is bad, the insurance will pay you the 2,250 Shillings and you will get earnings of 6,750 Shillings."

"If you buy 2 units of insurance it will cost you 3,000 Shillings of your endowment, and if you draw the green token your earnings will be of 13,000 Shillings if the weather is good, and of 17,500 Shillings if the weather is bad, since then the insurance will pay you 4,500 Shillings. If instead you draw the red token, you will make a loss of 10,000 Shillings and the insurance will not pay you anything if the weather is good; you will then end up with earnings of 3,000 Shillings. However, if you draw the red token and the weather is bad, the insurance will pay you the 4,500 Shillings and you will get earnings of 7,500 Shillings."

"If you buy 3 units of insurance it will cost you 4,500 Shillings of your endowment, and if you draw the green token your earnings will be of 11,500 Shillings if the weather is good, and of 18,250 Shillings if the weather is bad, since then the insurance will pay you 6,750 Shillings. If instead you draw the red token, you will make a loss of 10,000 Shillings and the insurance will not pay you anything if the weather is good; you will then end up with earnings of 1,500 Shillings. However, if you draw the red token and the weather is bad, the insurance will pay you the 6,750 Shillings and you will get earnings of 8,250 Shillings."

“Finally, if you buy 4 units of insurance it will cost you 6,000 Shillings of your endowment, and if you draw the green token your earnings will be of 10,000 Shillings if the weather is good, and of 19,000 Shillings if the weather is bad, since then the insurance will pay you 9,000 Shillings. If instead you draw the red token, you will make a loss of 10,000 Shillings and the insurance will not pay you anything if the weather is good; you will then end up with nothing. However, if you draw the red token and the weather is bad, the insurance will pay you the 9,000 Shillings and you will get earnings of 9,000 Shillings.”

“Bear in mind that it is more likely that the insurance pays you something when you make losses than you don’t receive anything, because in the case of bad weather there are three chances out of four to make a loss, whereas in case of good weather there is only one chance of four to make a loss. Similarly, it is less likely that the insurance pays you when you don’t lose your harvest.”

“After you have made your choice about the insurance you want to buy, your payment will be calculated in the following way. We will ask one of you to come forth and pick one bag from this one [Show the bag], which contains a red and a green bag. Each of these bags contains the number of tokens described before. Whereas the red bag has 3 red tokens, signalling losses, and 1 green token, meaning no losses, the green bag contains only 1 red token and 3 green ones. Once one of the bags is selected, each one of you will pick one token during the resolution phase, which together with your decision will determine how much money you go home with.”

**Decision Card**

“Everyone will take her decision as Person 1.”

“To make your decision we will use the following decision card. It shows the same 5 options as the ones presented on the table. Out of these 5 options we ask you to select one by ticking the appropriate box.” [Show the decision card, and indicate where they can find the different options and how they correspond to the options presented on the table. Explain where they have to indicate their insurance decision.]

**Questions II**

“Please raise your hand if you have any questions.” [The experimenter administrator answers participants’ questions in front of everybody as clearly and accurately as possible. If necessary, clarify the instructions. Refrain from giving any answers that may influence their decisions.]

**Control Questions**

“We will now ask some questions individually to see whether you understood the instructions.”

[Ask participants to turn and explain that they should place the decision card within the wooden structure.]

[The experimenter assistants call each participant one by one. They say the following:

"I am going to ask you some questions to see if you understood the instructions. Remember that in this part that you are Person 1, you are at risk of losing 10,000 Shillings due to a bad harvest and you can buy insurance to protect yourself against this event when the weather is bad. The insurance pays out when the weather is bad, both when you make losses and when you don't."

"You are paired with someone else in this room who is Person 2 and doesn't take any decision."

"You can buy no insurance, 1 unit, 2 units, 3 units or 4 units of insurance. Each option changes how much you take home when the weather is good or bad, and in case of good or bad harvest."

Finally, the experimenters ask the following four questions making reference to the decision cards that they carry with them.]

1. If you chose to buy one unit of insurance, how much would you go home with if a red token is drawn and the weather is bad? (6,750)
2. If you chose to buy three units of insurance, how much would you go home with if a green token is drawn and the weather is bad? (18,250)
3. If you chose to buy two units of insurance, how much would you go home with if a red token is drawn and the weather is good? (3,000)
4. How much of your endowment would you spend buying four units of insurance? (6,000)

[For each of the questions, record on the control question card whether they answered it correctly. If the participant gave a wrong answer for at least one of the questions, ask him/her what was not clear. Answer all the remaining questions participants as clearly and accurately as possible. If necessary, clarify the instructions; but not more than once.]

[At the bottom of the page the experimenter should answer the following question:

"Do you think the participant understood the instructions well?" Y=Yes/N=No]

**Decision Card**

[Before the participant goes back to her seat. The experimenter administering the control question explains how the decision card works by saying the following:]

"As Person 1 you will take the insurance decision using the following decision card. It shows the same 5 options as the ones presented on the table. Out of these 5 options we ask you to select one by ticking the appropriate box." [Show the decision card, and indicate where they can find the different options and how they correspond to the options presented on the table. Explain where they have to indicate their insurance decision.]

[Before the participant goes back to her seat give her the decision card with the ID are already filled in. Ask the participant not to write anything on it until we tell her. Remind them that if they need help or make a mistake they can ask us for help.]

**Decisions**

[Give each participant a pen.] "If you have no further questions, we will now begin. Please indicate the insurance option you choose. Remember, there are no wrong choices, so you should take up exactly as much insurance as you prefer."

"We emphasise that it is important that you make your choice in private. Do not show your decision card to the other participants and place it in the wooden structure in front of you. If you need assistance, please raise your hand so that one of us can come to you to assist you. Once you have made your choice, please fold the decision sheet and raise your hand so that we can come and collect your decision card."

"Take your time to make your decisions since they can affect how much money you take home."

[The participants remain seated. Any questions at this point should be addressed individually. After the participants have made their choice, they fold their decision card, and we collect them. Verify whether participants filled in the decision cards correctly. The central administrator enters the insurance decisions in an Excel data sheet. When all participants have made their decision, Part 1 is completed.]

### C.2.3 Part 2 (Treatment 1)

#### Instructions

[Remove poster for part 1.]

[Participants remain seated.] "Thank you, you have now all completed the first part of the task. We will now explain the second part."

"During this part you will be again paired with two other people in this room. Different people than before. You don't know who they are, but they are also here now, participating in this workshop."

"Same as before, in each pair there is again a Person 1 and a Person 2. Both persons have an endowment of 16,000 Shillings each. Person 1 will be again at risk of losing 10,000 Shillings due to a bad harvest and will need to decide again how much insurance she wants to buy. By contrast, Person 2 will not be at risk of losing her harvest and now will be given the opportunity of compensating Person 1 for her losses up to whatever amount she sees fit."

"You are paired with two different people in this part. In one pair you are Person 1 and in another pair you are Person 2."

"We will determine at random later on for whether you are paid for your decision as Person 1 or as Person 2."

[Role play to explain pairing by asking two participants to come forward. One of them takes the role of Person 1 and the other that of Person 2. With the volunteers present we explain:

"Both Person 1 and Person 2 have an endowment of 16,000 Shillings each. Person 1 is again at risk of losing 10,000 Shillings due to a bad harvest and will need to decide whether to buy insurance, and if so, how many units. Person 2 is not at risk of losing her harvest and now will be given the opportunity of compensating Person 1 for her losses up to whatever amount she sees fit."

Subsequently, the participant role-playing as Person 1 becomes Person 2 and another participant comes forward to fulfil the role of Person 1.]

"This part has two rounds and each of you will be asked to take a different decision in every round: an insurance decision as Person 1 and a sharing decision as Person 2."

"One of us will inform you personally if you are Person 1 or 2 in the round."

#### Questions I

"Please raise your hand if you have any questions." [The experimenter administrator answers participants' questions in front of everybody as clearly and accurately as possible.

If necessary, clarify the instructions. Refrain from giving any answers that may influence their decisions.]

## Round 1

*Choices Person 1*

[Stick the poster of the insurance decision card for part 2, and use it to explain the scenarios below.]

"As noted, those who are Person 1 will face the same situation every one of you faced before, in which there is a chance of losing 10,000 Shillings, and will have the chance to buy insurance against these losses. The only difference is that now Person 2 can compensate you when you make losses."

"Person 1 will be asked to choose how much insurance she wants to purchase. In other words, you as Person 1 are asked to choose again between the different insurance options. You may make the same decision that you made in the first part of the task, or you may decide to change your decision, and buy a different amount of insurance."

"The choice is between the different options on the table on display here, it represents the decision card where you will record your choice after it is handed in to you. You can choose exactly one of these options."

| **Person 1** | | ID: ____ Part: 2 Session: ____ | | | |
|---|---|---|---|---|---|
| | | ● - 10,000 | | ● - 0 | |
| **Insurance Units** | **Insurance Price** | **Good Weather** | **Bad Weather** | **Losses Bad Harvest** | **Sharing Person 2** |
| 0 ☐ | - 0 | +0<br>● Earnings: 6,000 ● Earnings: 16,000 | +0<br>● Earnings: 6,000 ● Earnings: 16,000 | - 10,000<br>- 10,000 | + ? |
| 1 ☐ | - 1,500 | +0<br>● Earnings: 4,500 ● Earnings: 14,500 | +2,250<br>● Earnings: 6,750 ● Earnings: 16,750 | - 9,250<br>- 11,500 | + ? |
| 2 ☐ | - 3,000 | +0<br>● Earnings: 3,000 ● Earnings: 13,000 | +4,500<br>● Earnings: 7,500 ● Earnings: 17,500 | - 8,500<br>- 13,000 | + ? |
| 3 ☐ | - 4,500 | +0<br>● Earnings: 1,500 ● Earnings: 11,500 | +6,750<br>● Earnings: 8,250 ● Earnings: 18,250 | - 7,750<br>- 14,500 | + ? |
| 4 ☐ | - 6,000 | +0<br>● Earnings: 0 ● Earnings: 10,000 | +9,000<br>● Earnings: 9,000 ● Earnings: 19,000 | - 7,000<br>- 16,000 | + ? |

"If you as Person 1 don't buy any insurance you will not pay anything. Same as before, if you draw the green token you will not make any losses and you will get to keep your endowment of 16,000 Shillings. Person 2 cannot transfer any amount to you since you would not have suffered any losses due to a bad harvest."

"If, on the other hand, you draw the red token, you will end up with losses of 10,000 Shillings. In this case, Person 2 can choose to share any amount from 0 to 16,000 Shillings of her endowment to compensate you for your losses."

"If you buy 1 unit of insurance it will cost you 1,500 Shillings of your endowment. If you draw the red token, you will make a loss of 10,000 Shillings and the insurance will not pay you anything if the weather is good; you will therefore lose 11,500 Shillings of your endowment (your losses plus the cost of the insurance). Person 2 can choose to share any amount of her endowment to compensate you. If however you draw the red token and the weather is bad, the insurance will pay you 2,250 Shillings, you will lose 9,250 Shillings (your losses net of the insurance payout plus the cost of the insurance). Person 2 can choose to share any amount of her endowment to compensate you for the losses."

"If you buy 2 units of insurance it will cost you 3,000 Shillings of your endowment. If you draw the red token, you will make a loss of 10,000 Shillings and the insurance will not pay you anything if the weather is good; you will therefore lose 13,000 Shillings (your losses plus the cost of the insurance). If however you draw the red token and the weather is bad, the insurance will pay you the 4,500 Shillings, you will lose 8,500 Shillings (your losses net of the insurance payout plus the cost of the insurance). In both cases when you draw the red token and make losses, Person 2 can choose to share any amount of her endowment to compensate you for the losses."

"If you buy 3 units of insurance it will cost you 4,500 Shillings of your endowment. If you draw the red token, you will make a loss of 10,000 Shillings and the insurance will not pay you anything if the weather is good; you will therefore lose 14,500 Shillings (your losses plus the cost of the insurance). If however you draw the red token and the weather is bad, the insurance will pay you the 6,000 Shillings, you will lose 7,750 Shillings (your losses net of the insurance payout plus the cost of the insurance). In both cases when you draw the red token and make losses, Person 2 can choose to share any amount of her endowment to compensate you for the losses."

"Finally, if you buy 4 units of insurance it will cost you 6,000 Shillings of your endowment. If you draw the red token, you will make a loss of 10,000 Shillings and the insurance will not pay you anything if the weather is good; you will therefore lose 16,000 Shillings (your losses plus the cost of the insurance). If however you draw the red token and the weather is bad, the insurance will pay you the 8,000 Shillings, you will lose 7,000 Shillings (your losses net of the insurance payout plus the cost of the insurance). In both cases when you draw the red token and make losses, Person 2 can choose to share any amount of her endowment to compensate you for the losses."

"Remember that if you draw a green token the possible outcomes are the same as in the first part. You will get higher earnings in case of bad weather than with good weather, because the insurance pays out an indemnity when the weather is bad, which is higher the more insurance you buy. Person 2 cannot transfer any amount to you when a green token is drawn, since then you as Person 1 would not have suffered any losses due to a bad harvest, even though you would still see your endowment reduced due to the cost of the insurance purchased if you buy any."

*Decision Card Person 1*

"As Person 1 you will take the insurance decision using the same card as before, with the only difference that this card has a column that reminds you of the amount you can lose and another reminding you that Person 2 can share some amount with you when you make losses. You need to mark your preferred option on the decision card." [Show the decision card, and indicate where they can find the different options. Explain where they have to indicate their insurance decision.]

*Questions II*

"Please raise your hand if you have any questions." [The experimenter administrator answers participants' questions in front of everybody as clearly and accurately as possible. If necessary, clarify the instructions. Refrain from giving any answers that may influence their decisions.]

*Choices Person 2*

"Person 2 is not at risk of losing any part of her endowment. She will not be able to buy insurance, however, this time she will be given the opportunity to compensate Person 1 for her losses up to whatever amount she sees fit using her endowment of 16,000 Shillings."

"So you as Person 2 need to decide how much, if any, of Person 1's losses you wish to compensate for every possible insurance decision taken by Person 1. The sharing decision you take for the actual insurance level chosen by Person 1 will determine how much you take home."

[Stick the posters of the losses-sharing cards and use them to explain the scenarios below.]

| **Person 2** | | ID: ____ Part: _2_ Session: ____ |
|---|---|---|
|  | | ● - 10000 |
| ***Insurance Units*** | ***Losses Person 1*** | ***Sharing*** |
| 0 | 10,000 | _________ Shillings |
| 1 | 11,500 | _________ Shillings |
| 2 | 13,000 | _________ Shillings |
| 3 | 14,500 | _________ Shillings |
| 4 | 16,000 | _________ Shillings |

| **Person 2** | | ID: ____ Part: _2_ Session: ____ |
|---|---|---|
|  | | ● - 10000 |
| ***Insurance Units*** | ***Losses Person 1*** | ***Sharing*** |
| 0 | 10,000 | _________ Shillings |
| 1 | 9,250 | _________ Shillings |
| 2 | 8,500 | _________ Shillings |
| 3 | 7,750 | _________ Shillings |
| 4 | 7,000 | _________ Shillings |

“If Person 1 draws a red token and has not bought any insurance, she will get a loss of 10,000 Shillings, regardless of the weather conditions. You as Person 2 can choose to share any amount of your endowment of 16,000 Shillings to compensate Person 1 for her losses, from 0 to 16,000 Shillings.”

“If, on the other hand, Person 1 draws a green token she will not suffer any losses from a bad harvest, and you cannot transfer any amount to her.”

“If Person 1 draws a red token and has bought 1 unit of insurance, she will lose 11,500 Shillings if the weather is good (10,000 of it are losses and 1,500 the cost of the insurance that has not paid out anything). You can choose to share any amount of your endowment to compensate person for her losses. If however Person 1 draws a red token and the weather is bad, she will lose 9,250 Shillings (10,000 of it are losses and 1,500 the cost of the insurance that has paid out 2,250). You can again choose to share any amount of your endowment to compensate Person 1 for her losses.”

"If Person 1 draws a red token and has bought 2 units of insurance, she will lose 13,000 Shillings if the weather is good (10,000 of it are losses and 3,000 the cost of the insurance that has not paid out anything). If however Person 1 draws a red token and the weather is bad, she will lose 8,500 Shillings (10,000 of it are losses and 3,000 the cost of the insurance that has paid out 4,500). In both cases when Person 1 draws a red token and makes losses, you as Person 2 can choose to share any amount of your endowment to compensate Person 1 for her losses."

"If Person 1 draws a red token and has bought 3 units of insurance, she will lose 14,500 Shillings if the weather is good (10,000 of it are losses and 4,500 the cost of the insurance that has not paid out anything). If however Person 1 draws a red token and the weather is bad, she will lose 7,750 Shillings (10,000 of it are losses and 4,500 the cost of the insurance that has paid out 6,750). In both cases when Person 1 draws a red token and makes losses, you can choose to share any amount of your endowment to compensate Person 1 for her losses."

"Finally, if Person 1 draws a red token and has bought 4 units of insurance, she will lose 16,000 Shillings if the weather is good (10,000 of it are losses and 6,000 the cost of the insurance that has not paid out anything). If however Person 1 draws a red token and the weather is bad, she will lose 7,000 Shillings (10,000 of it are losses and 6,000 the cost of the insurance that has paid out 9,000). In both cases when Person 1 draws a red token and makes losses, you can choose to share any amount of your endowment to compensate Person 1 for her losses."

[Ask two volunteers to come forward and role-play with them using the examples below. Use actual money to simulate the transactions.]

"For instance, if Person 1 does not buy any insurance and you, as Person 2, decide to compensate Person 1 with 5,000 Shillings because she has drawn a red token and made losses, she will end up with earnings of 11,000 Shillings and you will also take 11,000 Shillings home."

[Tell participants that this is just an example to help them understand the decision they need to make and that they should not guide their decisions based on it.]

"If Person 1 buys 3 units of insurance and you decide to compensate Person 1 with nothing, she will end up with earnings of 1,500 Shillings if the weather is good, and with 8,250 Shillings if the weather is bad. In either case you will take the full endowment of 16,000 Shillings home."

"If Person 1 buys 2 units of insurance and you decide to compensate Person 1 with 2,000 Shillings, she will end up with earnings of 5,000 Shillings if the weather is good, and with 9,500 Shillings if the weather is bad. In either case you will take 14,000 Shillings home."

[Remind participants that these are just examples to help them understand the decision they need to make and that they should not guide their decisions based on them.]

"Remember that if Person 1 draws a green token, you cannot transfer any amount to her, since Person 1 would not have suffered any losses due to a bad harvest, even though she may still have to pay the cost of insurance if she purchased any."

*Decisions Cards Person 2*

[Use loss-sharing posters in the explanation.]

"We will use these cards to record the amount that you, as Person 2, wish to share with Person 1. [Show the cards and use it in the explanations.] These cards allow you to express how much of your endowment you wish to share with Person 1 to compensate her for the losses in the event of a bad harvest. You can share any amount from your endowment of 16,000 Shillings, from 0 to 16,000."

"For both the case of good and bad weather, the cards show the insurance that Person 1 has bought and the amount she has lost. [Point at the card while you explain this.] As Person 2, you will need to decide how much, if any, of your endowment you want to share with Person 1 when she draws a red token for every possible level of insurance coverage Person 1 could have chosen, both in the event of good and bad weather."

"In other words, you will need to decide, both in the case of good and bad weather, how much you want to share if she buys no insurance, if she buys one unit of insurance, if she buys two units, if she buys three and if she buys the maximum units of insurance, which are four units." [Indicate the spaces where the amounts they wish to share in every case should be filled.]

"Remember that only the sharing decision you take for the insurance decision actually made by Person 1 will have actual consequences. However, you are asked to decide about all possible decision of Person 1 because we don't know yet what Person 1 would choose."

"For example, if Person 1 buys 2 units of insurance, we will look at how much you decided to share in this case and deduct it from your endowment." [Use the posters to illustrate this point.]

*Questions III*

"Please raise your hand if you have any questions." [The experimenter administrator answers participants' questions in front of everybody as clearly and accurately as possible. If necessary, clarify the instructions. Refrain from giving any answers that may influence their decisions.]

*Control Questions*

"We will now ask some questions to see whether you understood the instructions and inform you about the decision we ask you to make."

[Ask participants to turn.]

[The experimenter assistants call each participant one by one. They say the following:

"I am going to ask you some questions to see if you understood the instructions. In this round you are Person 1, you are at risk of losing 10,000 Shillings due to a bad harvest and you can buy insurance to protect yourself against this event when the weather is bad, that is, the insurance pays out when you make losses and the weather is bad."

"You are paired with someone else in this room who is Person 2 who may help you with your losses."

"You can buy no insurance, 1 unit, 2 units, 3 units or 4 units of insurance. Each option changes how much you take home when the weather is good or bad, and in case of good or bad harvest."

Finally, the experimenters ask the following question making reference to the decision cards that they carry with them.]

1. As Person 1, if you chose to buy one unit of insurance and you draw a red token with good weather, how much would you home? (4,500) How much would you take home if Person 2 decides to help you with 2,000 Shillings? (6,500)

[Record on the control question card whether they answered the question correctly. If the participant gave a wrong answer for at least one of the questions, ask her what was not clear. Answer all the remaining questions participants as clearly and accurately as possible. If necessary, clarify the instructions; but not more than once.]

[At the bottom of the page the experimenter should answer the following question: "Do you think the participant understood the instructions well?" Y=Yes/N=No]

*Decision Card Person 1*

[Before the participant goes back to her seat. The experimenter explains how the decision card works by saying the following:]

"As Person 1 you will take the insurance decision using the same card as before, with the only difference that this card has a column that reminds you of the amount you can lose and another reminding you that Person 2 can share some amount with you when you make loses [Show columns in the card]. You need to mark your preferred option on the decision card. [Show the decision card, and indicate where they can find the different options. Explain where they have to indicate their insurance decision.]"

[Before the participant goes back to her seat give her the decision card with the ID are already filled in. Ask the participant not to write anything on it until we tell her. Remind them that if they need help or make a mistake they can ask us for help.]

*Decisions*

"If you have no further questions, we will now begin. Please indicate clearly your choice. Remember, there are no wrong choices."

"We emphasise that it is important that you make your choice in private. Do not show your decision card to the other participants and place it in the wooden structure in front of you. If you need assistance, please raise your hand so that one of us can come to you to assist you. Once you have made your choice, please fold the decision sheet and raise your hand so that we can come and collect your decision card."

"Take your time to make your decisions since they can affect how much money you take home."

[The participants remain seated. Any questions at this point should be addressed individually. After the participants have made their choice, they fold their decision card, and we collect them. Verify whether participants filled in the decision cards correctly. When all participants have made their decision, Round 1 is completed.]

**Round 2**

*Instructions*

"After you have taken your decisions in the first round, you will take your decisions in the second round. A different decision than before."

*Control Questions*

"We will now ask some questions to see whether you understood the instructions and inform you about the decision we ask you to make."

[Ask participants to turn.]

[The experimenter assistants call each participant one by one. They say the following:

"I am going to ask you some questions to see if you understood the instructions. In this round you are Person 2, you are not at risk of losing your endowment. You are paired with someone in this room, Person 1, who is at risk of losing 10,000 Shillings due to a bad harvest and can buy insurance against this event when the weather is bad. The insurance pays out when the weather is bad, both when Person 1 makes losses and when she doesn't."

"As Person 2, you have the chance of compensating Person 1 for her losses for every possible decision she can take. In other words, you will need to decide, both in the case of good and bad weather, how much you want to share if she buys no insurance, if she buys one unit of insurance, if she buys two units, if she buys three and if she buys the maximum units of insurance, which are four units."

"However, only one of your sharing decisions will have actual consequences. We will only take from you the money you decide to share for the actual insurance decision taken by Person 1." [Use an example to make this point employing the decision cards.]

Finally, the experimenters ask the following question making reference to the decision cards that they carry with them.]

1. As Person 2, if Person 1 buy 2 units of insurance and she draws a red token with bad weather, how mush would she take home? (7,500) and you how much would she take home if you decide to share 4,000 Shillings with her? (11,500) And how much would you take home? (12,000)

[Record on the control question card whether the participant answered the question correctly. If the participant gave a wrong answer, ask him/her what was not clear. Answer all the remaining questions participants as clearly and accurately as possible. If necessary, clarify the instructions; but not more than once.]

[At the bottom of the page the experimenter should answer the following question: "Do you think the participant understood the instructions well?" Y=Yes/N=No]

*Decisions Cards Person 2*

[Before the participant goes back to her seat. The experimenter explains how the decision card works by saying the following:]

"We will use these cards to record the amount that you, as Person 2, wish to share with Person 1. [Show the cards and use it in the explanations.] These cards allow you to express how much of your endowment you wish to share with Person 1 to compensate her for the losses in the event of a bad harvest. You can share any amount from your endowment of 16,000 Shillings, from 0 to 16,000."

"For both the case of good and bad weather, the cards show the insurance that Person 1 has bought and the amount she has lost. [Point at the card while you explain this.] As Person 2, you will need to decide how much, if any, of your endowment you want to share with Person 1 when she draws a red token for every possible level of insurance coverage Person 1 could have chosen, both in the event of good and bad weather."

"In other words, you will need to decide, both in the case of good and bad weather, how much you want to share if she buys no insurance, if she buys one unit of insurance, if she buys two units, if she buys three and if she buys the maximum units of insurance, which are four units." [Indicate the spaces where the amounts they wish to share in every case should be filled.]

"Remember that only the sharing decision you take for the insurance decision actually made by Person 1 will have actual consequences. However, you are asked to decide about all possible decision of Person 1 because we don't know yet what Person 1 would choose."

"For example, if Person 1 buys 2 units of insurance, we will look at how much you decided to share in this case and deduct it from your endowment." [Use the posters to illustrate this point.]

[Ask the participant to think about their decision. Tell them that if they change their minds or make a mistake they can ask us for help.]

*Decisions*

"If you have no further questions, we will now begin. Please indicate clearly your choice. Remember, there are no wrong choices."

"We emphasise that it is important that you make your choice in private. Do not show your decision card to the other participants and place it in the wooden structure in front of you. If you need assistance, please raise your hand so that one of us can come to you to assist you. Once you have made your choice, please fold the decision sheet and raise your hand so that we can come and collect your decision card."

"Take your time to make your decisions since they can affect how much money you take home."

[The participants remain seated. After the participants have made their choices, they fold their decision card, and we collect them. Verify whether participants filled in the decision cards correctly. When all participants have made their decision, Part 2 is completed.]

### C.2.4 Part 3 (Treatment 5)

#### Instructions

[Remove posters for part 2.]

[Participants remain seated.] "Thank you, you have now all completed the second part of the task. We will now explain the final part."

"During this part you will be again paired with two other people in this room. Different people than before. You don't know who they are, but they are also here now, participating in this workshop."

"Same as before, in each pair there is again a Person 1 and a Person 2. Both persons have an endowment of 16,000 Shillings each. Person 1 will be again at risk of losing 10,000 Shillings due to a bad harvest, but this time she will not have access to insurance. Person 2, will not be at risk of losing her harvest and will again be given the opportunity of compensating Person 1 for her losses up to whatever amount she sees fit."

"You are paired with two different people in this part. In one pair you are Person 1 and in another pair you are Person 2."

"We will determine at random later on for whether you are paid for your decision as Person 1 or as Person 2."

[Role play to explain pairing. Person 1 remains the same as in the previous role-playing, whereas Person 2 changes from the first. With the volunteers present we explain:

"Both Person 1 and Person 2 have an endowment of 16,000 Shillings each. Person 1 is again at risk of losing 10,000 Shillings due to a bad harvest but this time will not have access to insurance. Person 2 is not at risk of losing her harvest and will again be given the opportunity of compensating Person 1 for her losses up to whatever amount she sees fit."

Subsequently, the participant role-playing as Person 1 becomes Person 2 and another participant comes forward to fulfil the role of Person 1.]

"Because Person 1 cannot take any decision, in this part you will all make a choice as Person 2 only. Person 2 needs to decide how much, if any, of Person 1's losses she wishes to compensate in a situation where Person 1 cannot buy any insurance to protect herself against those losses."

#### Choices

[Stick the loss-sharing card for Part 3 to the wall.]

"If Person 1 draws a green token she will keep her whole endowment, and you as Person 2 cannot transfer any amount to Person 1, since she would not have suffered any losses. If, on the other hand, Person 1 draws a red token, she will get a loss of 10,000 Shillings. In this case, you can then choose to share any amount of your endowment of 16,000 Shillings to compensate Person 1 for her losses, from 0 to 16,000 Shillings."

<table>
<tr><td colspan="2">Person 2</td><td>ID: ____ Part: 3 Session: ____</td></tr>
<tr><td colspan="3">● - 10000</td></tr>
<tr><td rowspan="2">No Insurance</td><td>Losses Person 1</td><td>Sharing</td></tr>
<tr><td>10,000</td><td>________ Shillings</td></tr>
</table>

[Ask two volunteers to come forward and role-play with them using the examples below.]

"For instance, if you decide to share 4,000 Shillings with Person 1 because she has drawn a red token and made losses, she will end up with earnings of 10,000 Shillings and you will take 12,000 Shillings home."

[Tell participants that this is just an example to help them understand the decision they need to make and that they should not guide their decisions based on them.]

"If you decide not to share anything with Person 1, she will end up with earnings of 6,000 Shillings and you will take the full endowment of 16,000 Shillings home."

"If you decide to share 2,000 with Person 1, she will end up with earnings of 8,000 Shillings and you will take the 14,000 Shillings home."

[Remind participants that these are just examples to help them understand the decision they need to make and that they should not guide their decisions based on them.]

**Decision Card**

[Use loss-sharing posters in the explanation.]

"Everyone will take her decision as Person 2 in this part."

"We will use this card to record the amount that you, as Person 2, wish to share with Person 1." [Show card in the poster and use it in the explanations.]

"This card allows you to express how much of your endowment you wish to share with Person 1 to compensate for her losses in case of a bad harvest. You can share any amount from your endowment of 16,000 Shillings, from 0 to 16,000 Shillings."

"The card shows the 10,000 Shillings Person 1 has lost. As Person 2, you will need to decide how much, if any, of your endowment you wish to share with Person 1, who doesn't have insurance, to compensate for her losses when she draws a red token."

**Questions**

"Please raise your hand if you have any questions." [The experimenter administrator answers participants' questions in front of everybody as clearly and accurately as possible. If necessary, clarify the instructions. Refrain from giving any answers that may influence their decisions.]

**Control Questions**

[The experimenter assistants call each participant one by one. They say the following:

"I am going to ask you some questions to see if you understood the instructions. Remember that in this round you are Person 2, you are not at risk of losing your endowment. You are paired with someone else in this room who is Person 1 and is at risk of losing 10,000 Shillings due to a bad harvest and cannot buy insurance to protect herself against this event."

"As Person 2, you can share any amount with Person 1 to compensate her for the losses, this is the decision you need to make."

Finally, the experimenters ask the following question making reference to the decision cards that they carry with them.]

1. If Person 1 draws a red token how much would she lose? (10,000)
2. As Person 2, if you help Person 1 with 2,000 how much would she take home? (8,000) How much would you take home? (14,000)

[Record on the control question card whether the participant answered the question correctly. If the participant gave a wrong answer, ask him/her what was not clear. Answer all the remaining questions participants as clearly and accurately as possible. If necessary, clarify the instructions; but not more than once.]

[At the bottom of the page the experimenter should answer the following question:

"Do you think the participant understood the instructions well?" Y=Yes/N=No]

**Decision Card**

[Before the participant goes back to her seat. The experimenter explains how the decision card works by saying the following:]

"We will use this card to record the amount that you, as Person 2, wish to share with Person 1." [Show card in the poster and use it in the explanations.]

"This card allows you to express how much of your endowment you wish to share with Person 1 to compensate for her losses in case of a bad harvest. You can share any amount from your endowment of 16,000 Shillings, from 0 to 16,000 Shillings."

"The card shows the 10,000 Shillings Person 1 has lost. As Person 2, you will need to decide how much, if any, of your endowment you wish to share with Person 1, who doesn't have insurance, to compensate for her losses when she draws a red token."

[Ask the participant to think about their decision. Tell them that if they change their minds or make a mistake they can ask us for help.]

**Decisions**

"If you have no further questions, we will now begin. Please indicate the insurance option you choose. Remember, there are no wrong choices, so you should take up exactly as much insurance as you prefer."

"We emphasise that it is important that you make your choice in private. Do not show your decision card to the other participants and place it in the wooden structure in front of you. If you need assistance, please raise your hand so that one of us can come to you to assist you. Once you have made your choice, please fold the decision sheet and raise your hand so that we can come and collect your decision card."

"Take your time to make your decisions since they can affect how much money you take home."

[The participants remain seated. After the participants have made their choices, they fold their decision card, and we collect them. Verify whether participants filled in the decision cards correctly. The central administrator enters the sharing decisions in an Excel data sheet. When all participants have made their decision, the session ends and we proceed to the resolution stage.]

## C.3 Resolution

"Thank you, you have now completed all parts of the task. Your earnings from your decisions will now be determined."

"In order to do so, we first need to select which of the three parts of the task will be used to determine your earnings, part 1, part 2 or part 3. For this, we put three cards with numbers 1 to 3 on them in a bag, and pick out one card without looking. The number on the card that is picked out determines the decision which will be used to calculate your earnings. [Ask one volunteer to pick out a card.]"

[Whichever number is drawn say:] "In this part you played both as Person 1 and Person 2, so we need to decide which decision will determine your earnings. We will do as follows, we will put two cards with the numbers 1 and 2 on this bag. If number 1 is selected those with IDs 1 to 10 will be paid for their decision as Person 1 and IDs 11 to 20 for their decision as Person 2. In contrast, if number 2 is drawn, those with IDs 11 to 20 will be paid for their decision as Person 1 and IDs 1 to 10 for their decision as Person 2. [Ask one volunteer to pick out a card.]"

[For everyone] "Before we proceed to determine the individual earnings, we need to know what the common weather conditions are, that is, the chances of getting a red or a green token. Remember that a green bag contains 3 green tokens for 1 red one, so if this bag is picked, there is a 1 in 4 chances that Person 1 makes a loss of 10,000 Shillings. If however the red bag, containing 3 red and 1 green tokens, is selected there is a 3 in 4 chances that Person 1 makes a loss of 10,000 Shillings."[Ask one volunteer to pick out the bag.]

"We now invite you to come forward, one by one, to determine your earnings."

[If type 1 pairs were selected, IDs 1 to 10 are called first in one by one to pick out a counter from the bag selected. We show them their decision card and explain them what their decision was in that pair as well as the decision of the person they were paired with if relevant, so that they understand how their earnings were calculated.]

[After IDs 1 to 10 have received their payment, IDs 11 to 20 are called in one by one. We explain them what their decision was in the selected pair as well as the decision of the person they were paired with if relevant, so that they understand how their earnings were calculated.]

[If type 2 pairs are selected, we follow the opposite order; with IDs 11 to 20 coming forward first to pick out the counter, followed by IDs 1 to 10.]

[After the session, put all decision cards in one big envelope, and write on it date, time and code of session. Close and seal the envelope.]

# Appendix D: Gender Sensitivity Analysis

## D.1 Imbalances

Given the differences in the gender of the participants taking part in Games 1 and 2, further tests were carried out to locate the source of the imbalance and assess its consequences for the main results.

### D.1.1 Initial Randomisation

According to the *p-value* of the comparison of gender across the experiment, such substantial difference in the proportion of men participating in the two games should only be observed less than once every hundred times.

We performed a test run of the random allocation to treatment in order to rule out the existence of an in-built bias in the randomising device. As expected, the new allocation resulted in a gender-balanced distribution of participants across the experiment, indicating that the original allocation was an anomaly.

### D.1.2 Sessions Affected

Finding out which sessions were most affected by the detected imbalance was the next step of the investigation, and a necessary condition to implement sensitivity analysis.

Table I.D1 depicts the proportion of men among the participants for every session of each game and the differences observed (columns [1] and [2]). The third column compares the proportion of men participating in the two games conducted on the same experimental day (*i.e.* Session), whereas the remaining columns show the differences for every session of each game with respect to the overall mean of men that took part in the experiment (46%).

The *t-tests* of the within-session differences of the proportion of males (column [3]) yielded only two significant results, for Session 3 and 7. These were also the sessions which further diverged from the overall mean of 46% of male participants in the experiment.

For example, in Session 7 of Game 1 there were 14 men as opposed to only 6 women, a ratio of more than 3 to 1 or a 70% male participation; by contrast, in the same session for Game 2 there were only 7 men for 13 women, a ratio slightly higher than one men for every two women, which meant that male participation was half that of the other session (just 35%).

We identified two other sessions with differences of twenty percentage points or more in the proportion of men taking part in one game relative to the other: Sessions 6 and 8. Together with the two other sessions singled out, they are the only ones which differ in more than fifteen points from the overall mean, for either game.

**Table I.D1: Imbalances by Sessions**

| Session | Game | | Differences | Differences Mean | Differences Mean |
|---|---|---|---|---|---|
| | 1 | 2 | Sessions | (*G1*) | (*G2*) |
| 1 | 0.5 | 0.35 | 0.15 | 0.04 | -0.11 |
| 2 | 0.45 | 0.33 | 0.12 | -0.01 | -0.13 |
| **3** | **0.5** | **0.2** | **0.3** | **0.04** | **-0.26** |
| 4 | 0.45 | 0.5 | -0.05 | -0.01 | 0.04 |
| 5 | 0.45 | 0.47 | -0.02 | -0.01 | 0.01 |
| **6** | **0.6** | **0.4** | **0.2** | **0.14** | **-0.06** |
| **7** | **0.7** | **0.35** | **0.35** | **0.24** | **-0.11** |
| **8** | **0.7** | **0.5** | **0.2** | **0.24** | **0.04** |
| 9 | 0.5 | 0.45 | 0.05 | 0.04 | -0.01 |
| 10 | 0.44 | 0.39 | 0.05 | -0.02 | -0.07 |
| **Mean** | **0.53** | **0.39** | **0.14** | **0.07** | **-0.07** |
| **Overall Mean** | **0.46** | | | | |

Dropping the two most troublesome sessions (3 and 7) already removes the gender imbalance from the sample, in other words, the significant difference detected for gender in Table I.11 at the 1% level disappears.

The core of the analysis conducted earlier is replicated here for the balanced subsample (without Sessions 3 and 7) and for a more restrictive subsample (without Sessions 3, 6, 7 and 8).

## D.2 Analysis

### D.2.1 *What is the Effect of Risk Sharing on Demand?*

Even though the significance of the some results wavers slightly with the reduced samples, especially the balanced one, the sensitivity analysis of the demand decision shows that the main conclusions remain unaltered. Risk sharing is proven to be a deterrent for demand.

**Table I.D2: Ordered Probit Regressions: Insurance Demand (Balanced Sample)$^{\Psi}$**

| **Specification** | **(1)** | **(2)$^{\psi}$** | **(3)** | **(4)$^{\psi}$** | **(5)** | **(6)$^{\psi}$** |
|---|---|---|---|---|---|---|
| **Variable** | **Insurance Units Purchased** | | **Index Insurance Units Purchased** | | **Indemnity Insurance Units Purchased** | |
| Index w/o Sharing (*T2*) | 0.289** | 0.32** | 0.292** | 0.333** | | |
| | (0.124) | (0.139) | (0.123) | (0.14) | | |
| Indem. w/ Sharing (*T3*) | 0.065 | 0.1 | | | | |
| | (0.177) | (0.124) | | | | |
| Indem. w/o Sharing (*T4*) | 0.145 | 0.173 | | | 0.08 | 0.076 |
| | (0.184) | (0.156) | | | (0.089) | (0.114) |
| Gender (1=Male) | | 0.19 | | 0.16 | | 0.289 |
| | | (0.123) | | (0.135) | | (0.244) |
| Age | | 0.011*** | | 0.019*** | | 0.005 |
| | | (0.003) | | (0.005) | | (0.004) |
| Years of Education | | -0.0122 | | 0.002 | | -0.0214 |
| | | (0.015) | | (0.013) | | (0.031) |
| Wealth Index | | 0.025 | | 0.039 | | 0.013 |
| | | (0.033) | | (0.044) | | (0.056) |
| Participant's Risk Preferences | | -0.04 | | -0.05 | | -0.018 |
| | | (0.037) | | (0.044) | | (0.059) |
| Knowledge of Insurance | | 0.035 | | -0.132 | | 0.168 |
| | | (0.143) | | (0.192) | | (0.242) |
| Experience with Shocks | | -0.112 | | -0.198 | | -0.013 |
| | | (0.119) | | (0.153) | | (0.187) |
| Enumerator Team 2 | | -0.025 | | -0.078 | | 0.154* |
| | | (0.12) | | (0.088) | | (0.087) |
| **Reference** | **Index w/ Sharing (*T1*)** | **Index w/ Sharing (*T1*)** | **Index w/ Sharing (*T1*)** | **Index w/ Sharing (*T1*)** | **Indem. w/ Sharing (*T3*)** | **Indem. w/ Sharing (*T3*)** |
| **N** | **628** | **620** | **312** | **312** | **316** | **308** |

Robust standard errors in parenthesis, $^{*}\ p < 0.1$, $^{**}p < 0.05$, $^{***}\ p < 0.01$

$^{\Psi}$ Details of the variables can be found in Table I.12.

$^{\psi}$ Village dummies included in this specification.

**Table I.D3: Ordered Probit Regressions: Insurance Demand (Restricted Sample)[Ψ]**

| **Specification** | **(1)** | **(2)$^{\psi}$** | **(3)** | **(4)$^{\psi}$** | **(5)** | **(6)$^{\psi}$** |
|---|---|---|---|---|---|---|
| **Variable** | **Insurance Units Purchased** | | **Index Insurance Units Purchased** | | **Indemnity Insurance Units Purchased** | |
| Index w/o Sharing (*T2*) | 0.394*** | 0.437*** | 0.386*** | 0.449*** | | |
| | (0.114) | (0.131) | (0.109) | (0.124) | | |
| Indem. w/ Sharing (*T3*) | 0.11 | 0.161 | | | | |
| | (0.184) | (0.125) | | | | |
| Indem. w/o Sharing (*T4*) | 0.151 | 0.186 | | | 0.044 | 0.028 |
| | (0.188) | (0.16) | | | (0.117) | (0.151) |
| Gender (1=Male) | | 0.07 | | 0.093 | | 0.048 |
| | | (0.144) | | (0.165) | | (0.279) |
| Age | | 0.009** | | 0.016*** | | 0.003 |
| | | (0.004) | | (0.006) | | (0.004) |
| Years of Education | | -0.003 | | -0.003 | | -0.005 |
| | | (0.013) | | (0.012) | | (0.026) |
| Wealth Index | | -0.018 | | 0.034 | | -0.061 |
| | | (0.027) | | (0.042) | | (0.038) |
| Participant's Risk Preferences | | -0.046 | | -0.12*** | | 0.018 |
| | | (0.114) | | (0.076) | | (0.088) |
| Knowledge of Insurance | | 0.143 | | -0.096 | | 0.332 |
| | | (0.184) | | (0.289) | | (0.277) |
| Experience with Shocks | | -0.205 | | -0.224 | | -0.124 |
| | | (0.139) | | (0.185) | | (0.214) |
| Enumerator Team 2 | | 0.006 | | -0.059 | | -0.221** |
| | | (0.114) | | (0.076) | | (0.088) |
| **Reference** | **Index w/ Sharing (*T1*)** | **Index w/ Sharing (*T1*)** | **Index w/ Sharing (*T1*)** | **Index w/ Sharing (*T1*)** | **Indem. w/ Sharing (*T3*)** | **Indem. w/ Sharing (*T3*)** |
| **N** | **468** | **460** | **232** | **232** | **236** | **228** |

Robust standard errors in parenthesis, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

[Ψ] Details of the variables can be found in Table I.12.

[ψ] Village dummies included in this specification.

#### D.2.2 What is the Effect of Insurance on Informal Risk Sharing?

The results for the key coefficients, namely that for *index insured*, are affected by the reduced samples in the analysis of the loss sharing data, yet they are still significantly different from zero with the same signs as before.

Overall, the sensitivity analysis shows that our results are not meaningfully affected by the gender imbalance, and that our main conclusions remain the same.

**Table I.D4: OLS Regressions: Sharing Decision (Balanced Subsample)$^{\Psi}$**

| **Specification** | **(1)** | **(2)$^{\psi}$** | **(3)** | **(4)** | **(5)$^{\psi}$** |
|---|---|---|---|---|---|
| **Variable** | | | **Amount Shared** | | |
| Index Insured ($T1$) | 190.8 | 184.9 | 546.2** | 1591** | 1457* |
| | (165.3) | (146.3) | (222.5) | (643.5) | (726.6) |
| Partner's Losses | | 0.04 | | 0.163** | 0.161** |
| | | (0.037) | | (0.068) | (0.069) |
| Index Insured ($T1$) x Partner's Losses | | | | -0.123 | -0.121 |
| | | | | (0.078) | (0.078) |
| Good Weather | | 175.7*** | | 175.7*** | 175.7*** |
| | | (59.28) | | (58.92) | (59.21) |
| Gender (1=Male) | | 302.7 | | | 328.9* |
| | | (230.7) | | | (187.3) |
| Age | | -3.89 | | | -2.385 |
| | | (11.23) | | | (8.966) |
| Years of Education | | 16.74 | | | 12.9 |
| | | (11.8) | | | (14.81) |
| Wealth Index | | -70.77* | | | -70.51** |
| | | (38.41) | | | (30.3) |
| Risk Preferences | | 24.74 | | | 2.125 |
| | | (108.6) | | | (79.41) |
| Knowledge of Insurance | | -106.2 | | | -86.32 |
| | | (352) | | | (276.9) |
| Experience with Shocks | | -131.8 | | | -223.4 |
| | | (195.3) | | | (166.5) |
| Enumerator Team 2 | | 510.4** | | | 427.5** |
| | | (179.4) | | | (195.5) |
| Constant | 1556*** | 603.9 | 1201*** | -361.6 | -660.7 |
| | (106.6) | (702.5) | (161.3) | (535.5) | (731) |
| **Reference** | **Not Insured (*T5*)** | **Not Insured (*T5*)** | **Ind. Insured (*T3*)** | **Ind. Insured (*T3*)** | **Ind. Insured (*T3*)** |
| **N** | **1872** | **1872** | **2339** | **2339** | **2334** |

Robust standard errors in parenthesis, $^{*}\ p < 0.1$, $^{**}p < 0.05$,$^{***}\ p < 0.01$

$^{\Psi}$ Details of the variables can be found in Table I.12.

$^{\psi}$ Village dummies included in this specification.

**Table I.D5: OLS Regressions: Sharing Decision (Restricted Subsample)$^{\Psi}$**

| **Specification** | **(1)** | **(2)$^{\psi}$** | **(3)** | **(4)** | **(5)$^{\psi}$** |
|---|---|---|---|---|---|
| **Variable** | **Amount Shared** | | | | |
| Index Insured ($T1$) | 58.75 | 190.1 | 316.3 | 2225** | 2229** |
| | (187.5) | (164.3) | (253.4) | (767.4) | (832.8) |
| Partner's Losses | | -0.009 | | 0.202** | 0.2** |
| | | (0.029) | | (0.086) | (0.087) |
| Index Insured ($T1$) x Partner's Losses | | | | -0.211** | -0.209** |
| | | | | (0.09) | (0.092) |
| Good Weather | | 195.3** | | 195.3** | 195.3** |
| | | (78.09) | | (77.55) | (77.99) |
| Gender (1=Male) | | 329.9 | | | 324.7 |
| | | (306.5) | | | (236.5) |
| Age | | -10.8 | | | -7.886 |
| | | (13.84) | | | (10.81) |
| Years of Education | | 7.485 | | | 4.76 |
| | | (11.41) | | | (13.88) |
| Wealth Index | | -114.3** | | | -110*** |
| | | (42.05) | | | (29.18) |
| Risk Preferences | | 105.4 | | | 56.48 |
| | | (143.6) | | | (101.4) |
| Knowledge of Insurance | | 100.5 | | | 120.7 |
| | | (485) | | | (358.9) |
| Experience with Shocks | | -237.6 | | | -325.6 |
| | | (276.9) | | | (228.2) |
| Enumerator Team 2 | | 467.1** | | | 359 |
| | | (202.3) | | | (208.2) |
| Constant | 1519.6*** | 1320* | 1262*** | -651.3 | -748.9 |
| | (120.5) | (702.7) | (208.9) | (668.2) | (889.6) |
| **Reference** | **Not Insured (*T5*)** | **Not Insured (*T5*)** | **Ind. Insured (*T3*)** | **Ind. Insured (*T3*)** | **Ind. Insured (*T3*)** |
| **N** | **1392** | **1390** | **1739** | **1739** | **1729** |

Robust standard errors in parenthesis, $^{*}\ p < 0.1$, $^{**}p < 0.05$, $^{***}\ p < 0.01$

$^{\Psi}$ Details of the variables can be found in Table I.12.

$^{\psi}$ Village dummies included in this specification.

# Risk Sharing, Insurance and Investment: Experimental Evidence from Rural Uganda


**Abstract**

Reducing the gap in agricultural technology adoption can lead to major improvements in productivity and poverty reduction in rural areas of developing countries. A major obstacle for investing in new technologies is the pervasive presence of risk in these places, an aspect that has increasingly gained attention. However, scarce research has been carried out on the impact of easing risk constraints through the provision of insurance on agricultural investment, due to the uninsurable status attributed to most farmers in the developing world, particularly those practising small-scale agriculture. Yet a new form of indexed insurance has recently emerged, which mitigates the problems of traditional insurance. Despite its potential, demand for index insurance has been disappointingly low, casting doubts about the welfare impact of the product, particularly on investment, which remains to be determined. In addition, the literature has largely failed to consider the influence that informal risk sharing could bear in the relationship between insurance and investment. This paper investigates whether formal insurance can promote agricultural investment, and the role of risk sharing as a mediating and direct factor. Our main contribution is to study the impact that both factors exert on investment, separately and, especially, in combination. To this end, we conduct a framed field experiment in eastern Uganda, where insurance status and the availability of risk sharing are varied exogenously to examine their influence over investment behaviour. We find that being formally insured, in any of its forms, does not influence investment decisions. By contrast, risk sharing appears to increase investment to some extent, yet only when the investor is not insured or insured by a fallible cover. In addition, the paper investigates whether being insured matters for the level of informal support that investors receive. Our findings show that being insured crowds out informal risk sharing towards investors, but that this effect is more pronounced when the cover is perfectly compliant.

# I Introduction

Differences in technology adoption across countries account for major disparities in income per capita globally (Caselli and Coleman, 2001; Comin and Hobijn, 2004). In few other sectors these technological differences are as stark and consequential as in agriculture. Three out of four poor people in developing countries live in rural areas, with the majority of them relying on agriculture for their livelihoods; making it the sector from whose growth the poorest benefit the most (FAO, 2003; World Bank, 2007). Improving agricultural productivity is also a growing need for achieving food security in the face of a rising population, which increasingly concentrates, precisely, in the regions lagging technologically behind (UN, 2017).[1]

As a result of the pressing need of closing the technological gap, interventions aimed at increasing productivity in agriculture are commonplace in developing countries (World Bank, 2002; IMF, 2010). Many of them focus on increasing the use of inputs, which are credited to account for very large differences in yields (Morris *et al.*, 2007), and are divisible investments affordable even by poor farmers (Fafchamps, 2003). Despite the prospect of large returns (Duflo *et al.*, 2008), investment in agricultural technology, and in inputs specifically, has been much lower than the level required to close the productivity gap (Foster and Rosenzweig, 2010).

A major obstacle for adoption is the pervasive presence of risk in rural areas of developing countries, an aspect that has increasingly gained attention in the literature. In one of the latest reviews of determinants of adoption, Foster and Rosenzweig (2010) highlight the prominence that risk has acquired in the research agenda, given the strong signs indicating that incompleteness of insurance can play a critical role in delaying the uptake of new technologies and constraining input use, especially in a context that exacerbates risk due to environmental conditions.[2] The authors contrast this apparent consensus with the paucity of studies examining directly how these factors affect the process of technology adoption itself. Among these few examples are Lamb (2003), showing that income insecurity lowers the use of fertiliser, and, especially Dercon and Christiaensen (2011), who present evidence that consumption risk due to poor rainfall (conductive to harvest failure) can have a sizeable negative effect on fertiliser uptake.

Even more scarce is the research carried out specifically on the impact of easing risk constraints through the provision of insurance on agricultural investment (Cole *et al.*, 2012; Carter *et al.*, 2014). To a large extent this is explained by the uninsurable status

[1] The world's population is projected to grow from 7.6b in 2017 to 8.6b in 2030 and to 9.8b in 2050. Of the 2.2b people that will be added to the world's population by 2050, 1.3b will be in Africa, where poverty is more acute and widespread, and which by then will have doubled in size to reach 2.6b people (UN, 2017).

[2] For a review of the literature on technology adoption see Pérez-Viana (2019a), the third chapter of this thesis.

attributed to most farmers in the developing world, particularly those practising small-scale agriculture. The development of an insurance market was considered unfeasible in this context, especially, due to serious enforcement barriers—namely, costly claim verification—and also informational problems, leading to moral hazard and adverse selection (Morduch, 2006).

However, a new form of insurance has recently emerged, which mitigates these problems or even eliminates them altogether. Index insurance is a financial product linked to an index, typically related to environmental conditions. Payments are determined not on the basis of individual losses but on the value of the index, assumed to be highly correlated with them. Having an index as a trigger for payments avoids the need of costly individual loss assessments. Moreover, the low risk of manipulation of the index eliminates the perils of moral hazard and adverse selection. Promising as it is, index insurance is not without problems. Its key limitation is that beneficiaries are still exposed to basis risk—the imperfect correlation between the index and the losses experienced by the beneficiary. As a result, a policy-holder may experience a loss and yet not receive any insurance payment (Barnett and Mahul, 2007).

In spite of its potential, demand for index insurance has been disappointingly low.[3] This record has led some commentators to voice their scepticism about the welfare impact of the product (Binswanger-Mkhize, 2012), making a pressing need to confirm the stimulating prospects of index insurance. Yet research on the welfare impacts of the product has been slow to emerge and remains scarce, as pointed out by many observers (Dercon *et al.*, 2009; Cole *et al.*, 2012; Carter *et al.*, 2014).

Of particular interest is proving its beneficial effects on agricultural production. Based on the seminal work of Sandmo (1971), who established that an increase in the riskiness of the returns to production reduces its scale, farmers should increase production as the level of risk falls (Hill and Viceisza, 2012).[4] Likewise, it is well documented that farmers in developing countries engage in risk avoidance strategies in order to reduce their exposure; these involve pursuing low risk activities at the expense of higher expected returns (Carter *et al.*, 2014). Therefore, a reduction in the extent of the risk borne by farmers ought to lessen the need of resorting to such strategies.

The main exponent of this scant literature is the pioneering study of Karlan *et al.* (2014), who showed that credit constraints are not binding for agricultural investment, which appears to be much more affected by uninsured risk. The authors report that interest in products that can reduce risk is largely driven by trust in the payouts, which increases significantly with farmer's own receipt or someone in the network getting paid. This find-

[3] See Pérez-Viana (2019b), the first chapter of this dissertation, for an empirical study of insurance demand and a review of the related literature, including the causes of this underwhelming uptake.

[4] The work of Sandmo (1971) has been adapted to small-scale agricultural production by Fafchamps (2003) among others.

ing is of great significance, especially considering that basis risk can increase substantially the uncertainty about the payouts, something which however the paper does not delve in, leaving the question open about how the belief in the fulfilment of the insurance payments affects investment behaviour.

Until recently, the literature has also failed to consider the influence that informal risk sharing could bear in the relationship between insurance and investment. Networks of informal support have long existed in rural areas of developing countries, where they fulfil a key role in protecting their members against negative shocks (Townsend, 1994; Fafchamps and Lund, 2003). Yet these networks are also held responsible for diluting the incentives to invest (Platteau, 2009), due to the strong redistributive norms underpinning their functioning. In regard to insurance, recent research has postulated that issues about trust and deficiencies of the product, namely basis risk, could be mitigated through synergies with informal sharing arrangements (Dercon *et al.*, 2014). However, few studies have examined how this interaction affects investment.

Mobarak and Rosenzweig (2012, 2013) provide a fairly unique example of an empirical study exploring risk-taking behaviour in response to insurance within the context of informal sharing arrangements. Their findings are inconclusive though, as they report that farmers randomly offered insurance who are also involved in arrangements characterised by a higher degree of risk sharing increase the production of more profitable crops, yet only marginally in statistical terms. This line of inquiry requires further investigation, in order to determine whether formal insurance can promote agricultural investment, and the role of risk sharing as a mediating and direct factor.

Our main contribution is precisely to investigate the influence that formal insurance as well as informal risk sharing wield on investment, both separately and, especially, combined. With this aim in mind, we conduct a framed field experiment where insurance status and the availability of risk sharing are varied exogenously to assess their impact on investment behaviour.

We find that being formally insured, in any of its forms, does not influence investment decisions. By contrast, risk sharing appears to increase investment to some extent, yet only when the investor is not insured or insured by a fallible cover (*i.e.* indexed cover).

In addition, this paper investigates whether being insured matters for the level of informal support that investors receive. We employ random variation in insurance status to study the risk-sharing behaviour towards risk takers. Our findings show that being insured crowds out informal risk sharing towards investors, but that this effect is more pronounced when the cover is perfectly compliant (*i.e.* it is of the indemnity type).

The following section reviews the literature, identifies the existing gaps and describes our contribution in more detail. In Section III, we develop the theoretical framework, which bears the key predictions about the effect of insurance and risk sharing on investment. Section IV, describes the area and the experimental design employed to gather the data for the study. Section V contains the analysis of these data, which is discussed next in light of the prior literature and the characteristics of our design to conclude the paper.

# II Literature Review and Contribution

Interest in insurance stems from its potential to both reduce the negative impact of weather shocks regularly experienced by the poor, as well as to enable households to modify their risk management strategies in a way conductive to enhance welfare. In particular, insurance can relax the need of smallholder farmers to engage in risk avoidance and change their *ex-ante* investment behaviour, facilitating their involvement in riskier and more profitable enterprises.

Some of the earlier efforts to assess whether easing the level of risk through the provision of insurance encourages investment took the form of, following Harrison and List's (2004) nomenclature, artefactual or framed field experiments conducted with farmers.

Galarza and Carter (2011) undertake such study with farmers in Peru to investigate the relationship among risk preferences, loan take-up, and insurance purchase decisions. The focus of their investigation is whether the introduction of insurance encourages demand for credit by reducing the fear of losing collateral, which prevents borrowers from accessing the credit market. In their experiment, choices and outcomes attempt to recreate real life decisions faced by farmers, in particular, participants have to choose between a safe production project and a more profitable enterprise which requires taking an uninsured loan. To complete the array of choices, in the second part of the game the experimenters introduce a third project, producing using an insured loan. The final outcome depended on the realisation of two shocks: a covariate and an idiosyncratic one. The project's profits are insufficient to repay the uninsured loan if the common shock hits, regardless of the realisation of the idiosyncratic shock. Conversely, opting for an insured loan guarantees its repayment under all circumstances. Failure to repay the loan precludes participants from accessing further loans in later rounds and decreases by half the value of their endowment. The results show that only a quarter of participants are risk rationed, choosing the safe project in the first part of the game. More than half among them, switched to the insured loan option when it became available. This choice was especially popular in the rounds with the highest stakes, where more than 50 percent of the subjects opted for it. The econometric analysis of the main determinants of the decisions yielded some unexpected results, namely, that only low and moderately risk averse subjects chose the safest projects, while highly risk averse individuals decided to take up the uninsured loan. The complexity of the experiment and proceedings, where participants had to consider up to 60 possible outcomes with dynamic incentives, casts some doubts about the validity of the author's design to examine the relationship between insurance and investment.

Galarza and Carter's (2011) article provides a prime example of how replicating reality too faithfully in a framed experiment can lead it astray from its objective, arguably, generating a source of exogenous, controlled variation that captures the phenomenon of interest. Such task that can only be performed keeping the exercise tractable and understandable to participants, by abstracting from aspects of reality that are not of primary concern.

In a similar, yet simpler vein, Hill and Viceisza (2012) conduct a better-focused framed field experiment to test the key hypothesis that insurance provision induces farmers to take greater but more profitable risks. The premise of their research is firmly grounded on Sandmo's (1971) seminal hypothesis about the deterring effect on production of higher risk in the returns. Additionally, they investigate whether individuals behave in accordance to the law of small numbers when faced with (weather) risk. This heuristic tool would lead an individual to think that early draws of one signal (such as good weather) increase the chances of subsequent draws of the other signals (like bad weather). The justification for their methodology stems from the difficulty of identifying exogenous variation in risk to allow studying the impact of reducing it on production decisions. Moreover, field experiments can rid the test of constraints such as credit and trust, which may hamper the interpretation of the results with real investment data. Given its prominence as a productivity enhancing device, the investment decision was framed as fertiliser uptake in the experiment; participants had to decide how many bags of fertiliser to buy, from zero to two, with each bag increasing returns 25% or 100 %, depending on the session. Subjects participated either in one of two treatments, differentiated by the availability of insurance in the later rounds, mandatory when present. Their results show that insurance has significantly positive effects on fertiliser purchase, and that these investment decisions are also dependent on the weather conditions in previous rounds. However, the nature of Hill and Viceisza's (2012) design, which allowed wealth to be accumulated through the successive rounds of the game, gave rise to unintentional differences in endowment levels for the key comparisons. Participants in the insurance treatment were significantly richer than their counterparts in the control group, leading to potential behavioural biases. The authors attempt to correct for this source of bias employing matching methods, which is unusual in the analysis of experimental data. It is also worth noting that the within-subject differences in investment were minimal, among participants in the treatment arm, between the rounds where insurance was not available and when it was introduced. In terms of external validity, the insurance product on offer was an ideal indemnity cover, largely unavailable in rural areas of developing countries, due to the well-known issues of moral hazard, adverse selection and high verification costs.

Brick and Visser (2015) seemingly overcome the latter flaw, employing a series of laboratory experiments in South Africa to examine whether the provision of index insurance induces individuals to opt into riskier but potentially more profitable activities. However, in their setting, the outcome of the investment and the insurance payout depend on the same indicator, weather conditions, precluding the existence of basis risk, characterised by the imperfect correlation of losses and payouts. The paper therefore provides yet another examination of the effect of traditional—however incomplete it might be—insurance on investment, rather than of an indexed cover. In conjunction with this flawed aim, the authors use the controlled environment in the experiment to test the hypothesis of a risk-attitudes induced poverty trap—separate from credit constraints and wealth effects—and the role of insurance in breaking this cycle. In the game, they presented subjects with three options varying in expected value and variance. These choices are framed as opting for applying traditional seeds, purchasing high-yielding seeds with a loan and the latter option bundled with index insurance, under varying weather conditions. In a similar fashion to Hill and Viceisza (2012), the decisions in the game are compared to those taken under the same conditions but without the insurance option; presently, by the same subjects instead of different ones. Prior to these experiments, risk preferences for the sample were elicited through a variant of the Multiple Price List format (Holt and Laury, 2002). The results of the analysis show that farmers are in general markedly risk averse, and those identified as such, tend to opt into traditional agriculture in the experiment instead of more profitable production methods, despite the availability of insurance and irrespective of the production risk (*i.e.* the prevailing weather conditions). These findings are taken by the authors as evidence in favour of the poverty-trap hypothesis, which insurance cannot effectively break due to the presence of unprotected losses in production.

Despite the enquiries reviewed above were motivated by the rise of index insurance as a promising instrument for poverty reduction, knowingly or not, they are unable to capture the key characteristic of this type of cover, namely, basis risk. As a result, they ultimately fail to become meaningful tests for the response of investment behaviour to the introduction of a feasible form of insurance.

Jozwik (2015) attempts to overcome the shortcomings of the earlier literature with another framed field experiment examining investment behaviour among Ghanian cocoa farmers under different types of insurance. The decision in the experiment is framed as investing in fertiliser—the 'new' technology—for growing cocoa, which can only be achieved by taking a loan. This investment option is riskier and more profitable, with propitious conditions, than producing employing an 'old' technology which does not require a loan. Depending on the treatment, the fertiliser loan option comes with (1) no insurance attached, (2) mandatory subsidised insurance with 1 in 8 probability of basis risk or (3) obligatory full insurance with no basis risk but unfairly priced. The choice faced by participants was binary in all treatments: to produce using fertiliser or not. Participants' decisions were contingent on a random event, framed as the prevailing weather. The weather could be good for farming or adverse, but bad conditions could affect everyone or just an individual. An occurrence of the later kind meant that index insurance did not pay out. One out of four times the weather was bad, and half of those times the bad weather affected solely the participant's investment. The analysis of the experimental data shows that the differential feature of the insurance schemes matters considerably. While strong evidence is found that compliant insurance, priced 167% above the actuarially fair rates, fostered fertiliser investment significantly, the opposite was true about insurance with basis risk, which failed to raise fertiliser uptake. Nevertheless, the internal validity of the comparisons across treatments is hampered by the fact that the different prospects differ not only in their variability, but also in their expected value. These differences are accentuated in the treatments featuring insurance, since the covers also differ in cost, as well as effectiveness. Indexed insurance is subsidised and can underperform, leaving the farmer with nothing 1 out 8 times; an adequate representation of downward basis risk, which however is also characterised by an upward component. Yet the latter is excluded by design, providing just a partial characterisation of index insurance and weakening further the treatment comparisons.

The irruption of index insurance as a promising instrument for poverty reduction has given rise not only to the varied artefactual and framed experiments reviewed above, but also to several randomised field trials conducted to evaluate the benefits that the provision of the indexed cover could yield in real-life settings.

One of the first field experiments assessing the impact of index insurance on agricultural technology adoption was implemented by Giné and Yang (2009) in Malawi. The investigation focuses on whether bundling insurance with a loan (aimed at financing adoption of high-yield varieties of maize and groundnut) increases demand for the loan. Their hypothesis is that rainfall insurance should make farmers more likely to take on risk, in the form of higher levels of borrowing to invest in new crops. Surprisingly, their results indicate that take up is lower by 13 percentage points among farmers offered insurance with the loan. The authors suggest that this can be caused by the implicit insurance unwittingly provided by the limited liability embedded in the loan contract. In case of default, farmers would only be accountable for the value of their produce, which can be lower than the amount of the loan in a bad state. In this scenario, bundling insurance with credit overinsures farmers and effectively increases the interest rate of the loan. The determinants of take-up are presented as further support for this narrative. Among the farmers offered the insured loan, uptake is significantly associated with education, income and wealth. According to the authors, these socio-economic characteristics may be proxiying for farmer's default costs (*i.e.* harvest revenue that can be seized by the lender); suggesting that the higher these costs are, the greater the insurance demand. Despite its relevance and timeliness, the paper does not possess the semblance of an appropriate test of the effects of insurance on investment. This is due, first, to the rather indirect measurement of investment through loan uptake, which introduces a host of other issues related to credit constraints that likely clouds the effect of the cover on investment. Secondly, the inadequacy of the test stems from the ill-predicted and ambiguous incentives created by the insurance scheme, whose appeal seemingly depended on the cost of default.

Cole *et al.* (2017) implement a better crafted experimental design to study how an index insurance product against insufficient rainfall affects production decisions among a sample of Indian farmers. In line with Sandmo (1971), they hypothesise that the provision of insurance leads households to engage in production activities yielding higher returns but also bearing higher risks. The authors develop a model derived from this hypothesis, which predicts that improved availability of *ex-post* insurance against production risk leads to greater *ex-ante* investment in risky production activities. The prediction is put to the test in an experiment involving 1,479 Indian farmers. All participants were visited by an enumerator and given a scratch card revealing one of two treatments, a certificate valid for a number of weather insurance policies ('treatment group'), or a check for a monetary amount ('control' group). The latter was estimated to equal the expected payout of the policies handed to the treatment group, and it was provided to rid the experimental comparison from any wealth effects, arising from the expected value of insurance. The cover protected farmers from insufficient rain during the first phase—out of three—of the monsoon season. Payoffs were calculated based on the registered rainfall by a nearby weather station; if the cumulative rainfall during the covered period was below a threshold amount, payouts linear in the rainfall deficit were disbursed. The results indicate that insurance provision does not affect total production investments, yet it leads to a small but significant shift towards higher-risk, higher-return cash crops, especially, among educated farmers. The authors argue that the lack of effects on total output is due to the presence of fixed short-run production factors or financial constraints. However, these factors do not seem to prevent changes in the composition of investment toward riskier prospects. In fact, the exceedingly short time elapsed between the baseline and the follow-up—barely four months and before even farmers received any payouts—makes drawing meaningful conclusions on the basis of this evidence a questionable exercise. In this short period, it can be hardly expected that smallholders fully grasp the implications for their farming activities of a complex insurance product, and feed these lessons into their investment decisions.

In a preliminary results paper, Cai *et al.* (2014) investigate the impact of being insured on farmers' economic behaviour, by randomising the availability of weather insurance for small farmers in China. In their case, however, the provision of insurance appears to have no significant effects whatsoever on any of the decisions studied (production, saving and borrowing), despite the large differences recorded. For example, production of rice increases for insured households, and so does savings put aside (around 30% from the base value), all of which are imprecisely measured nonetheless. In the experiment, the selection to the treatment was dependent on the prior purchase of the insurance product, which, in turn, was affected by the different treatments implemented to increase take-up. In order to take the particularities of their design into account, the authors implemented an Instrumental Variables (IV) identification strategy in the analysis, exacerbating the imprecision of the statistical inference.

Karlan *et al.*'s (2014) study is at the vanguard of the scarce research conducted on the impact of index insurance on technology adoption in developing countries. The paper investigates how agricultural investment is affected by incomplete insurance and credit markets. The authors, firstly, lay down a model predicting farmer investment behaviour under different scenarios conditional on which market fails: insurance, capital or both. On the basis of these predictions, they work out the implications of relaxing the constraints associated with inefficiencies in those markets. The first emerging hypothesis is that when capital markets are imperfect, providing a cash grant will increase risky investment. In contrast, under these circumstances making insurance available would reduce investment in a risky asset. Only when insurance markets are imperfect and credit markets operate efficiently, insurance provision can increase investment in risky ventures. To assess their theoretical predictions, Karlan *et al.* (2014) conduct several experiments in northern Ghana in which farmers are randomly assigned to receive cash grants, opportunities to obtain rainfall index insurance contracts or a combination of the two. They find that insurance significantly increases investment and leads to riskier productive choices. In contrast to common perception, they show that credit constraints are not binding for investment, which is much more affected by uninsured risk. The result implies that when protected against a major risk to their livelihoods, farmers are able to find the resources to increase investment in their farms. These pivotal findings demonstrate the direct role of risk in hindering investment, and that limitations in accessing capital are not as binding as generally thought. It is worth noting though, that the strong relationship between insurance—particularly of the indexed kind—and agricultural investment found in this paper is at odds with the findings of most of the related literature mentioned above; especially, involving real-world products in developing countries, where often the link is much weaker or cannot be statistically proven. Another notable exception being Cai *et al.*'s (2015) field experiment in China, where insurance is shown to increase investment in the breeding of sows.

Despite providing important insights on how risk matters for investment and that insurance can help farmers overcome it, Karlan *et al.* (2014) touch on important issues that are not properly elucidated. A case in point is the effect of trust in the insurance payouts on investment decisions. Farmers offered the indexed cover needed to opt in the scheme and choose the level of coverage, a decision they faced several times over the course of the experiment. In line with several papers studying the demand for indexed products (Cole *et al.*, 2013, 2014; Cai *et al.*, 2014, 2015), the authors highlight the importance of trust for continuous uptake. They explain that farmers do not seem to believe that payments will be made when the trigger event occurs, and, as a consequence of this, when the farmer or someone in the network receives payouts, demand for the product increases significantly. Nevertheless, the paper does not examine how trust in the payouts affects investment behaviour.

The notion of trust is fairly broad and encompasses facets that the literature does not really delve into. Trust can refer to the reputation of the provider, the rapport with the vendor, all the way to the perceived chance that the product would perform, and can extend even to the very concept of insurance as a useful tool. The current body of research, with Karlan *et al.* (2014) at its head, appears to focus on the two latter aspects. These elements comprise but a part of trust, and thus, they can be better described as the perceived reliability of the product, rather than trust as a whole.

In the present context, reliability can be a crucial factor for the success of insurance in promoting technology adoption, at least for two reasons. First of all, due to lack of awareness, insurance induces farmers to act cautiously in response to it. Second and most important, reliability is key because the insurance products that can be marketed to smallholders suffer from basis risk, increasing unambiguously the uncertainty about their performance. It is unlikely that a farmer changes her investment portfolio to include riskier prospects, unless there is a reasonable expectation that the insurance will deliver. As a result, finding ways of improving trust on the performance of insurance can be of paramount importance for the success of the product and, thereby, its scalability.

In the search for such a tool, and to understand the ultimate impact that insurance can have on investment more generally, one needs to account for a vital factor in the financial lives of poor rural people: informal risk sharing (Fafchamps and Lund, 2003). These networks are what most closely resemble insurance in this context. They enable consumption smoothing when households suffer from shocks which do not affect the average income of the community, *i.e.* individual risk, leaving mostly common risk, which afflicts the whole community (Ravallion and Dearden, 1988; Udry, 1994; D'Exelle and Verschoor, 2015). Informal networks appear to be fairly successful at performing this smoothing task, leading to substantial reductions in the sensitivity of consumption to household-specific risk (Townsend, 1994). Nevertheless, the buffer these networks provide comes at a steep cost according to many observers. The strong redistributive norms underpinning their functioning are faulted with diluting the incentives to invest (Platteau, 2009), and are even counted as one of the most important factors causing the meagre growth performance of poor rural economies (Baland *et al.*, 2011; Di Falco and Bulte, 2011).

Although many studies have examined investment behaviour in developing countries, a smaller number have focused on its relationship with risk sharing, and only a few have investigated the matter experimentally in a controlled environment.[5] Some of the studies in the latter list are primarily concerned with the decision to join risk-sharing groups rather than on the investment decision itself (Barr and Genicot, 2008; Attanasio *et al.*, 2012; Barr *et al.*, 2012). Barr and Genicot (2008), for example, assess the impact of the level of commitment to sharing within the informal group on the extent of risk

[5] See Chapter 3 (Pérez-Viana, 2019a) for a review of the literature.

sharing, measured by the number of groups formed and their size. They find that a higher degree of commitment favours greater risk sharing and also encourages investment. Group formation in this context appears to be driven by prior relationships and affinity in risk preferences (Attanasio *et al.*, 2012; Barr *et al.*, 2012). Other lines of research have incorporated borrowing into the enquiry, providing a link with the microfinance literature (Giné *et al.*, 2010; Fischer, 2013). The inclusion of borrowing changes the incentives for sharing considerably, as individuals need to ponder about continued access to finance in addition to other considerations for sharing risk, like reciprocity or altruism (Cox and Fafchamps, 2008; Fafchamps, 2008). Some of the lessons emerging from these experiments in relation to investment are that joint liability and control over the partner's choice can discourage risk taking (Giné *et al.*, 2010; Fischer, 2013). These findings led Fischer (2013) to propose equity-like financing, in which partners share both the benefits and risks of more profitable projects, as a way forward from the traditional joint- or individual-liability contracts.

To some extent the effect on investment of such arrangement was tested by D'Exelle and Verschoor (2015), yet omitting borrowing from the experimental setting. The authors conducted a framed field experiment in Eastern Uganda to investigate the relationship between risk sharing and investment, where, depending on the treatment, the partner could share with the investor losses, profits or both at the same time. The authors develop a straightforward theoretical framework which predicts that investment should be higher with loss sharing and lower with profit sharing, assuming that some transfers take place, which is supported by the strong sharing norms prevailing in the area of study.[6] Within the sharing treatments, they also vary social distance by making the members of the group anonymous or known, and by randomising their village origin, which could be the same or different. In the experiment, groups were formed by pairs of individuals who were assigned different roles, one participant was the investor and the other the supporting partner, who could only share the proceeds or losses of the investor.[7] D'Exelle and Verschoor's (2015) results are striking. Contrary to the predictions, investment levels are higher when loss sharing is ruled out, yet they are significantly so only when the partners know each other, especially, when the investor is paired with a wealthier or less-risk averse person. Moreover, the amount invested is higher when only profit sharing is possible, an effect that is more salient when paired to a friend. The authors attribute these findings to a combination of altruism and expected reciprocity. In particular, the negative effect of losses is due to, as far as the argument goes, the aversion of the investors to burdening their partners with the consequences of the risks they take and become indebted to them. Similar sentiments of reciprocity, building up debts that can be reclaimed, and altruism—increasing shareable profits—are credited for encouraging higher investment when

[6] The model provides the foundation for the theoretical framework of the present paper.

[7] This was the layout for the second part of the game; in the first, all participants played the investment game individually, assuming the role of the investors.

profits can be shared. These arguments are supported by the salience of the effect when the investor is paired to a friend, someone towards whom the sentiments of reciprocity and altruism are heightened.

D'Exelle and Verschoor's (2015) work serves as inspiration for the present enquiry both in thematic—as the focus here likewise is on the consequences of risk sharing for investment—as well as in methodological terms, given that the authors' model provides the foundation for our theoretical framework and also some elements are inspired in their experimental design. Nevertheless, the research presented here pursues a distinct aim, being concerned not just with how risk sharing affects investment, but also with how it does so alongside formal insurance. Accommodating this feature sets the study in a very different path and changes the nature of the contribution.

In regard to their interaction with formal insurance, risk sharing networks have been presented as complementary to indexed securities by some of the most prominent studies examining the demand for the product (Dercon *et al.*, 2014; Mobarak and Rosenzweig, 2012, 2013, 2014). In essence, these papers posit that informal risk sharing can complement the coverage of index insurance, by partially absorbing basis risk. The reduction of basis risk, in turn, would instil trust in the cover, seen as a key step for reversing its disappointing uptake record (Cole *et al.*, 2012, 2013), and increase the chances that insurance prompts changes in investment behaviour (Karlan *et al.*, 2014). However, the possibility that pre-existing risk-sharing arrangements hamper formal insurance uptake cannot be dismissed (Arnott and Stiglitz, 1991; De Janvry *et al.*, 2014).[8] Moreover, the availability of formal protection can also crowd out informal support (Attanasio and Rıos-Rull, 2000; Lin *et al.*, 2014; Boucher and Delpierre, 2014), leading even to a fall in risk-taking and welfare depending on the cost of insurance (Boucher and Delpierre, 2014), which undermines further the case for complementarity. It is therefore an open question how the interaction of these two forms of protection would affect investment.

As part of their pioneering research on index insurance in India, where they investigated the issue of low demand from the perspective of the interaction between informal and formal insurance, Mobarak and Rosenzweig (2012, 2013, 2014) also study the impact that formal insurance may have on risk taking among farmers. Their working hypotheses are based on a cooperative risk-sharing framework adapted from Arnott and Stiglitz (1991). The main implication of the model for risk taking is that groups with a higher degree of individual loss sharing may decrease risk taking, especially in the aftermath of a shock, because of their compensation duties. On account of this situation, the availability of formal insurance should mitigate the need of applying risk reduction strategies and favour *ex-ante* risk taking in agriculture. These predictions are validated to a large extent by the empirical work undertaken by the authors. First off, their results reveal that

[8] For a full investigation of the interaction between formal insurance and informal risk sharing, as well as a review of the literature, see the first Chapter of this thesis (Pérez-Viana, 2019b).

among households experiencing a shock, those who are members of sub-caste groups or *jatis* with a higher degree of idiosyncratic loss indemnification are significantly more likely to embark in risk-reduction strategies. Secondly, making index insurance randomly available to farmers increases the cultivation of more profitable (but presumably less resilient) rice varieties, and reduces the production of rice types deemed more drought resilient (but seemingly less lucrative). These effects are indeed more pronounced, albeit only marginally, for farmers involved in arrangements with a higher level of risk sharing (Mobarak and Rosenzweig, 2012). The authors also report that farm output rises when insurance is offered especially in areas with higher levels of rainfall, associated with more favourable conditions for the growing of rice, under which investment in modern inputs pay larger dividends (Mobarak and Rosenzweig, 2013).

Lastly, Mobarak and Rosenzweig (2014) carry out a general-equilibrium study of labour market effects of the provision of index insurance. Their estimates indicate that increased risk taking of insured farmers raises wage levels but also labour demand volatility, thereby increasing the wage risk of landless households. Consistent with this, the authors show through simulations that landless households are more likely to purchase weather insurance when farmers also take on insurance, presumably because they are aware of the impact of insurance on wage risk.

Munro (2015) conducts a framed field experiment with Indian farmers where she investigates empirically the relationship between group weather insurance and investment decisions. In her experiment, participants, arranged in groups of three, were presented with an investment prospect with three options differing in its expected value and variance, and were invited to make a decision under three different conditions, depending on the treatment they were assigned to. These treatments varied in the type of index insurance arrangement subjects were protected by, based on individual or group payouts, and the access to information about the investment behaviour of the other members in the group, which could be made public or kept private. The author finds that group insurance decreases risk taking when groups internally manage the insurance payout distribution and have full information about the members decisions. More generally, groups, who also engage in informal risk sharing, pressure investors to take on less risk under perfect information conditions. Like other parts of her work, Munro's (2015) study suffers from an identification problem of the source of experimental exogeneity. Apart from the type of insurance arrangement and the access to information about the peers' decision, treatments differed in the amount of debate and discussion about the allocation of the insurance payout and informal support; the extent of this bargaining could have affected the investment decisions. The design lacks enough treatments to disentangle the sources of variation introduced which could have influenced investment in such a complex scenario, featuring a large number of elements at play.

The literature reviewed above contains insufficient evidence of the large welfare gains expected to accrue from the provision of formal insurance to poor farmers in rural areas of developing countries, where it was previously unavailable (Dercon *et al.*, 2009; Cole *et al.*, 2012; Carter *et al.*, 2014; Cole and Xiong, 2017). In order to justify the commitment of the sizeable resources needed to scale up this nascent industry, further research is required to forcefully establish that new feasible forms of insurance can lead to significant welfare improvements—like the promotion of agricultural investment, the most common indicator investigated so far. Insurance needs to prove its worth in a context where risk sharing networks operate widely, conditioning investment behaviour and its response to formal protection.

Such is the context within our study seeks to make a contribution, by investigating the impact that formal insurance as well as informal risk sharing exert on investment, both separately and, especially, in combination. To this end, we conduct a framed field experiment in eastern Uganda, where insurance status and the availability of risk sharing are varied exogenously to examine their influence over investment behaviour. This methodology allows, in the words of Falk and Heckman (2009:535), "tight control over decision environments" in order to evaluate theoretical hypotheses and causally infer the conclusions of these tests. In our experiment, particularly, we exercise control over the insurance status of participants, who can be insured or not when investing, and over the possibility that they receive support from their peers. Aside from this pivotal aspect, our methodological approach possesses another important advantage in research involving insurance. Only in a controlled environment, such as the one devised, both researcher and consumer can have a precise idea of the conditions under which the insurance operates. Achieving such level of certainty in a study involving real products is extremely difficult to do, given the informational requirements (*i.e.* decades of reliable time-series losses and indemnities data) and the many other additional factors involved (Clarke and Kalani, 2011).

In addition to the above purpose, this paper makes use of the random variation in insurance status to investigate whether being insured or not matters for receiving informal support.

As noted, risk sharing is commonplace in rural areas of developing countries, where it plays a crucial role, as people rely on transfers from informal networks to smooth consumption due to the volatility of their income streams (Barr and Genicot, 2008; Fafchamps, 2008). Many factors contribute to the likelihood of sharing, empirical research has identified the role of group selection (Barr *et al.*, 2012) and operational rules (*e.g.* in-built enforcement mechanisms [Barr and Genicot, 2008]), compatible risk preferences and social networks (Attanasio *et al.*, 2012), and reciprocity in repeated interactions (Charness and Genicot, 2009).

Recent research has shifted the focus to the perceived control over risk exposure. Cettolin and Tausch (2015) hypothesise that control over exposure to risk decreases individuals' willingness to share risk by dampening the motivation to provide assistance. It is precisely this aspect which the introduction of formal insurance alters. Insurance reduces the level of risk in a prospect and can change the perception of whether an individual is worthy of help. Someone who is better insured and possesses greater control over the risks taken may therefore be perceived as less deserving and be denied assistance.

Furthermore, the introduction of formal insurance may change the risk sharing landscape even for those who do not acquire it, for example, by improving the autarky position and facilitating a withdrawal from common informal arrangements of those insured, affecting other members who remain unprotected (Attanasio and Rıos-Rull, 2000). Also, it can make individuals who refuse to insure being regarded as less worthy of help (Lenel and Steiner, 2017).[9]

However, the sensitivity of informal risk sharing to formal insurance may also depend on the actual ability of the product to control the exposure to risk. This feature differs between indemnity and index insurance. Whereas an indemnity security always delivers when the investment fails, an indexed cover may fail to perform. As a result, for the same level of resources committed, an individual index insured faces a greater variability in the investment than someone who enjoys the protection of an indemnity cover. In line with the aforementioned hypothesis about risk exposure, the former individual might thus be seen as in greater need of help than the latter.

Even though individuals facing a prospect with a higher variance for a given level of investment might be seen as more deserving of assistance, this very feature is inherent to the act of investing. If an individual presented with a volatile investment commits substantial resources, the level of risk taken might be considered excessive by the benefactor and result in the withdrawal of assistance, the more so the higher the variance of the investment is. However, in a society characterised by risky investment and accustomed to the sharing of risk, this perception might be mitigated, and only arise in levels of risk taking above the norm.

In sum, the crux of our hypothesis is that, for the same level of investment, an individual facing a more volatile investment would be regarded as more deserving of help. However, due to the fact that the level of investment is endogenous, taking risk when an investment is volatile could be penalised with the withdrawal of assistance; yet this reaction is unlikely to occur for moderate levels of investment.

[9] As will be explained later, we account for these factors in the design by fixing the level of insurance. Despite their importance, these considerations are not the focus of the present investigation and we abstract from them. For a treatment of these matters, see Pérez-Viana (2019b) elsewhere in this thesis.

Cettolin and Tausch (2015) do not find support for their conjecture about the reduction in risk sharing as control over exposure increases, with a standard pool in a western laboratory.[10] We re-examine the issue with a non-standard pool in a lab-in-the-field experiment. In this manner, the present paper contributes to the empirical literature on risk sharing by investigating the effect of formal insurance and its characteristics on informal support towards risk takers.

The following section presents our theoretical framework and the key predictions about the impact of insurance and risk sharing on investment.

[10] They observe, however, some influence of the control over risk held by the vulnerable partner. When individuals are responsible for their risk exposure, risk sharing decisions are systematically conditioned on the risk tolerance of the sharing partner, whereas this is not the case when risk exposure is random.

# III Theoretical Framework

## III.1 Basic Setting

Throughout this section, we develop a framework to derive the main behavioural hypotheses for the decisions made in the experiment. The model is inspired by the work of D'Exelle and Verschoor (2015), however, insurance did not feature in their model, which we introduce in sub-section III.3 and constitutes the main focus of the theory.

The framework will allow us to evaluate how agricultural investment behaviour is affected, first, by the possibility of sharing the risk inherent to investing and, second, by having access to the insurance market.

In the model, the farmer can invest in a risky input (*e.g.* fertiliser) as much of her wealth $Y$ as she chooses, $x \in [0, Y]$. Investing in this input yields a return of $r > 1$, leading to a payoff $Y + (r - 1)x$ if successful, which occurs in state of the world $s = S$, associated with a probability $\pi$, where $0 < \pi < 1$. If, by contrast, the investment fails, $s = F$, the farmer is left with $Y - x$.

The farmer displays risk-averse or risk-neutral preferences over wealth, characterised by a von Neummann-Morgensten utility function $u$ satisfying $u' > 0$ and $u'' \leq 0$. As a result, she maximises her expected utility as follows:

$$EU(x) = \pi u[Y + (r - 1)x] \; + \; (1 - \pi)u[Y - x] \tag{1}$$

## III.2 Model with Risk Sharing

Let us now assume that the farmer is part of a group she can appeal to in the event of an investment failure. Under these circumstances, the second term of equation (1) would become $(1 - \pi)u[Y - (1 - l)x]$, with $0 \leq l \leq 1$, where $l$ denotes the share of the losses that the investor expects to be compensated for.

Standard economic behaviour would predict that the proportion of losses shared would be zero, leading the investor to disregard the chance of obtaining a transfer, which would leave the optimisation function unaltered with respect to equation (1). However, the strong sharing norms prevailing in rural areas of developing countries, well-documented in the literature reviewed above, make very likely that $l > 0$. As a result, the prospect of a transfer will have bearing on the investment decision of the farmer. In fact, it can be shown that investment with loss sharing will be at least as high as without it, $x_l^* \geq x^*$, which we prove next.

If $x \in ]0, Y[$, the first-order condition (FOC) for the case without risk sharing is the following (see Appendix A for the Khun-Tucker conditions):

$$\Phi(x^*) = \pi(r-1)u'[Y + (r-1)x^*] \; - \; (1-\pi)u'[Y - x^*] = 0 \tag{2}$$

Whereas the FOC, under the same conditions, when the farmer can resort to the support of the group is:

$$\Phi_l(x_l^*) = \pi(r-1)u'[Y + (r-1)x_l^*] \; - \; (1-\pi)(1-l)u'[Y - (1-l)x_l^*] = 0 \tag{3}$$

The concavity of $u$ implies that $\Phi(\cdot)$ is decreasing in $x$. Therefore, if we can show that $\Phi(x_l^*) < 0$, it must follow that $x^* < x_l^*$.

Substituting $x_l$ in equation (2) we get:

$$\Phi(x_l^*) = \pi(r-1)u'[Y + (r-1)x_l^*] \; - \; (1-\pi)u'[Y - x_l^*] \tag{4}$$

Given that by virtue of equation (3):

$$\pi(r-1)u'[Y + (r-1)x_l^*] = (1-\pi)(1-l)u'[Y - (1-l)x_l^*] \tag{5}$$

We can substitute the first term in eq.(4) to obtain the following expression:

$$\Phi(x_l^*) = (1-\pi)(1-l)u'[Y - (1-l)x_l^*] \; - \; (1-\pi)u'[Y - x_l^*] \tag{6}$$

When $l > 0$ and $u'' \leq 0$, which similarly follows from the concavity of $u$, the first term is smaller than the second. Given that with $l > 0$, we have that $Y - (1-l)x \geq Y - x$, $u'$ remains equal or decreases with larger values, so we get that $u'(Y - (1-l)x) \leq u'(Y - x)$. This result together with the fact that $(1-\pi)(1-l) < (1-\pi)$ makes the first term smaller than the second. It follows therefore that $\Phi(x_l^*) < 0$ and thereby that $x^* < x_l^*$.

If $x^*$ and/or $x_l^*$ are corner solutions, we either have $x^* < x_l^*$ or $x^* = x_l^*$. The former occurs when $x^* = 0$ and/or $x_l^* = Y$. The latter is the case when $x^* = x_l^* = 0$ or $x^* = x_l^* = Y$. Therefore, putting all the cases together we conclude that $x^* \leq x_l^*$.

**Proposition 1:** *If $l > 0$, optimal investment levels will be such that $x^* \leq x_l^*$.*

We do not claim originality up to this point; in contrast, the extension of the theoretical framework that follows was devised for the sole purpose of this paper.

## III.3 Model with Insurance

We consider next a situation where the investment of the farmer, who displays risk aversion ($u'' < 0$), is insured by a formal cover.[11] The insurance compensates a fraction of the losses in case of failure, $\alpha x$, and has a cost which increases with the amount insured, $p \in [0,1]$. The insurance is fairly priced or subsidised, implying that its cost, $px$, is equal to or lower than the expected value of its payouts (Clarke, 2011, 2016):

$$(1-\pi)\alpha x \geq px \geq 0 \Rightarrow (1-\pi)\alpha \geq p \geq 0 \tag{7}$$

Under the insurance arrangement, the amount earned by the farmer if the investment is successful is $Y + (r-p-1)x$, the return of the investment is diminished by the cost of the insurance. As for the case of a failed investment, the agent obtains a payout of $Y - (1+p-\alpha)x$.

The maximisation problem then becomes:

$$EU_{IM}(x) = \pi u[Y + (r-p-1)x] \; + \; (1-\pi)u[Y - (1+p-\alpha)x] \tag{8}$$

Provided $x_{im} \in ]0, Y[$, The first-order condition in this setting is:[12]

$$\Phi_{im}(x^*_{im}) = \pi(r-p-1)u'[Y+(r-p-1)x^*_{im}] - (1-\pi)(1+p-\alpha)u'[Y-(1+p-\alpha)x^*_{im}] = 0 \tag{9}$$

Once again, we need to demonstrate that $x^* < x^*_{im}$.

In order to prove this statement we shall distinguish between the case when $p = 0$ and that of $p > 0$. In the former case, it is easy to show that eq.(9) collapses to eq.(3), replacing parameter $l$ by $\alpha$, implying that $x^* < x^*_{im}$, as proven in the previous section.

If $p > 0$, the proof no longer holds and $x^* < x^*_{im}$ must be demonstrated.

We rely again on the concavity of $u$, which implies that $\Phi(\cdot)$ is decreasing in $x$. Once more, if we can show that $\Phi(x^*_{im}) < 0$ it must be that $x^* < x^*_{im}$.

Substituting $x^*_{im}$ in equation (2), which is the FOC of the basic setting, we get:

$$\Phi(x^*_{im}) = \pi(r-1)u'[Y + (r-1)x^*_{im}] \; - \; (1-\pi)u'[Y - x^*_{im}] \tag{10}$$

Given that according to equation (9):

[11] Henceforth the farmer is assumed to be risk averse.

[12] See Kuhn-Tucker conditions in appendix A.

$$\pi(r-p-1)u'[Y+(r-p-1)x^*_{im}] \;=\; (1-\pi)(1+p-\alpha)u'[Y-(1+p-\alpha)x^*_{im}] \quad (11)$$

we can add and subtract the terms of eq. (11) in eq. (10) to get:

$$\begin{aligned}\Phi(x^*_{im}) &= \pi(r-1)u'[Y+(r-1)x^*_{im}] \;-\; (1-\pi)u'[Y-x^*_{im}] \\ &\quad -\; \pi(r-p-1)u'[Y+(r-p-1)x^*_{im}] \;+\; (1-\pi)(1+p-\alpha)u'[Y-(1+p-\alpha)x^*_{im}]\end{aligned} \quad (12)$$

We can then rearrange the equation as follows:

$$\begin{aligned}\Phi(x^*_{im}) &= \pi\big\{(r-1)u'[Y+(r-1)x^*_{im}] \;-\; (r-p-1)u'[Y+(r-p-1)x^*_{im}]\big\} \\ &\quad +\; (1-\pi)\big\{(1+p-\alpha)u'[Y-(1+p-\alpha)x^*_{im}] \;-\; u'[Y-x^*_{im}]\big\}\end{aligned} \quad (13)$$

In order to ascertain the sign of equation (13), we will look at the components of each of the terms in the equation. Effectively, we will compare the outcomes with and without insurance—in case of both investment success and failure—to shed light on investment behaviour.

By definition $r-1>0$, and given that insurance has a cost, $p>0$, the implication is that $r-1>r-p-1$. As for the utilities in the first part (FP) in brackets of eq. (13), we have that $Y+(r-1)x^*_{im} > Y+(r-p-1)x^*_{im}$, and since $u'$ decreases with larger values, it must be that $u'[Y+(r-1)x^*_{im}] < u'[Y+(r-p-1)x^*_{im}]$. The latter result would make the first term smaller than the second, and the FP of eq. (13) negative. However, our earlier statement about $r-1>r-p-1$ also implies that $\pi(r-1)>\pi(r-p-1)$, offsetting the negative difference in the utilities and rendering the sign of the FP ambiguous.

By contrast, the analysis is clear-cut in the second part (SP) of eq. (13). As we established at the beginning of this sub-section $(1-\pi)\alpha \geq p$, which implies that $\alpha>p$ as $1-\pi$ is less than 1. The greater size of $\alpha$ with respect to $p$, invariably implies that $1+p-\alpha<1$, and therefore that $(1-\pi)>(1-\pi)(1+p-\alpha)$, indicating that the second term in the SP of equation (13) would be greater than the first.[13] This result is confirmed by the comparison of utilities. The fact that $1+p-\alpha<1$, similarly means that $Y-(1+p-\alpha)x^*_{im} > Y-x^*_{im}$, and hence $u'[Y-(1+p-\alpha)x^*_{im}] < u'[Y-x^*_{im}]$. Therefore, it follows that the second part (SP) is unambiguously negative. We collect the findings of the above logical derivations

[13] The term $1+p-\alpha$ is still greater than 0, given that $\alpha\in(0,1)$ and $p>0$.

below:

$$\Phi(x^*_{im}) = \underbrace{\pi\big\{(r-1)u'[Y+(r-1)x^*_{im}] \;-\; (r-p-1)u'[Y+(r-p-1)x^*_{im}]\big\}}_{(+/-)}$$
$$\underbrace{+\,(1-\pi)\big\{(1+p-\alpha)u'[Y-(1+p-\alpha)x^*_{im}] \;-\; u'[Y-x^*_{im}]\big\}}_{(-)} \lesseqgtr 0 \quad (14)$$

Consequently, the sign of equation (14) remains ambiguous in spite of the negative sign of the SP, due to the ambiguity of the FP, which lies squarely on the fact that $\pi(r-1) > \pi(r-p-1)$.

It can be proven (see Appendix B) that if insurance is fairly priced or subsidised $(1-\pi)\alpha \geq p$ and the probability of investment success is equal or smaller than the probability of failure $\pi \leq 1-\pi$ investment would be higher under insurance conditions, $x^* < x^*_{im}$, which we express in the following proposition:[14,15]

**Proposition 2:** *If $(1-\pi)\alpha \geq p$ and $\pi \leq 1-\pi$, optimal investment levels will be such that $x^* \leq x^*_{im}$.*

The outcome of the proposition yields an intuitive result, an investor will commit higher resources when the investment is fairly insured (or protected by a subsidised cover) and there are equal (or lower) chances of success and (than of) failure. In case that succeeding in the investment is more likely than failing, the benefits of insurance are not as clear-cut, and the level of investment will depend on how the reduction in the returns due to the premium weighs in the mind of the decision maker with respect to the receipt of a payout if the investment fails. A more risk averse investor is likely to value positively trading a small reduction in the return for a payout in the bad state, provided that the likelihood of such state is not too low.

## III.4 Model with Non-compliant Insurance

Let us adapt the earlier framework to a situation in which there is a non-zero probability that the cover does not perform as expected, both in terms of failing to mitigate the losses of an unsuccessful investment and of providing compensation even when the investment succeeds. The occurrence of these events is explained by the indexed nature of the cover, whose payouts depend on the weather conditions.

[14] Not considering corner solutions, $x^* = x^*_{im} = 0$ and $x^* = x^*_{im} = Y$

[15] As we shall see later, both the fairness of the premium and the equal probability of investment success and failure represent accurately the experimental setting.

More precisely, payouts are disbursed when the weather conditions in the community are bad, which happens $q$ of the times. Same as before, these payouts are proportional to the amount invested, $\alpha x$. The implicit introduction of basis risk into the framework, defined as the imperfect correlation between the index and the losses, gives rise to payoffs which could not take place before. As noted earlier, it is now possible that a failed investment goes uncompensated, while the agent still needs to meet the cost of the insurance, $px$, leaving her with $Y-(1+p)x$. On the other hand, the investor can be successful, yet receive a payout in addition to the proceeds of the investment: $Y+(r-1)x+(\alpha-p)x$.

These scenarios comprise the full array of possible payoffs, alongside those taking place with compliant (indemnity) insurance. As a result, the maximisation problem for the investor becomes:

$$\begin{aligned} EU_{IX}(x) = {} & q\big\{\pi u[Y+(r-1)x+(\alpha-p)x] \;+\; (1-\pi)u[Y-(1+p-\alpha)x]\big\} \\ & +(1-q)\big\{\pi u[Y+(r-p-1)x] \;+\; (1-\pi)u[Y-(1+p)x]\big\} \end{aligned} \tag{15}$$

In the absence of basis risk, equation (15) would become eq.(8), given that the payoffs would be the same regardless of the weather conditions. With a compliant insurance, the cover would not pay out a compensation when the investment is successful, therefore $\alpha x$ would disappear from the utility function in the first term, which would then be equal to $Y+(r-p-1)x$ (*i.e.* the third term in eq.[8]). Likewise, the investor would always obtain an insurance payout in the event of a failed investment, resulting in the addition of $\alpha x$ to the utility in the last term, which becomes $Y-(1+p)x+\alpha x = Y-(1+p-\alpha)x$, same as the second term in eq. (15). These equivalences imply that the weather probabilities in eq.(15) multiply the same terms, becoming superfluous, and yielding equation (8).

If $x_{ix} \in ]0, Y[$, the first-order condition for the maximisation problem in eq.(15) is:[16]

$$\begin{aligned} \Phi_{ix}(x^*_{ix}) = q\big\{ & \pi(r-p-1+\alpha)u'[Y+(r-p-1+\alpha)x^*_{ix}] \\ & -\;(1-\pi)(1+p-\alpha)u'[Y-(1+p-\alpha)x^*_{ix}]\big\} \\ & +\;(1-q)\big\{\pi(r-p-1)u'[Y+(r-p-1)x^*_{ix}] \\ & \qquad -\;(1-\pi)(1+p)u'[Y-(1+p)x^*_{ix}]\big\} = 0 \end{aligned} \tag{16}$$

For simplicity we denote the marginal utilities in eq.(16) as follows:[17]

[16] See appendix A for the Kuhn-Tucker conditions.
[17] The first letter of the notation denotes whether the investment was successful ($S$) or failed ($F$), the second letter refers to the weather, which is either good ($G$) or bad ($B$).

$$u'[Y + (r - p - 1 + \alpha)x^*_{ix}] = u'[SB] \tag{17}$$

$$u'[Y - (1 + p - \alpha)x^*_{ix}] = u'[FB] \tag{18}$$

$$u'[Y + (r - p - 1)x^*_{ix}] = u'[SG] \tag{19}$$

$$u'[Y - (1 + p)x^*_{ix} = u'[FG] \tag{20}$$

We can rearrange equation (16):

$$\Phi_{ix}(x^*_{ix}) = \pi\big\{q(r - p - 1 + \alpha)u'[SB] \; + \; (1 - q)(r - p - 1)u'[FB]\big\} \\ - \; (1 - \pi)\big\{q(1 + p - \alpha)u'[FB] \; + \; (1 - q)(1 + p)u'[FG]\big\} = 0 \tag{21}$$

Due to the concavity of $u$, which implies that $\Phi(\cdot)$ is decreasing in $x$, if $\Phi(x^*_{ix}) < 0$ it must be that $x^* < x^*_{ix}$.

Substituting $x^*_{ix}$ in equation (2), which is the FOC of the basic setting, we get:

$$\Phi(x^*_{ix}) = \pi(r - 1)u'[Y + (r - 1)x^*_{ix}] \; - \; (1 - \pi)u'[Y - x^*_{ix}] \tag{22}$$

Given that according to equation (21):

$$\pi\big\{q(r - p - 1 + \alpha)u'[SB] \; + \; (1 - q)(r - p - 1)u'[SG]\big\} \; = \\ (1 - \pi)\big\{q(1 + p - \alpha)u'[FB] \; + \; (1 - q)(1 + p)u'[SG]\big\} \tag{23}$$

We can add and subtract the terms of eq. (23) in eq. (22) to get:

$$\Phi(x^*_{ix}) = \pi(r - 1)u'[Y + (r - 1)x^*_{ix}] \; - \; (1 - \pi)u'[Y - x^*_{ix}] \\ - \; \pi\big\{q(r - p - 1 + \alpha)u'[SB] \; + \; (1 - q)(r - p - 1)u'[FB]\big\} \\ + \; (1 - \pi)\big\{q(1 + p - \alpha)u'[FB] \; + \; (1 - q)(1 + p)u'[FG]\big\} \tag{24}$$

Equation (24) can be rearranged as follows:

$$\Phi(x_{ix}^*) = \pi\Big\{(r-1)u'[Y+(r-1)x_{ix}^*] - \Big(q(r-p-1+\alpha)u'[SB]+(1-q)(r-p-1)u'[FB]\Big)\Big\}$$
$$+ \ (1-\pi)\Big\{\Big(q(1+p-\alpha)u'[FB] \ + \ (1-q)(1+p)u'[FG]\Big) \ - \ u'[Y-x_{ix}^*]\Big\} \quad (25)$$

Rearranging the equation in the above manner allows us to compare the outcomes with and without index insurance. However, the lack of full compliance of the cover translates into two different states of the world both when the investment succeeds or fails—as outcomes vary with the weather conditions—hampering the comparisons drawn. As a result, the effect of being index insured on investment is ambiguous and $\Phi(x_{ix}^*) \lesseqgtr 0$.

**Proposition 3:** *Index insurance has an ambiguous effect on investment.*

Nevertheless, the framework devised let us point out some important characteristics of the cover. For example, if we assumed that the weather is bad ($q = 1$), equation (25) would become:

$$\Phi(x_{ix}^*) = \underbrace{\pi\{(r-1)u'[Y+(r-1)x_{ix}^*] \ - \ (r-p-1+\alpha)u'[Y+(r-p-1+\alpha)x_{ix}^*]\}}_{(-/+)}$$
$$+ \ \underbrace{(1-\pi)\{(1+p-\alpha)u'[Y-(1+p-\alpha)x_{ix}^*] - \ u'[Y-x_{ix}^*]\}}_{(-)} \lesseqgtr 0 \quad (26)$$

The sign of $\Phi(x_{ix}^*)$ remains ambiguous, but we can analyse the forces at work and isolate the underlying mechanisms. On the one hand, receiving a payout has an unambiguous positive effect on investment, making $Y-(1+p-\alpha)x_{ix}^* > Y-x_{ix}^*$ and therefore $u'[Y-(1+p-\alpha)x_{ix}^*] < u'[Y-x_{ix}^*]$. At the same time, $(1-\pi)(1+p-\alpha) < (1-\pi)$, given that $\alpha > p$ as shown earlier. These two results in combination turn the second part (SP) of eq.(26) unambiguously negative, indicating that investment would be higher when is index insured, $x_{ix}^* > x^*$. On the other hand, the sign of the first part (FP) of the equation is ambiguous, since $Y+(r-p-1+\alpha)x_{ix}^* > Y+(r-1)x_{ix}^*$ and therefore $u'[Y+(r-p-1+\alpha)x_{ix}^*] < u'[Y+(r-1)x_{ix}^*]$, even though $r-p-1+\alpha > r-1$. Consequently, we are unable to conclude whether investment is higher with index insurance if the weather is bad. The reason for this is the distorting effect of upward basis risk on investment, which reduces the marginal utility of the investment when it succeeds and the weather is bad, through the disbursement of an insurance payout.

**Proposition 4:** *If $q = 1$, receiving an index insurance payout wields a positive effect on investment, although the overall effect of index insurance on investment remains ambiguous.*

If we now turn to the opposite scenario to the previous, that is good weather ($q = 0$), eq.(25) would look as follows:

$$\Phi(x_{ix}^*) = \underbrace{\pi\big\{(r-1)u'[Y+(r-1)x_{ix}^*] \;-\; (r-p-1)u'[Y+(r-p-1)x_{ix}^*]\big\}}_{(-/+)} \\ + \underbrace{(1-\pi)\big\{(1+p)u'[Y-(1+p)x_{ix}^*] - \; u'[Y-x_{ix}^*]\big\}}_{(+)} \lesseqgtr 0 \quad (27)$$

Even though the sign of the equation remains equally ambiguous, some significant changes have taken place. The ambiguity of the FP is unchanged, yet its source is in the returns to the investment, $\pi(r-1) > \pi(r-p-1)$, rather than the utility of investing, $Y+(r-1)x_{ix}^* > Y + (r-p-1)x_{ix}^*$ (implying that $u'[Y + (r-1)x_{ix}^*] > u'[Y + (r-p-1)x_{ix}^*]$). More importantly, the SP of equation changes sign from negative to positive, indicating that index insurance exerts a deterring effect on investment. This shift is caused by the lack of a payout when the investment fails and the obligation to pay the premium, which leads to $Y-(1+p)x_{ix}^* < Y - x_{ix}^*$ and therefore $u'[Y-(1+p)x_{ix}^*] > u'[Y-x_{ix}^*]$, rendering the sign of the SP unambiguously positive. This side of the analysis shows the distinct negative effect of downward basis risk on investment.

**Proposition 5:** *If $q = 0$, downward basis risk exerts a negative impact on investment, although the overall effect of index insurance on investment remains ambiguous.*

Overall, the influence of index insurance on investment is ambiguous, although it is likely to be more positive the lower basis risk is. To the extent that the complete absence of basis risk would make the investment decision akin to that taken with fully-compliant insurance, as demonstrated at the beginning of this sub-section. We learned that the prospect of receiving a payout in case of failure fosters investment, whereas not obtaining an indemnity when the investment fails and still facing the cost of the premium depresses it.

Drawing from the findings of the analysis, we can infer that basis risk dilutes the benefits of insurance and exacerbates its drawbacks. The reduction in the utility of insurance, especially for a risk averse individual, stems, primarily, from the possibility of non-compliance in the event of a failed investment. This contingency prevents the investor from avoiding the worst state, in which the loss from the investment is not mitigated by a payout, but the cost of insurance is still due. Precisely, the added obligation of paying the premium even when the investment is lost increases the negative effect of the premium on investment, the more so the higher is the individual's aversion to risk.

## III.5 Risk Sharing and Insurance

In our model the availability of risk sharing will always have a positive influence on investment, even in the presence of insurance, as long as informal transfers are free of any costs attached to them.

As predicted in the analysis for the model with risk sharing, informal transfers ensure that $x^* > x_l^*$ for non-corner solutions, due to the increase in utility in the event of a failed investment.

This prediction carries over to a situation where insurance is available, as informal transfers do not interact directly with insurance in the model, which can be seen in utility function maximised by the agent:

$$EU_{IMRS}(x) = \pi u[Y + (r - p - 1)x] \; + \; (1 - \pi)u[Y - (1 + p - \alpha - l)x] \tag{28}$$

Even though the informal transfer is redundant with respect to the insurance payout, it would still yield a rise in utility.[18]

The positive effect of risk sharing on investment will be especially pronounced in the case of index insurance, because a transfer mitigates the inflated losses in the worst state, offsetting, to a certain degree, the disadvantages brought about by the indexed nature of the cover. This can be seen more clearly in equations (26) and (27). The first of the them, eq.(26), depicts the comparison of outcomes with and without index insurance when the weather is bad, $q = 1$; the addition of transfers would leave the equation as follows:

$$\begin{aligned} \Phi(x^*_{ix}) = &\underbrace{\pi\big\{(r-1)u'[Y + (r-1)x^*_{ix}] \; - \; (r - p - 1 + \alpha)u'[Y + (r - p - 1 + \alpha)x^*_{ix}]\big\}}_{(-/+)} \\ &+ \underbrace{(1-\pi)\big\{(1 + p - \alpha - l)u'[Y - (1 + p - \alpha - l)x^*_{ix}] - \; u'[Y - x^*_{ix}]\big\}}_{(-)} \lesseqgtr 0 \end{aligned} \tag{29}$$

In words, it would reinforce the negative sign of the second part (SP), confirming the positive effect of insurance on the amount invested when the weather is bad.[19]

The most significant change occurs in the event of good weather, here the inclusion of informal assistance transforms equation (27):

[18] In fact, it can be shown, through a similar analysis as in Section III.2, that investment is indeed higher with transfers than without them also when insurance is available.

[19] Nevertheless, the overall influence of insurance on investment remains ambiguous.

$$\Phi(x^*_{ix}) = \underbrace{\pi\big\{(r-1)u'[Y+(r-1)x^*_{ix}] \; - \; (r-p-1)u'[Y+(r-p-1)x^*_{ix}]\big\}}_{(-/+)} + \underbrace{(1-\pi)\big\{(1+p-l)u'[Y-(1+p-l)x^*_{ix}] - \; u'[Y-x^*_{ix}]\big\}}_{(-/+)} \lesseqgtr 0 \quad (30)$$

That is, the SP of the equation no longer bears a definite positive sign, which denoted a fall in the amount invested. Furthermore, provided that $l > p$, the sign of the SP would become negative, given that then $(1-\pi)(1+p-l) < (1-\pi)$ and that $Y-(1+p-l)x^*_{ix} > Y-x^*_{ix}$, which means that $u'[Y-(1+p-l)x^*_{ix}] < u'[Y-x^*_{ix}]$. This switch in sign implies that investment under index insurance would be higher than without insurance thanks to the availability of transfers in the former case.

**Proposition 5:** *Risk sharing (l) always has positive effect on investment, including when insurance is present.*

**Proposition 6:** *In the case of index insurance, informal transfers can offset the negative effect of downward basis risk provided $l > p$.*

We can therefore conclude that risk sharing can mitigate the effects of basis risk and increase the appeal of investment under a cover that is not fully compliant.

# IV Experimental Design and Implementation

## IV.1 Area of Study

We conducted a framed field experiment in a rural region of eastern Uganda. The region, located in the Greater Mbale area, comprises the districts of Sironko and Lower Bulambuli, formerly known as Sironko District.[20] This area is close to the border with Kenya and benefits from substantial, bimodal rainfall, which determines the two cropping seasons around which farmers organise their activities (Humphrey and Verschoor, 2004). The vagaries of the weather are arguably the most important source of risk with 53% and 76% of communities affected by a drought or a flood, respectively, in the last 12 years, and milder but prolonged dry spells or periods of heavy rain taking place more frequently.[21] The area is estimated to be inhabited by around 300,000 people in its 1,270 square kilometres, with a large majority of the population having a Bagisu ethnical background and professing some form of Christianity (UBOS, 2014; Verschoor *et al.*, 2016).

Table II.1 below shows descriptive statistics from a representative sample of the area.[22]

**Table II.1: General Descriptives$^{\Psi}$**

| Variable | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| Gender (1=Male) | 0.51 | 0.5 | 0 | 1 |
| Age | 40 | 14 | 18 | 73 |
| Education (years) | 6 | 3 | 0 | 13 |
| Married | 0.8 | 0.4 | 0 | 1 |
| Size Households | 5.85 | 2.73 | 1 | 19 |
| Bagisu Ethnicity | 0.95 | 0.22 | 0 | 1 |
| Christian | 0.91 | 0.28 | 0 | 1 |
| Farmer | 0.82 | 0.39 | 0 | 1 |
| Land holdings | 1.72 | 3.3 | 0 | 75 |

Source: Authors' calculations (2012).
Sample size: 1,802 households.
$^{\Psi}$ Sample weights employed.

Most people are married and scarcely educated, with barely 5 years of formal education. Household size averages almost six members, and half of them are estimated to be dependents. People in this area are primarily farmers of their own land; 98 percent of households

[20] A map of the area can be found in Appendix A of Pérez-Viana (2019b).

[21] The source of these statistics is a survey conducted in 2012 by Verschoor, D'Exelle and Pérez-Viana (2016). Anecdotal evidence from the time reveals that the impact of these events in a farmer's livelihood can be substantial, for example, reducing a regular harvest of 12 bags of maize to only 3 when a drought sets in.

[22] The descriptives were calculated with data from Verschoor *et al.* (2016) collected in the 2012 survey, containing information about 1,800 households.

cultivate some land and 82 percent report working on the household farm as their primary activity. The remainder of the population typically grows crops as a secondary activity alongside running their own businesses. However, land holdings are small, at around 1.7 acres on average, with few big farmers living in the area.

## IV.2 Sample Selection and Fieldwork Implementation

In the selection of the sample for the study, we employed the sampling framework of Verschoor *et al.* (2016), who gathered a representative sample of the area in 2012.[23]

Two sub-counties were selected purposively from the ten selected in the 2012 study.[24] Subsequently, a random draw gave us the names of the 20 villages which took part in the study.

In each of these villages, a list of all adults (18+) by household was compiled and up to 20 adults were randomly selected from the list, subject to the condition that they belonged to different households and that farming was their primary activity.

Data collection for the present and the previous paper (Pérez-Viana, 2019b) took place between August and October of 2016, and proceeded as follows. First, the enumerator team visited all participants to administer the household survey, subsequently, the experiments were carried out in each sub-county. In particular, the data we draw upon comes from a series of experiments conducted a week after those that generated the data for Pérez-Viana (2019b). The candidate supervised on site the entire data collection operation.

In each sub-county, the experiments were conducted in a central venue (typically a school), conveniently located for participants. Selected subjects from two different villages came every day and took part in the games for about three hours. Two sessions were run in parallel, administered each by one of the two enumerator teams. Attrition was very low, with more than 95% of the selected participants taking part in the study.

## IV.3 Experiment

### IV.3.1 Participants

Prior to the experiment, participants from each of the selected villages were divided randomly into four groups, differentiated by the treatments they took part in—Games 1A, 1B, 2C or 2D. Each group from every village participated in one of the ten experimental sessions, each of which was attended by ten subjects from two different villages in equal

[23] A full description of the framework is given in the third Chapter of this thesis (Pérez-Viana, 2019a).
[24] A sub-county is a smaller administrative unit contained within a district.

proportion (*i.e.* five from each village). Participants allocated to Games 1A and 2C attended the morning sessions, whereas the remainder came in the afternoon to participate in one of the other games. Protocols were in place to avoid contamination.[25]

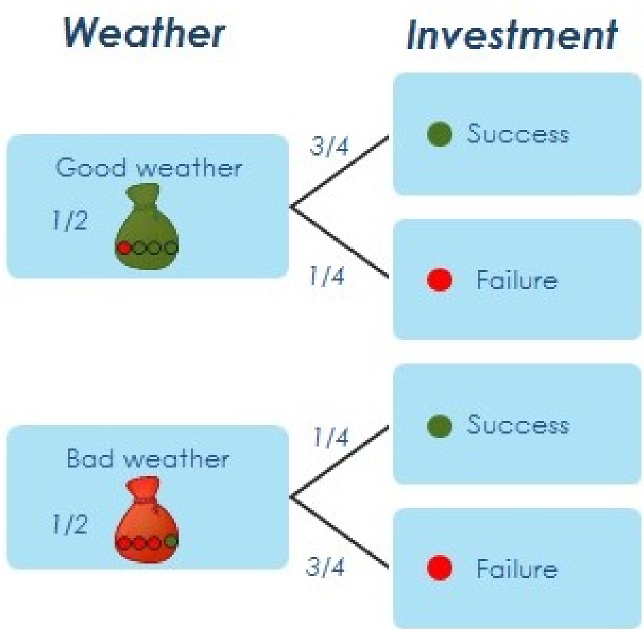
**Table II.2: Experimental Sessions**

| | Game 1A | Game 1B | Game 2C | Game 2D |
|---|---|---|---|---|
| Sessions | 10 | 10 | 10 | 10 |
| Villages | 20 | 20 | 20 | 20 |
| Participants | 99 | 101 | 100 | 99 |

### IV.3.2 Setting

At the beginning of the session, subjects in the game were assigned an endowment of 8,000 Ugandan Shillings, and were paired with another individual.[26] One of the members of the pair, Person 1, was asked to decide how much she wished to invest under varying circumstances. The returns to the investment depended on random variation framed as weather conditions, with set probabilities for good and bad outcomes. A diagrammatic representation of this situation is shown in Figure II.1. The other partner, Person 2, in some cases was given the chance to compensate Person 1 for the losses derived from her investment.

**Figure II.1: Probability Structure Experiment**




[25] Participants for the afternoon session arrived before the morning session was over, and waited in a separate venue.

[26] 8,000 Shillings are approximately two dollars and a half ($2.36), equivalent to two days' wages of an agricultural labourer.

The outcome of the investment decision depended on two types of shocks, an idiosyncratic and a covariate one. The outcome of the latter shock determined the weather conditions, that is, the probability distribution determining whether the investment failed or succeeded. This shock affected everyone investing in the same way, and its occurrence was decided by a randomising device. The second type of shock, of idiosyncratic nature, was the realisation of the investment decision—whether it yielded profits or losses. Contrarily to the weather shock, this one affected every investor in a different way, so that not everyone may have experienced losses if the investment of some other player failed. Idiosyncratic shocks, and thereby losses from investing, were more likely to happen in the event of bad weather, although the chances it hit were still randomly determined.[27] In terms of the theoretical framework, this means that the value of $\pi$, the probability of a successful investment, would vary *ex-post* depending on the realisation of the common shock, taking a higher value when the weather is good and a lower one with bad weather. However, the model represents the *ex-ante* situation, where the probability of success is fixed at one half ($\pi = 1/2$) for all the investment decisions Person 1 takes.[28]

### IV.3.3 Treatments

Participants were subjected to a number of treatments resulting from the combination of two different dimensions: insurance status of Person 1 and risk sharing technology available to the partners. The first dimension consists of whether Person 1's investment was insured through an indexed cover, an indemnity cover or not insured at all. The second dimension simply broke down into whether risk sharing was permitted or not. The combination of the two dimensions gives rise to a matrix of treatments which can be summarised in the following table:

**Table II.3: Treatment Matrix**

| Risk Sharing/Insurance | Index | Indemnity | No Insurance |
|---|---|---|---|
| **Risk Sharing** | T1 | T3 | T5 |
| **No Risk Sharing** | T2 | T4 | T6 |

In all treatments, Person 1 was given the chance to invest her endowment, obtaining a positive return if the investment succeeded and a loss otherwise.

[27] This structure is loosely based on Clarke and Kalani (2011).

[28] The unconditional probability of success, *i.e.* state of the world $S$, is the sum of the probability under favourable weather conditions plus the chances of success with bad weather:

$$P(s = S) = \pi = \frac{1}{2} \times \frac{3}{4} + \frac{1}{2} \times \frac{1}{4} = \frac{1}{2}$$

The first four treatments (*T1* to *T4*) were characterised by the fact that investors were insured. In the first two (*T1* and *T2*), it was mandatory for Person 1 to buy an index insurance policy as part of the investment, which provided a payout in the event of common bad weather. The next two (*T3* and *T4*) required Person 1 to purchase indemnity insurance, which entitled the investor to a payout, but in this case when the investment failed.

Apart from being insured, in *T1*, Person 1 was also part of an informal arrangement that allowed for risk sharing. Person 2 could assist when Person 1's investment failed and compensate the latter's losses up to whatever amount she saw fit. By contrast, in *T2*, Person 2 could not help Person 1, who relied entirely on the insurance payment.

Mirroring the first two treatments, in *T3*, Person 1 was also part of a risk-sharing arrangement, by which Person 2 could aid her in the event of a failed investment. *T4* did not allow for such transfers, and Person 1 was again fully dependent on the insurance for assistance when the investment failed.

The main feature of the last two treatments, *T5* and *T6*, was the lack of insurance for Person 1. The two solely differed in that loss sharing with Person 2 was only possible in *T5*.

The distribution of the treatments in the games where different subjects participated was the following:

**Table II.4: Treatments by Game**

| | **Game 1A** | **Game 1B** | **Game 2C** | **Game 2D** |
|---|---|---|---|---|
| First Treatment | T5 | T6 | T5 | T6 |
| Second Treatment | T1 | T2 | T3 | T4 |
| Participants | 99 | 101 | 100 | 99 |

### IV.3.4 Decisions

In all treatments Person 1 was required to make an investment decision, framed as the amount they wished to invest in an agricultural business (*e.g.* fertiliser), with a choice ranging from nothing at all up to 6,000 Shillings, in increments of 1,000 Shillings.

If the investment was successful, it was increased two-and-a-half-fold, so that the profit was equal to the amount invested and a half; however, if it failed, all the investment was lost.[29] In other words, the return $r$ in the expected utility functions the investor maximises was always 2.5.

[29] For example, if a participant invested 1,000 and was successful, then the 1,000 become 2,500 shillings. If however the investment failed, the 1,000 invested were lost.

The investment decision determined the payoff received by the participant together with the random draws for the weather conditions and the investment outcome. The more invested, the higher the expected value of the payoff, but also the largest the variance.

Insurance provided a hedge against a bad outcome and, subject to its availability in the treatment, was always compulsory. For every 1,000 Shillings invested, the investor had to purchase a policy of 250 Shillings, which paid an indemnity of 500 Shillings in case of good weather or a failed investment—depending on whether the type of cover was indexed or indemnity, respectively. That is, coverage $\alpha$ provided by the insurance was half the amount invested ($\alpha = 0.5$), and, in turn, the premium charge was half the latter figure ($p = (1-\pi)\alpha = 0.25$). Table II.5 provides a summary of the characteristics of the add-on insurance.

**Table II.5: Insurance Characteristics**

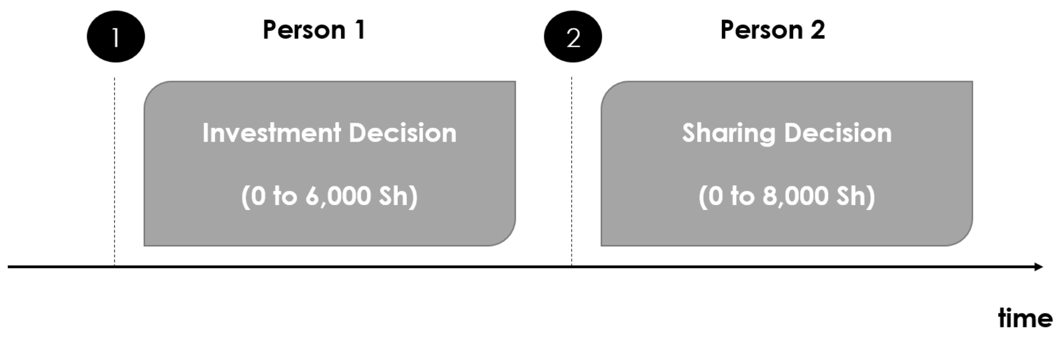
| | **Index Insurance** | **Indemnity Insurance** |
|---|---|---|
| Payout per unit | 500 | 500 |
| Unconditional Probability of Payout ($\pi$) | 1/2 | 1/2 |
| Premium/ Expected Payout per unit | 250 | 250 |
| Loading (mark-up over fair premium) | 0% | 0% |

Both types of insurance were fairly priced, their only difference was due to basis risk, which only the indexed product suffered. This feature implied that the coverage requirement could leave the player worse off when the investment failed and no payout was disbursed, because she still had to pay the premium. Conversely, Person 1 could also end up better off than in any other circumstances, receiving a payment after a successful investment, because the weather turned out bad.[30]

In *T2* and *T4*, Person 1 relied exclusively on the indemnity from the insurance product. However, in *T1* and *T3*, Person 2 could transfer any amount from her endowment, from 0 to 8,000 Shillings, to compensate Person 1 in case of a failed investment. This was also the case in *T5*, where only informal transfers could take place, but not in *T6*, where Person 1 did not have access to any form of assistance to counter a failed investment. In order to elicit the sharing decision, we implemented a strategy method by which Person 2 had to decide how much she wished to transfer for every possible amount invested by Person 1. Before being asked to decide, Person 2 was shown the full array of investment options and the extent of Person's 1 potential losses for each of these choices. Figure II.2 below shows the timeline for the decisions taken:

[30] In fact, the reason investment was restricted to 6,000 Shillings rather than the full endowment was that, due to basis risk, Person 1 could lose 1,500 in premium costs in addition to the amount invested, leaving only 500 of the endowment. Higher levels of investment would therefore leave Person 1 with losses beyond her endowment.

**Figure II.2: Timeline Decisions**




The sequence of decisions always followed the pattern described in the figure for all treatments implemented. First, Person 1 took her investment decision, and subsequently Person 2 decided how much she wished to share, if such option was permitted in the treatment.

### IV.3.5 Other Design Choices

The experimental setup tried to avoid that (anticipated) post-experimental transfers influenced decision-making among participants by making all the pairings anonymous.

However, half of the participants in every session were co-villagers and the other half belonged to a different village; a feature that ensured social distance was kept low among participants, making likely that risk sharing took place, as it would in real life. Transfers of income are frequent and central to financial security in rural communities of the developing world, and in Sub-Saharan Africa in particular (Fafchamps, 2003, 2008). As a result, there is a high chance of observing transfers when the need arises. Furthermore, in our area of study, D'Exelle and Verschoor (2015) report a sizeable level of loss sharing in an experiment simulating a situation close to the one described here, and carried out in the same area.

We avoided that participants fulfilled the role of Person 1 and 2 simultaneously to restrict the source of random variation, so that the investment decision was dependent only on anticipated risk sharing, rather than on the investment choice of the partner as well. Under simultaneity with the same partner, an investor would also have to consider the investment decision of the partner. If, for instance, the partner chooses to invest heavily, she would end up requesting support for a higher amount if the investment fails, as well as diminishing her own capacity to assist the first investor. These free-riding considerations may influence the investment decision aside from the possibility of receiving transfers.

Furthermore, investment losses, which as mentioned can compromise severely the ability of the partners to assist one another, would also undermine the salience of risk sharing in the experiment and cloud the comparisons of investment decisions within and across treatments.

Even though the participants were not investor and assisting partner at the same time, they experienced both the role of Person 1 and Person 2 during the experiment, by assuming them in sequence.[31] Nevertheless, individuals were paired with different partners for the investment (as Person 1) and sharing decision (as Person 2) to prevent the imposition of reciprocity.[32]

### IV.3.6 Payoffs

Table II.6 depicts the payoffs for an investor in every state of the world, insured or not. Expected payoffs are calculated by adding or subtracting the proceeds or losses from the investment, depending on the outcome, as well as the insurance payout minus its cost, when insurance is present.

The expected payoffs shown in the previous table result in the experimental payoffs depicted in Tables II.7 and II.8. For every possible level of investment, the first row shows the pertinent calculation, adding and subtracting the necessary elements, and the second the resulting net payoff. Table II.7 presents the payoffs in the treatments where no insurance was available or the investment was insured by an indemnity-type cover. By contrast, Table II.8 shows only the payoffs for the treatments where the investment was index insured.

[31] For example, every participant assumed the role of Person 1 first in *T1*, and later on that of Person 2 in the second round of the treatment.

[32] See the implementation sub-section below for further details.

**Table II.6: Expected Payoffs Investor**

| | Payoff | | | | Expected Payoff |
|---|---|---|---|---|---|
| Weather ($W$): | Good | | Bad | | |
| Prob. $W$: | $q$ | | $1-q$ | | |
| Outcome/State ($s$): | Success ($S$) | Failure ($F$) | Success ($S$) | Failure ($F$) | |
| Prob. $s$: | $\pi$ | $1-\pi$ | $\pi$ | $1-\pi$ | |
| Not Insured | $Y+(r-1)x$ | $Y-x$ | $Y+(r-1)x$ | $Y-x$ | $\pi[Y+(r-1)x]+(1-\pi)(Y-x)$ |
| Indemnity Insured | $Y+(r-p-1)x$ | $Y-(1+p)x+\alpha x$ | $Y+(r-p-1)x$ | $Y-(1+p)x+\alpha x$ | $\pi[Y+(r-p-1)x]+(1-\pi)[Y-(1+p)x+\alpha x]$ |
| Index Insured | $Y+(r-p-1)x$ [1] | $Y-(1+p)x$ [2] | $Y+(r-1)x+(\alpha-p)x$ [3] | $Y-(1+p)x+\alpha x$ [4] | $q\pi[1]+q(1-\pi)[2]+(1-q)\pi[3]+(1-q)(1-\pi)[4]$ |

**Table II.7: Experimental Payoffs Investor**

| Weather: | Good | Bad | Good | Bad | |
|---|---|---|---|---|---|
| Prob. W.: | 1/2 | 1/2 | 1/2 | 1/2 | |
| Outcome/State ($s$): | Success ($S$) | Success ($S$) | Failure ($F$) | Failure ($F$) | |
| Prob. $s$: | 3/8 | 1/8 | 1/8 | 3/8 | |
| Prob. Outcome: | 1/2 | | 1/2 | | |

| Investment | Payoff (UGX) | | Expected Payoff |
|---|---|---|---|
| **Not Insured (*T5* & *T6*)** | | | |
| 0 | 8,000 | 8,000 | |
| | 8,000 | 8,000 | 8,000 |
| 1,000 | 8,000+1,000·1.5 | 8,000-1,000 | |
| | 9,500 | 7,000 | 8,250 |
| 2,000 | 8,000+2,000·1.5 | 8,000-2,000 | |
| | 11,000 | 6,000 | 8,500 |
| 3,000 | 8,000+3,000·1.5 | 8,000-3,000 | |
| | 12,500 | 5,000 | 8,750 |
| 4,000 | 8,000+4,000·1.5 | 8,000-4,000 | |
| | 14,000 | 4,000 | 9,000 |
| 5,000 | 8,000+5,000·1.5 | 8,000-5,000 | |
| | 15,500 | 3,000 | 9,250 |
| 6,000 | 8,000+6,000·1.5 | 8,000-6,000 | |
| | 17,000 | 2,000 | 9,500 |
| **Indemnity Insured (*T3* & *T4*)** | | | |
| 0 | 8,000 | 8,000 | |
| | 8,000 | 8,000 | 8,000 |
| 1,000 | 8,000+1,000·1.5-250 | 8,000-1,000-250+500 | |
| | 9,250 | 7,250 | 8,250 |
| 2,000 | 8,000+2,000·1.5-250·2 | 8,000-2,000-250·2+500·2 | |
| | 10,500 | 6,500 | 8,500 |
| 3,000 | 8,000+3,000·1.5-250·3 | 8,000-3,000-250·3+500·3 | |
| | 11,750 | 5,750 | 8,750 |
| 4,000 | 8,000+4,000·1.5-250·4 | 8,000-4,000-250·4+500·4 | |
| | 13,000 | 5,000 | 9,000 |
| 5,000 | 8,000+5,000·1.5-250·5 | 8,000-5,000-250·5+500·5 | |
| | 14,250 | 4,250 | 9,250 |
| 6,000 | 8,000+6,000·1.5-250·6 | 8,000-6,000-250·6+500·6 | |
| | 15,500 | 3,500 | 9,500 |

**Table II.8: Experimental Payoffs Investor (Index Insured)**

| Weather: | Good | Bad | Good | Bad | |
|---|---|---|---|---|---|
| Prob. W.: | 1/2 | 1/2 | 1/2 | 1/2 | |
| Outcome/State ($s$): | Success ($S$) | Success ($S$) | Failure ($F$) | Failure ($F$) | |
| Prob. Outcome/State ($s$): | 3/8 | 1/8 | 1/8 | 3/8 | |
| Investment | Payoff (UGX) | | | | Expected Payoff |
| Index Insured (*T1* & *T2*) | | | | | |
| 0 | 8,000 | 8,000 | 8,000 | 8,000 | |
| | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 |
| 1,000 | 8,000+1,000·1.5-250 | 8,000-1,000-250 | 8,000+1,000·1.5-250+500 | 8,000-1,000-250+500 | |
| | 9,250 | 6,750 | 9,750 | 7,250 | 8,250 |
| 2,000 | 8,000+2,000·1.5-250·2 | 8,000-2,000-250·2 | 8,000+2,000·1.5-250·2+500·2 | 8,000-2,000-250·2+500·2 | |
| | 10,500 | 6,500 | 11,500 | 5,500 | 8,500 |
| 3,000 | 8,000+3,000·1.5-250·3 | 8,000-3,000-250·3 | 8,000+3,000·1.5-250·3+500·3 | 8,000-3,000-250·3+500·3 | |
| | 11,750 | 4,250 | 13,250 | 5,750 | 8,750 |
| 4,000 | 8,000+4,000·1.5-250·4 | 8,000-4,000-250·4 | 8,000+4,000·1.5-250·4+500·4 | 8,000-4,000-250·4+500·4 | |
| | 13,000 | 3,000 | 15,000 | 5,000 | 9,000 |
| 5,000 | 8,000+5,000·1.5-250·5 | 8,000-5,000-250·5 | 8,000+5,000·1.5-250·5+500·5 | 8,000-5,000-250·5+500·5 | |
| | 14,250 | 1,750 | 16,750 | 4,250 | 9,250 |
| 6,000 | 8,000+6,000·1.5-250·6 | 8,000-6,000-250·6 | 8,000+6,000·1.5-250·6+500·6 | 8,000-6,000-250·6+500·6 | |
| | 15,500 | 500 | 18,500 | 3,500 | 9,500 |

### IV.3.7 Time frame and Implementation

The implementation of the experiment followed a series of defined steps, shown in Table II.9.

**Table II.9: Time Frame**

| Time | Event |
|---|---|
| t=1 | Setting up games & pairing |
| t=2 | Explanations Part 1 (later on Part 2) |
| t=3 | Decisions (back to t=2 for Part 2) |
| t=4 | Resolution |
| t=5 | Payment |

For full details about the implementation see Appendix C, which contains the entire experimental script for one of the games implemented.

***Step 1: Setting up the games (t=1)***

Participants arrived at the venue for registration and were allocated to one of two rooms, representing different sets of treatments. Those summoned for the morning slot took part either in Games 1A or 2C. The first game comprised treatments where risk sharing was permitted and Person 1's investment was uninsured or insured by an indexed cover (*T5* and *T1*, respectively). Game 2C also featured two risk sharing treatments (*T5* and *T3*), with the only difference that in one of them the investment was indemnity rather than index insured (*T3*), unlike the previous game.

Subjects gathered for the afternoon session took part in games consisting of treatments without risk sharing. In a similar fashion to the morning session, they played either Game 1B, where the investment of Person 1 was not protected or it was index insured (*T6* and *T2*), or Game 2D. The latter game was also made up of two treatments without risk sharing (*T4* and *T6*), differing from the previous game solely in that the cover featured in the treatment with insured investment was of the indemnity type (*T4*).

***Step 2: Pairing (t=1)***

Participants were paired with other individuals taking part in the session. Each partner fulfilled a different role, however, each role was taken by every partner in sequence. For example, every participant assumed the role of Person 1 first in *T1*, and later on that of Person 2 in the second round of the treatment.

In general, Person 1 was presented with the investment prospect and had to decide how much to invest. In contrast, Person 2 chose the extent to which she would compensate Person 1 if her investment failed, using as much of her own endowment as she wanted.

Subjects were paired with a different individual for every decision they made. For instance, in *T3*, the participant's partner while taking the role of the investor during the first round of the treatment was different from the one she was paired with in the second, when she played as Person 2. This procedure was explained to participants in simple terms through role playing at the explanations stage.

***Step 3: Explanations (t=2)***

Subjects were explained the game.

They were presented with a probability structure common to all treatments (Figure II.1 above), where Person 1's investment decision was subjected to the two above-mentioned types of shocks.

The game consisted of two stages, differentiated by the availability of insurance.

**Part 1**

In the first part, subjects participated in a treatment where insurance was not available; either *T5*—in which risk sharing was permitted—if they came in the morning, or for those attending the afternoon session, *T6*—where informal transfers were not allowed.

*T5* comprised two rounds, as opposed to the single one in *T6*. In the former treatment, participants played as Person 1 in the first round (the only round played by participants in *T6*) and as Person 2 in the second. They were informed, privately, about the role they were to fulfil in the round during the administration of the control questions in order to substantiate the existence of both persons in the pair.

After the explanations, understanding was tested and participants proceeded to the decision stage.

The game went back to the explanations step for the second part of the experiment.

**Part 2**

Once subjects had made their choices in Part 1, the next one began.

Contrarily to the previous part, the treatments in the present one involved some form of compulsory insurance.

Half of the participants played treatments in which index insurance was the mandatory cover (either *T1* or *T2*), and the other half took part in the indemnity insurance treatments (*T3* or *T4*). Within these two halves of 'index' and 'indemnity insurance' participants, morning participants took part in treatments where Person 2 could compensate the investment losses of Person 1 (*T1* for the 'index' participants and *T3* for the 'indemnity' ones), and those coming in the afternoon participated in treatments where this was not possible (*T2* or *T4*). In other words, a quarter of the total number of subjects took part in each of the four treatments implemented in this part (*T1* to *T4*), as seen below.

**Table II.10: Insurance Treatments by Game**

| | Index | | Indemnity | |
|---|---|---|---|---|
| | Game 1A | Game 1B | Game 2C | Game 2D |
| Treatment | T1 | T2 | T3 | T4 |
| Risk Sharing | Yes | No | Yes | No |
| Participants | 99 | 101 | 100 | 99 |

In those treatments in which Person 2 was active (*T1* and *T3*), there were two rounds, for only one in the treatments where Person 2 just observed (*T2* and *T4*). In the first round, all participants took their investment decisions as Person 1, and in the second, they decided as Person 2. Once again, in order to reinforce the presence of the other person in the pair, participants were informed of the role they were fulfilling privately during the administration of the control questions.

The game progressed to the decision stage after the explanations had been delivered.

***Step 4: Decisions (t=3)***

After participants had been explained a part (or only a round), they were asked to take their decisions. In particular, Person 1 had to decide how much of her endowment, if any, to invest, ticking the appropriate box in a card like the one below.

**Figure II.3: Example Decision Card Person 1 (T3)**

| **Person 1** | | ID:____ Part:__1__ Session:____ | | |
|---|---|---|---|---|
| **Investment** | | **Success** | **Failure** | **Sharing Person 2** |
| ☐ | 0 | + 0 Earnings: 8,000 | - 0 Earnings: 8,000 | |
| ☐ | 1,000 | + 1,500 Earnings: 9,500 | - 500 Earnings: 7,000 | + ? |
| ☐ | 2,000 | + 3,000 Earnings: 11,000 | - 1,000 Earnings: 6,000 | + ? |
| ☐ | 3,000 | + 4,500 Earnings: 12,500 | - 1,500 Earnings: 5,000 | + ? |
| ☐ | 4,000 | + 6,000 Earnings: 14,000 | - 2,000 Earnings: 4,000 | + ? |
| ☐ | 5,000 | + 7,500 Earnings: 15,500 | - 2,500 Earnings: 3,000 | + ? |
| ☐ | 6,000 | + 9,000 Earnings: 17,000 | - 3,000 Earnings: 2,000 | + ? |

Person 2 on the other hand, needed to decide how much, if any, of Person 1's losses from a failed investment she wished to compensate and record them in a card.

The decisions of Person 2 were elicited using a strategy method, by which the participant could determine how much she wanted to transfer for every possible amount invested by Person 1. An example of the card filled by participants is:

**Figure II.4: Example Decision Card Person 2 (T5)**

| **Person 2** | | ID: ____ Part: _1_ Session: ____ |
|---|---|---|
| ● - Inv | | |
| ***Investment*** | ***Losses Person 1*** | ***Sharing*** |
| 1,000 | 1,000 | ________ Shillings |
| 2,000 | 2,000 | ________ Shillings |
| 3,000 | 3,000 | ________ Shillings |
| 4,000 | 4,000 | ________ Shillings |
| 5,000 | 5,000 | ________ Shillings |
| 6,000 | 6,000 | ________ Shillings |

Immediately after the decisions for a given part (or round) were taken, the experiment went back to the explanations step (t=2) to continue with the next part.

***Step 5: Resolution (t=4)***

Once subjects had decided about how much they wished to invest and, if necessary, how much losses they would compensate in all treatments they participated, a random draw selected which treatment was resolved to determine their gains.

As soon as this was known, the realisation of the common shock was randomly determined through a public draw of a green or a red bag.

The selected bag was employed to determine, individually and privately, whether Person 1's investment was successful. Prior to this, one type of pair was selected, out of the two each participant was involved in every part.

***Step 6: Payments (t=5)***

After the resolution and depending on the decisions made by both members of the pair, payments were calculated for the selected treatment and pair.

Each participant was explained their outcome individually and paid privately.

#### IV.3.8 Understanding

Ensuring the understanding of the experiment by participants was one of the key objectives of the design and the implementation went to great lengths in order to achieve it.

The experiment was conducted with small groups of twenty participants in compact classrooms, which however allowed sufficient separation between participants. The setting and decisions were explained thoroughly to all participants by the lead experimenter. Each part (*i.e.* treatment) was explained in full before any decisions were taken. At this point, participants were asked to seat individually with one of the enumerators who informed them of the role they were playing (*i.e.* Person 1 or 2) and remind them of the decision to be taken.[33] Once this was done understanding was tested.

The aim of the control questions was not to test the numeracy skills of participants but rather their comprehension of the game employing the decision card—the tool where they would record their choices. All questions were based on their capacity to make use of the card effectively, and they most frequently involved pointing at the part of the card where the exact answer could be found. There were a maximum of eight questions of this kind, depending on the Game, half of them posed after the first stage of the explanations was completed and the rest asked after the remaining parts were explained. The overall percentage of correct answers was very high, above 90%. The precise wording of the questions can be found in Appendix C.

[33] Each experimental session took around two hours and a half to complete.

# V Analysis

This section presents the main empirical results, which serve us to evaluate the hypotheses arising from the theoretical framework about the influence of formal and informal insurance on investment behaviour. In the second part of the section, we also look at the effect that the different insurance statuses of the investor exert on risk sharing.

## V.1 Descriptives

Before proceeding with the analysis, we present a set of descriptive statistics and balancing tests. The tests below assess the balance across the index and indemnity insurance subsamples. Additionally, the same tests are carried out to assess the balance within these two subsamples (*i.e.* across games) in Appendix D.

**Table II.11: Summary Statistics and Balancing Tests$^{\Psi}$**

| Variable | Mean (Standard Deviation) Total (N=396) | Index (N=200) | Indemnity (N=196) | t-stat | p-value |
|---|---|---|---|---|---|
| Gender (1=Male) | 0.458 | 0.515 | 0.4 | -2303** | 0.022 |
| | (0.498) | (0.5) | (0.49) | | |
| Age | 38.67 | 39.4 | 37.93 | -1.096 | 0.274 |
| | (13.31) | (13.53) | (13.08) | | |
| Married | 0.79 | 0.76 | 0.821 | 1.502 | 0.134 |
| | (0.408) | (0.428) | (0.384) | | |
| Household size | 5.626 | 5.59 | 5.663 | 0.278 | 0.781 |
| | (2.62) | (2.55) | (2.696) | | |
| Years of Education | 5.78 | 5.875 | 5.682 | -0.586 | 0.559 |
| | (3.271) | (3.311) | (3.237) | | |
| Bagisu Tribe | 0.972 | 0.97 | 0.975 | 0.271 | 0.786 |
| | (0.164) | (0.171) | (0.158) | | |
| Protestant | 0.604 | 0.615 | 0.592 | -0.47 | 0.639 |
| | (0.49) | (0.489) | (0.493) | | |
| Land Holdings | 1.29 | 1.317 | 1.262 | -0.455 | 0.649 |
| | (1.184) | (1.213) | (1.156) | | |
| Wealth Index | -0.019 | -0.053 | 0.016 | 0.286 | 0.775 |
| | (2.424) | (2.344) | (2.508) | | |
| Participant's Risk Preferences | 2.227 | 2.22 | 2.235 | 0.01 | 0.921 |
| | (1.465) | (1.458) | (1.477) | | |
| Knowledge of Insurance | 0.232 | 0.25 | 0.214 | -0.84 | 0.401 |
| | (0.423) | (0.434) | (0.411) | | |
| Experience with Shocks | 0.374 | 0.37 | 0.378 | 0.155 | 0.877 |
| | (0.484) | (0.484) | (0.486) | | |

Mean statistic provided for each variable, with standard deviation in brackets below.
Stars denote significance levels: $^{*}\ p < 0.1$, $^{**}p < 0.05$,$^{***}\ p < 0.01$
$^{\Psi}$ Details of the variables can be found in Table II.12.

The majority of the farmers participating in the study are women, although all participants were randomly selected out of the adult members of the household working on the farm. Similarly to the area statistics, most subjects are married, scarcely educated and live in large households. Our farmers are relatively poor, possessing only slightly more than an acre of land. A substantial proportion has experienced severe shocks in the last two years, involving a fall in total and food consumption, yet their knowledge of insurance and its use is very limited.

From all the balancing checks carried out, only the gender of participants is significantly different across subsamples.

As noted, we conduct the same tests as in Table II.10 between, first, Games 1A and 1B, which comprise the 'index' subsample; and, second, Games 2C and 2D, which make up the 'indeminity' group. These within-subsample tests yield no significant differences at the conventional 5% level (see Appendix D).

## V.2 Study Variables

The table below contains a list and a description of all the variables used in the analysis.

## Table II.12: Study Variables

| Variable | Description |
|---|---|
| Amount Invested | Amount invested by Person 1 in the experiment |
| Index w/ Sharing (*T1*) | Participation in *T1* (where index insurance was compulsory with the investment and risk sharing was permitted) [dummy] |
| Index w/o Sharing (*T2*) | Participation in *T2* (where index insurance was compulsory with the investment and risk sharing was not allowed) [dummy] |
| Indemnity w/ Sharing (*T3*) | Participation in *T3* (where indemnity insurance was compulsory with the investment and risk sharing was permitted) [dummy] |
| Indemnity w/o Sharing (*T4*) | Participation in *T4* (where indemnity insurance was compulsory with the investment and risk sharing was not allowed) [dummy] |
| No ins. w/ Sharing (*T5*) | Participation in *T5* (where insurance was not available and risk sharing was permitted) [dummy] |
| Index w/o Sharing (*T6*) | Participation in *T6* (where insurance was not available and risk sharing was not allowed) [dummy] |
| Insured | Whether Person 1's investment was insured (dummy) |
| Type of Insurance: Index | Whether the type of cover Person 1's investment was insured under was of the indexed type (dummy) |
| Risk sharing | Whether the investor could receive any support from the partner (Person 2) [dummy] |
| Partner's Losses | Amount lost by Person 1 when the investment failed |
| Index Insured (*T1*) | Whether the partner's (Person 1) investment was protected by an indexed cover (dummy) |
| Indemnity Insured (*T3*) | Whether the partner's (Person 1) investment was protected by an indemnity cover (dummy) |
| Good Weather | Weather conditions under which sharing decision was taken (1=Good) (dummy) |
| Gender (male) | Participant is male (dummy) |
| Age | Participant's age |
| Married | Whether participant was married |
| Household size | Number of members of the participant's household |
| Years of Education | Participant's years of formal education |
| Bagisu Tribe | Whether participant's belongs to the Bagisu tribe |
| Protestant | Whether the participant professes some form of Protestantism |
| Land Holdings | Number of acres owned by the household |
| Wealth Index | First principal component in a principal component analysis (PCA) of the HH's assets $^{\psi}$ |
| Participant's Risk Preferences | Hypothetical willingness to invest (1 least risk averse to 6 most averse) |
| Knowledge of Insurance | More than half of the answers correct in a test about insurance |
| Experience with Shocks | Having suffered a serious income shock which lead to a reduction in total and food consumption |
| Enumerator Team 2 | Session where decision was taken was led by second team of enumerators |

$^{\psi}$ Our overall measure of wealth is calculated through principal components analysis (PCA) of a comprehensive list of household assets reported by the participants in the study. Details can be found in Pérez-Viana (2019a), who employs the same methodology to construct the measure of wealth.

## V.3 *What is the Effect of Insurance and Risk Sharing on Investment?*

We begin the analytical part of the paper by addressing the main question that motivated our enquiry. In search for an answer, we evaluate the main predictions of the theoretical framework about the positive influence that both insurance and risk sharing are expected to wield on investment.

### V.3.1 Comparative Analysis

Prior to presenting the empirical model and the specifications derived from it, let us look at how investment differs across treatments in the table of frequencies shown below:

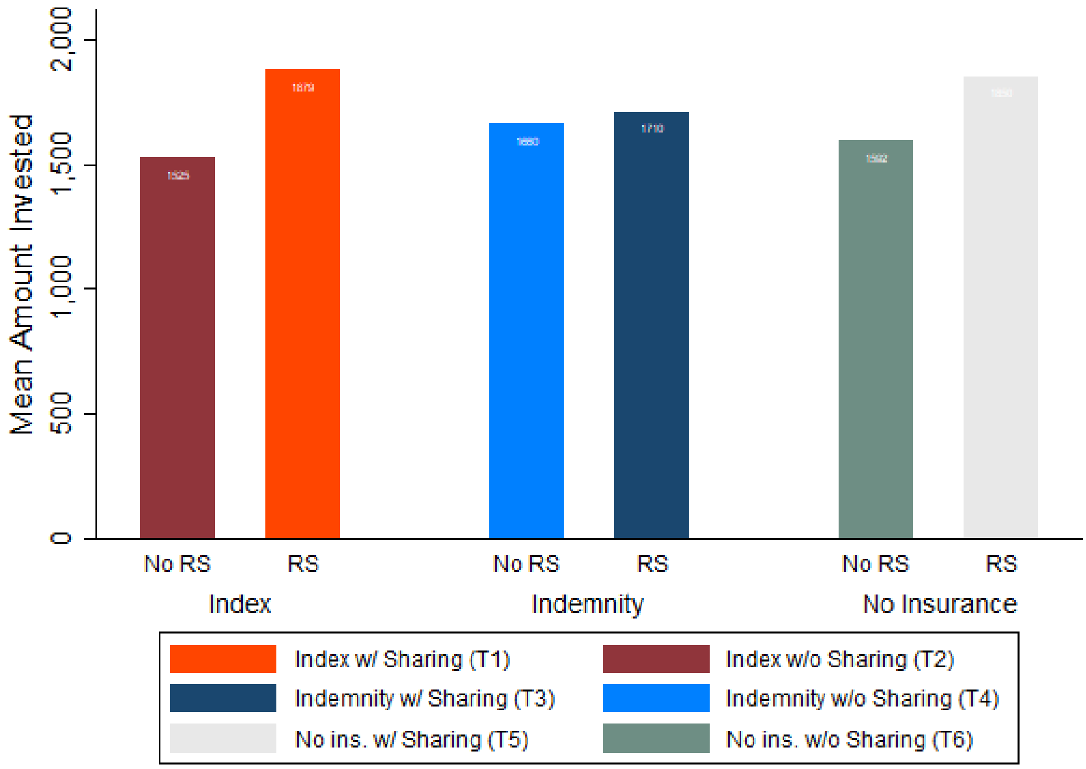
**Table II.13: Investment Frequencies**[Ψ]

| | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | Index Insurance | | Indemnity Insurance | | No Insurance | |
| Investment | w/ risk sharing (*T1*) | w/o risk sharing (*T2*) | w/ risk sharing (*T3*) | w/o risk sharing (*T4*) | w/ risk sharing (*T5*) | w/o risk sharing (*T6*) |
| 0 | 34<br>(34.34) | 39<br>(38.61) | 35<br>(35) | 36<br>(36) | 62<br>(31) | 66<br>(32.84) |
| 1000 | 23<br>(23.23) | 28<br>(27.72) | 27<br>(27) | 31<br>(31) | 53<br>(26.5) | 64<br>(31.84) |
| 2000 | 16<br>(16.16) | 10<br>(9.9) | 8<br>(8) | 9<br>(9) | 33<br>(16.5) | 30<br>(14.93) |
| 3000 | 5<br>(5.05) | 9<br>(8.91) | 10<br>(10) | 7<br>(7) | 12<br>(6) | 11<br>(5.47) |
| 4000 | 3<br>(3.03) | 4<br>(3.96) | 9<br>(9) | 2<br>(2) | 8<br>(4) | 7<br>(3.48) |
| 5000 | 4<br>(4.04) | 3<br>(2.97) | 4<br>(4) | 2<br>(2) | 9<br>(4.5) | 3<br>(1.49) |
| 6000 | 14<br>(14.14) | 8<br>(7.92) | 7<br>(7) | 13<br>(13) | 23<br>(11.5) | 20<br>(9.95) |
| Total | 99 | 101 | 100 | 100 | 200 | 201 |

[Ψ] Proportion of participants investing a specific amount in brackets for every treatment (column).

Overall, participants were cautious about taking risk in the experiment. More than a third did not invest at all, and the most common quantity invested was the lowest possible: 1,000 Shillings. It is hard to appreciate major differences across treatments in the table, as no clear pattern emerges. However, investment appears to be higher with risk sharing than without it within treatments with the same type of insurance status. We turn then to a more visual representation of the data in the form of bar charts of the average investment (Figure II.5).

**Figure II.5: Amount Invested by Treatment**




In the chart, we can see more clearly the fairly similar levels of investment across the different groups of treatments, organised by insurance status, but the distinct differences within the groups, which save for the indemnity case, range in the 300 Shillings (approximately 18% of the total average amount invested in the experiment, which was 1,706 Shillings). We next carry out pairwise comparisons to examine statistically the extent of the influence of risk sharing on the investment decision. It is worth noting that these comparisons are between subjects, despite being within insurance status groups, as different participants took part in the risk sharing treatments and in those where informal transfers were not permitted.

As we can see in Table II.14, the pairwise *t-tests* within insurance status treatments yield no significant differences in investment. Nevertheless, substantially larger amounts were invested when risk sharing was available and the investor was index or not insured; to the extent, that a one-tailed right test is significant at the 10% level in the latter case.

Bearing in mind that the main motivation for our enquiry is to study the influence of formal insurance on investment, let us carry out pairwise tests comparing the investment levels with and without insurance under similar circumstances of informal support (Table II.15).

**Table II.14: Risk Sharing Comparisons: Two-sided t-tests**

| | Index Insurance | | Between Diff. | Indemnity Insurance | | Between Diff. | No Insurance | | Between Diff. |
|---|---|---|---|---|---|---|---|---|---|
| Treatment | *T1* (w/ Risk Sharing) | *T2* (w/o Risk Sharing) | (*T1*-*T2*) | *T3* (w/ Risk Sharing) | *T4* (w/o Risk Sharing) | (*T3*-*T4*) | *T5* (w/ Risk Sharing) | *T6* (w/o Risk Sharing) | (*T5*-*T6*) |
| Amount Invested | 1879 | 1525 | 354 | 1710 | 1660 | 50 | 1850 | 1592 | $258^{*\phi}$ |
| | (211.6) | (183.8) | (140) | (188.7) | (202.1) | (137.9) | (140.9) | (130.1) | (191.7) |
| N | 99 | 101 | 200 | 100 | 100 | 200 | 200 | 201 | 401 |

Standard errors in parenthesis, t-test p-values: $^{*}\ p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

$^{\phi}$ Significant difference only in one-tailed t-test.

**Table II.15: Insurance Comparisons: Two-sided t-tests**

| | Risk Sharing | | | No Risk Sharing | | |
|---|---|---|---|---|---|---|
| Comparisons | Within Diff. *T1* - *T5* (Index Ins.) (No Ins.) | Within Diff. *T3* - *T5* (Indem. Ins.) (No Ins.) | Between Diff.$^{\psi}$ (Risk Sharing) | Within Diff. *T2* - *T6* (Index Ins.) (No Ins.) | Within Diff. *T4* - *T6* (Indem. Ins.) (No Ins.) | Between Diff.$^{\varphi}$ (No Risk Sharing) |
| Amount Invested | -10.1 | -110 | 99.89 | -138.6 | 140 | -278.6$^{*\phi}$ |
| | (176.1) | (143.5) | (227) | (141.4) | (137.8) | (197.5) |
| N | 99 | 100 | 199 | 101 | 100 | 201 |

Standard errors in parenthesis, t-test p-values: $^{*}$ $p < 0.1$, $^{**}p < 0.05$,$^{***}$ $p < 0.01$

$^{\psi}$ Between subject difference resulting from comparing the mean of (*T1*-*T5*) to that of (*T3*-*T5*) [i.e. estimate of (*T1*-*T5*)-(*T3*-*T5*)].

$^{\varphi}$ Between subject difference resulting from comparing the mean of (*T2*-*T6*) to that of (*T4*-*T6*) [i.e. estimate of (*T2*-*T6*)-(*T4*-*T6*)].

$^{\phi}$ Significant difference only in one-tailed t-test.

From what we observe in these results, insurance fails to wield any discernible influence on investment, and, in some cases, it even leads to lower risk taking on average, although not significantly so in statistical terms. Interestingly, when risk sharing is not possible, investors protected by a compliant cover commit significantly higher resources than those who are indexed insured.

Overall, these are a puzzling results which call for further scrutiny, a task addressed in the econometric analysis that follows.

### V.3.2 Regression Analysis

The use of the regression methodology allows us to control for other factors that may influence investment decisions other than the exogenous elements we vary, and to maximise the statistical power of our tests by employing all our available data.

We deploy a series of empirical regression models to address the titular question of this subsection—regarding the influence of insurance and risk sharing on investment—which share the following common linear structure:

$$y_i = \boldsymbol{X_i}\boldsymbol{\beta} + u_i \tag{31}$$

where $\boldsymbol{X_i}$ includes the key explanatory variables and the control variables.

The linearity assumption is supported by the continuous nature of the investment decision and the randomisation embedded in the design.

Throughout the various specifications, our first empirical model tests whether being insured and having the chance to receive transfers from the partner affect the level of investment. To this effect, we construct the variables *Insured* (a binary indicator of whether the subject's investment was insured) and *Risk Sharing* (dummy denoting whether assistance was allowed), and estimate a series of specifications in Table II.16, based on the following empirical model:

$$Inv_{ij} = \alpha + \beta_1 Insured_{ij} + \beta_2 Index_{ij} + \gamma Risk\ Sharing_{ij} + \delta X_{ij} + \eta_j + u_{ij} \tag{32}$$

$Inv_{ij}$ represents the amount invested by participant $i$, our unit of observation; a decision taken twice by each participant—under different circumstances—during the experiment. $X_{ij}$ includes all the control variables (gender, education, age, wealth, risk preferences, knowledge of insurance and enumerator team dummies) and $\eta_j$ are location (*i.e.* village) dummies. $Index_{ij}$ specifies that the type of cover protecting the investor is of the indexed kind.

The model is estimated in sequence across the specifications, incorporating each of the key elements one at a time, so as to observe how their influence changes depending on the factors controlled for. Specification (1) features only the $Insured$ status, to this (2) adds the controls $X_{ij}$. Models (3) and (4) incorporate the variable $Index_{ij}$, with and without controls, respectively. In contrast, the only variable in specification (5) is whether risk sharing is available, to which controls are added in the model displayed in column (6). The process culminates in the final specification, which estimates the model laid down in eq.(32).

Throughout the analysis, we implement a clustered estimator of the variance-covariance matrix, robust to the correlation of the errors within experimental sessions.

**Table II.16: OLS Regressions: Investment$^{\Psi}$**

| **Specification** | **(1)** | **(2)$^{\psi}$** | **(3)** | **(4)$^{\psi}$** | **(5)** | **(6)$^{\psi}$** | **(7)$^{\psi}$** |
|---|---|---|---|---|---|---|---|
| **Variable** | **Amount Invested** | | | | | | |
| Insured | -31.26 | -35.6 | -53.4 | -15.55 | | | -14.64 |
| (1=Yes, 0=No) | (82.13) | (167.2) | (173.6) | | | | (103.6) |
| Type of insurance: Index | | | 43.72 | -39.5 | | | -40.73 |
| (1=Yes, 0=No) | | | (290.1) | (145.1) | | | (141.5) |
| Risk Sharing | | | | | 215.8 | 214 | 214 |
| (1=Yes, 0=No) | | | | | (252.3) | (130.1) | (130.3) |
| Gender | | 602*** | | 604.2*** | | 616.2*** | 618.5*** |
| (1=Male) | | (192.46) | | (189.4) | | (195) | (192.9) |
| Age | | 4.997 | | 5.041 | | 5.064 | 5.109 |
| | | (6.107) | | (6.085) | | (6.04) | (6.057) |
| Years of Education | | 26.98 | | 27.12 | | 29.02 | 29.17 |
| | | (28.95) | | (29) | | (28.93) | (29.02) |
| Wealth Index | | 58.36 | | 58.23 | | 56.42 | 56.29 |
| | | 54.57 | | (54.14) | | (54.9) | (54.91) |
| Enumerator Team 2 | | 278.1** | | 278.4** | | 280.2** | 280.5** |
| | | (124.5) | | (124.9) | | (120) | 120.3 |
| Participant's Risk Preferences | | -86.61* | | -86.63* | | -82.18* | -82.22* |
| | | (44.97) | | (45.07) | | (46.13) | (46.23) |
| Knowledge of Insurance | | -210.83 | | -210.52 | | -235.17 | -234.9 |
| | | (226) | | (226.1) | | (223.2) | (223.5) |
| Constant | 1713*** | -81.39 | 1713*** | -83.93 | 1589*** | -222.4 | -209.1 |
| | (121.6) | (473.4) | (121.7) | (466) | (176.2) | (447.5) | (461.4) |
| **N** | **787** | **787** | **787** | **787** | **801** | **787** | **787** |

Robust standard errors in parenthesis, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

$^{\Psi}$ Details of the variables can be found in Table II.12.

$^{\psi}$ Village dummies included in this specification.

The regression analysis of the pooled investment decision (Table II.16) does not alter the general picture provided by the comparative analysis, namely that, overall, neither formal insurance nor informal risk sharing exert any meaningful influence on investment. Both the coefficients for the construes representing being insured and having access to the partner's help are not significantly different from zero. Yet, in our preferred specification the positive effect of being able to receive assistance is close to the 10% threshold.

There are some other noteworthy findings as well. For example, men tend to invest much more heavily than women, and those who are less risk averse, as measured by the hypothetical indicator, do invest significantly more. Both results are in line with expectations, as it is well-established that higher risk aversion deters investment (Vargas Hill, 2009; Liu, 2013; Pérez-Viana, 2019a), and a number of studies have found that men are less averse to financial risk than women (Binswanger, 1980; Tanaka et al., 2010).

We also find that the implementation team had a bearing on the amount invested, and that a large number of location (village) dummies are highly significant, indicating that the investment behaviour was very much determined by the origin of the subjects.

Notwithstanding these results, the differences in investment within insurance status due to risk sharing observed earlier in the comparative (Tables II.14 and II.15) and visual (Figure II.5) parts of the analysis, and the sizeable positive effect of informal transfers on investment (seen in Table II.16) invite us to dig deeper.

In order to fulfil this goal, we utilise the treatments in the experiment as our key explanatory variables, which denote the different combinations of insurance status and risk sharing technology under which subjects could invest (shown in the treatment matrix of Table II.3).

In what follows, we employ both the pooled sample of investment decisions as well as subsamples defined by insurance status; however, all specifications share the following common structure:

$$Inv_{ijk} = \alpha + \beta Treatment_k + \delta X_{ij} + \eta_j + u_{ijk} \tag{33}$$

where $Treatment_k$ represents the treatment conditions under which the investment decision was taken.

Different samples are used throughout the specifications in Table II.17. The first two utilise the pooled data with all the investment decisions as before. In contrast, specifications (3) and (4) restrict the observations to those investment decisions taken when index insurance was the mandatory cover. Likewise, (5) and (6) employ a sub-sample of the amount invested under the protection of the indemnity cover exclusively. Finally, the last two specifications estimates the model with the decisions made when no insurance was available.

## Table II.17: OLS Regressions: Investment (Treatments)$^{\Psi}$

| Specification | (1) | (2)$^{\psi}$ | (3) | (4)$^{\psi}$ | (5) | (6)$^{\psi}$ | (7) | (8)$^{\psi}$ |
|---|---|---|---|---|---|---|---|---|
| **Variable** | | | | **Amount Invested** | | | | |
| Index w/ sharing (*T1*) | 287 | 257.36 | 348.8 | 337.7* | | | | |
| (1=Yes, 0=No) | (300.4) | (154.15) | (383.2) | (165.8) | | | | |
| Index w/o sharing (*T2*) | -61.84 | -122.25 | | | | | | |
| (1=Yes, 0=No) | (254) | (184.9) | | | | | | |
| Indem. w/ sharing (*T3*) | 81.63 | 99.26 | | | 27.64 | -23.11 | | |
| (1=Yes, 0=No) | (332.9) | (186) | | | (439.1) | (203.5) | | |
| Indem. w/o sharing (*T4*) | 54 | 116.9 | | | | | | |
| (1=Yes, 0=No) | (243.2) | (157.7) | | | | | | |
| No ins. w/ sharing (*T5*) | 241.5 | 243.9 | | | | | 241.5 | 221.1 |
| (1=Yes, 0=No) | (241) | (155.5) | | | | | (240.5) | (143.7) |
| Gender | | 615.4*** | | 662.7*** | | 621.3 | | 561.4** |
| (1=Male) | | (193.4) | | (206.3) | | (364.4) | | (222.3) |
| Age | | 5.155 | | 16.92* | | -5.592** | | 4.916 |
| | | (6.058) | | (9.398) | | (8.72) | | (7.038) |
| Years of Education | | 30.33 | | -25.7 | | 96.93 | 14.98 | |
| | | (29.14) | | (56.3) | | (42.52) | (29.92) | |
| Wealth Index | | 55.63 | | 36.13 | | 56.5 | | 68.26 |
| | | (54.49) | | (62.78) | | (99.69) | | (56.91) |
| Enumerator Team 2 | | 279.4** | | -1490 | | 264 | | 141.6 |
| | | (119.2) | | (1110) | | (240.5) | | (134.8) |
| Participant's Risk Preferences | | -84.66* | | -55.03 | | -112.6 | | -105.3* |
| | | (46.31) | | (58.82) | | (84.39) | | (52.6) |
| Knowledge of Insurance | | -245.3 | | -64.24 | | -623.7 | | -128.17 |
| | | (224.7) | | (287.2) | | (394.2) | | (255.6) |
| Constant | 1592*** | -215.82 | 1530*** | 706.7 | 1646*** | 376 | 1592*** | 117.6 |
| | (160.2) | (467.34) | (284) | (1212) | (325) | (668.4) | (159.9) | (560) |
| **Reference** | **No ins. w/o sharing (*T6*)** | **No ins. w/o sharing (*T6*)** | **Index w/o sharing (*T2*)** | **Index w/o sharing (*T2*)** | **Indem. w/o sharing (*T4*)** | **Indem. w/o sharing (*T4*)** | **No ins. w/o sharing (*T6*)** | **No ins. w/o sharing (*T6*)** |
| N | **787** | **787** | **199** | **199** | **194** | **194** | **394** | **394** |

Robust standard errors in parenthesis, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

$^{\Psi}$ Details of the variables can be found in Table II.12.

$^{\psi}$ Village dummies effects included in this specification.

When examining investment under similar insurance conditions in the subsamples, different patterns emerge from those in the analysis conducted in Table II.16, echoing what we observed earlier in the descriptives. Specifically, that risk sharing is shown to foster investment among those who are index insured (column [4] above), as indicated by the significantly higher amount invested in the first treatment with risk sharing. The effect identified is economically large (over 300 Shillings) given the low levels of investment registered in the experiment, which set the global median value at just one thousand.

An equally positive difference due to transfers is observed between investors without access to insurance (columns [7, 8]), yet it is not statistically significant.

In spite of these findings, the overall conclusion about the lack of relevance of being insured and being able to receive informal assistance still holds, as the lack of significant results in the pooled sample bears witness. However, this is not a general rule, as risk sharing does make a difference for investment by those who are index insured.

Men continue to prove much more willing to take risk than women, and higher risk aversion still bogs investment down. The impactful role of the implementation team in the decision to invest appears to stem solely from its influence in the indemnity treatments, as it does not seem to matter in the analysis conducted with the other subsamples.

**Result 1.** *Being insured does not influence investment decisions.*

**Result 2.** *Risk sharing appears to increase investment, yet only when the investor is index or not insured.*

## V.4 *What is the Effect of Insurance on Risk Sharing towards Risk Takers?*

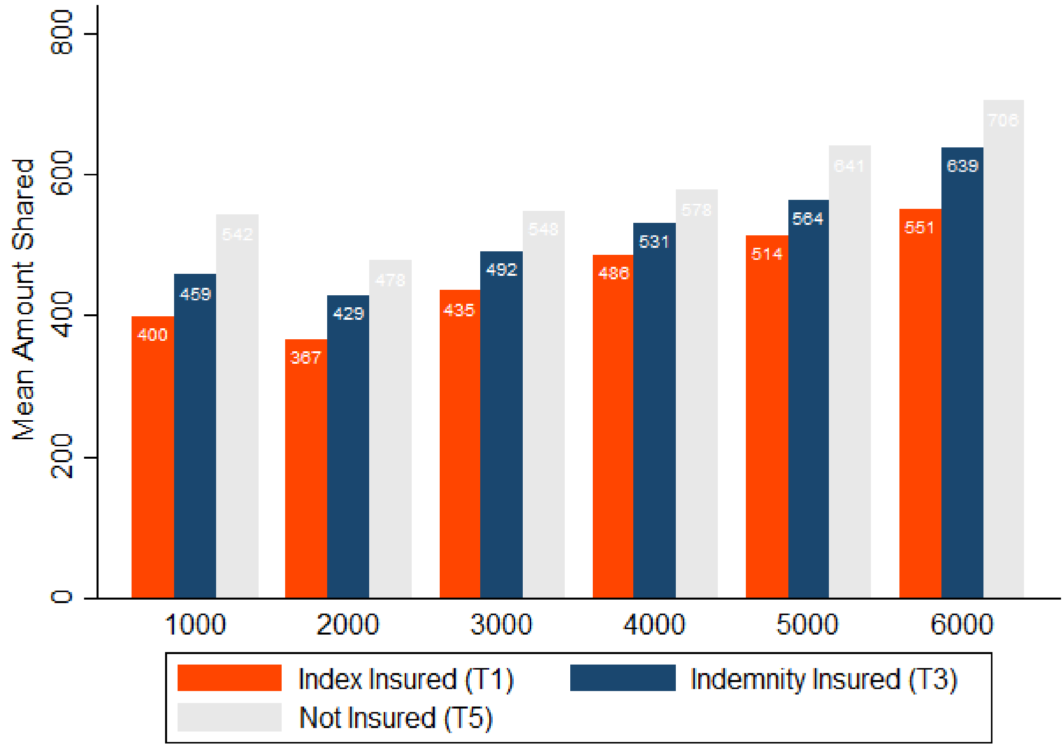
We now turn to the study of how informal support towards the investors is affected by their insurance status.

In this analysis we employ the amount Person 2 decided to transfer to the investor (Person 1) as the dependent variable. The helping partner could transfer any amount of her endowment she wished, from zero up to the full amount (8,000 Shillings), regardless of the losses experienced by Person 1 if the investment failed. As noted when describing the design, sharing decisions were elicited through a strategy method, by which Person 2 determined how much of the investor's losses to compensate for every possible level of investment the latter could choose (1,000 to 6,000 Shillings, in increments of 1,000). As a result of this procedure, the number of decisions recorded by treatment varies depending on the amount invested by Person 1 and the type of insurance that protected her investment.[34]

### V.4.1 Comparative Analysis

As before, we start with the visual representation of the data. Below is the distribution of risk sharing, under the three insurance conditions, by amount invested:

**Figure II.6: Amount Shared by Treatment**




The trend described by the sharing data is increasing in the amount invested, an event that made the losses sustained by the partner (Person 1) larger when the investment failed. In addition, visible differences in the amount shared can be seen in the figure, all following the same pattern: risk sharing is higher towards those who are indemnity rather than index insured, but the volume of transfers is larger towards uninsured investors, who benefit from the highest levels of generosity. Despite the apparent positive gap in informal assistance within insured investors, pairwise tests yield no significant average differences at any investment level.

Of great interest are the pairwise comparisons in transfers received by those insured as opposed to not so, which are larger in magnitude and interesting conceptually. In

[34] In *T5* Person 2 takes six sharing decisions, one for every amount Person 1 can invest. The sharing choices remain the same in *T3*, however, they increase to twelve under index insurance *T1*, due to the duplication of the number of investment outcomes as a result of the conditional performance of the indexed security depending on the weather, by which payouts are disbursed with bad weather but not under favourable conditions.

contrast to the previous three-way comparisons which pooled all the sharing data, we focus here on pairwise comparisons within subjects. This is explained by the fact that, in every game where sharing was allowed, Persons 2 were partnered to an unprotected investor at first, and, in the second part, to an (index or indemnity) insured partner in the games they participated. On account of these design features, we proceed to carry out the tests separately with the samples for the appropriate games (1A, in the case of the 'index subsample', and, 2C, for the 'indemnity' one) and obtain the following results, presented graphically below (stars denote significance levels of pairwise *t-tests*: $^{*}\,p < 0.1$, $^{**}p < 0.05$,$^{***}\,p < 0.01$).

**Figure II.7: Amount Shared (Index vs No Insurance) [Game 1A]**

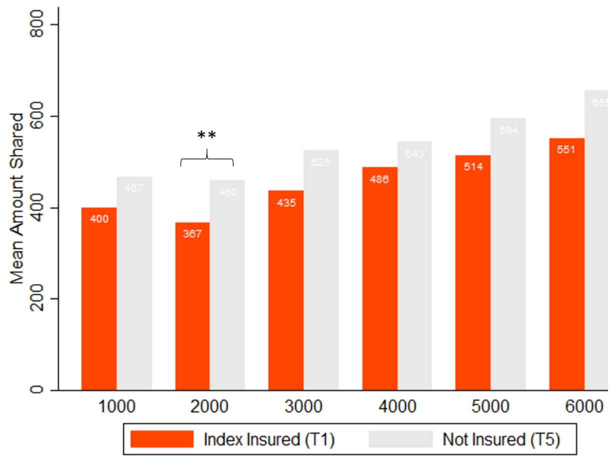
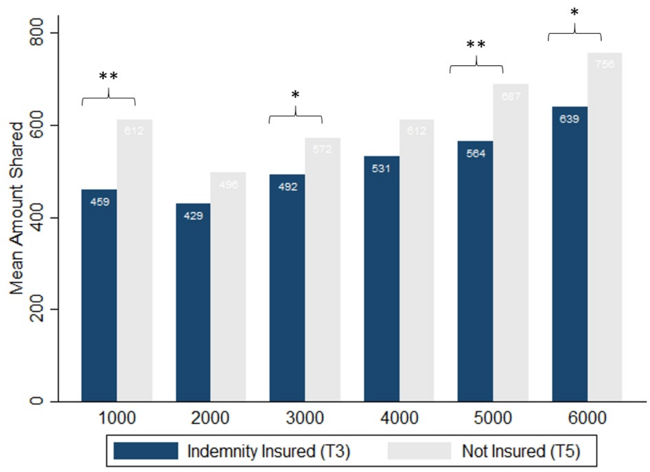



**Figure II.8: Amount Shared (Indem. vs No Ins. [Game 2C]**




Sizeable differences in transfers received can be observed especially towards those not insured with respect to investors protected by an indemnity cover, with four of the differences in average amounts shared—out of the six possible levels of investment—being statistically significant.

### V.4.2 Regression Analysis

In order to carry out more rigorous testing of the patterns hinted above, we deploy several empirical regression models with the following common linear structure:

$$y_i = \boldsymbol{X_i \beta} + u_i \tag{34}$$

where $\boldsymbol{X_i}$ includes the key explanatory variables and the control variables.

We begin investigating the impact that the partner being insured exercises on the amount transferred by Person 2. Table II.18 below presents multiple specifications in which the key explanatory variable is insurance status.

In the first, insurance status is embodied by a dummy for whether Person 1 is insured or not ($Insured$), regardless of the specific form of insurance. Then, we add another bivariate term ($Index$) to distinguish the type of cover as indexed or not (column [2]). Specification (3) includes the losses sustained by Person 1 as a result of the failed investment. The last specification interacts the losses with the two insurance indicators and controls for the weather conditions and several other factors to avoid them confounding the impact of insurance status. This latter empirical model takes the following form:

$$Amount\ Shared_{ij} = \alpha + \beta_1 Insured_{ij} + \beta_2 Index_{ij} + \gamma Losses + \tau Insured_{ij} \text{ x } Losses + \varphi Index_{ij} \text{ x } Losses + \delta X_{ij} + \eta_j + u_{ij} \tag{35}$$

where $Amount\ Shared_{ij}$ is the amount shared by participant $i$, acting as Person 2, with the investor in the event of a failed investment. A decision taken multiple times by each participant, depending on the features of the treatment, as described earlier. The subscript $j$ indicates the village the participant hails from, whose effects are controlled by the term $\eta_j$.

Same as before, we implement a clustered estimator of the variance-covariance matrix that is robust to the correlation of the errors within experimental sessions.

**Table II.18: OLS Regression: Sharing Decision**[Ψ]

| **Specification** | **(1)** | **(2)** | **(3)** | **(4)**[ψ] |
|---|---|---|---|---|
| **Variable** | | **Amount Shared** | | |
| Insured | -104.6** | -75.71 | -45.23 | -71.59 |
| (1=Yes, 0=No) | (41.47) | (67.73) | (69.34) | (65.21) |
| Type of Insurance: Index | | -43.2 | -73.8 | -56.66 |
| (1=Yes, 0=No) | | (117.6) | (119) | (95.13) |
| Partner's Losses | | | 0.035*** | 0.037*** |
| | | | (0.008) | (0.007) |
| Insured x Losses | | | | 0.016 |
| | | | | (0.021) |
| Index Insured x Losses | | | | -0.02 |
| | | | | (0.029) |
| Good Weather | | | | -24.13 |
| | | | | (44.86) |
| Gender | | | | 194.1* |
| (1=Male) | | | | (94.79) |
| Age | | | | 0.641 |
| | | | | (3.827) |
| Years of Education | | | | -6.861 |
| | | | | (19.42) |
| Wealth Index | | | | 1.946 |
| | | | | (11.04) |
| Enumerator Team 2 | | | | 100.8** |
| | | | | (46.37) |
| Participant's Risk Preferences | | | | 4.786 |
| | | | | (32.03) |
| Knowledge of Insurance | | | | -6.067 |
| | | | | (108.1) |
| Constant | 577.9*** | 582.2*** | 456*** | -118.1 |
| | (73.77) | (74.64) | (67.65) | (143.2) |
| **N** | **2954** | **2954** | **2954** | **2954** |

Robust standard errors in parenthesis, * $p < 0.1$, **$p < 0.05$,*** $p < 0.01$

Ψ Details of the variables can be found in Table II.12.

ψ Village dummies included in this specification.

The results of the regressions above seem to indicate that being insured crowds out informal support when the investment fails, yet this effect is economically small and weak, to the point that in several specifications we cannot reject the null hypothesis that insurance status does not influence sharing.

By contrast, the extent of the investor losses drives transfers up very significantly, meaning that those who invest more receive higher total support when their investment fails; a trend already observed in Figures II.6 to II.8 and now confirmed statistically. Nevertheless, this effect is economically fairly small, for every 100 Shillings of additional losses, sharing increases just in three an a half monetary units.

Men are more generous than women when it comes to provide monetary assistance, and those who played the game in the first room tend to donate higher amounts.

Despite the faint effect of insurance status on the willingness to share the investor's losses, we could appreciate earlier some significant differences in transfers when comparing subsets of sharing decisions. For this reason, we continue with the analysis, now examining the decisions taken by the aiding partner under two distinct insurance status at a time. The first two specifications employ sharing decisions taken when Person 2 was indemnity or not insured; (3) and (4) are also estimated with transfers towards unprotected and insured investors, but the latter's protection comes from an indexed rather than an indemnity cover; finally, the last two regressions feature only sharing decisions in benefit of insured investors. The common empirical model for the three preferred specifications is:

$$AmountShared_{ijk} = \alpha + \beta InsuranceStatus_k + \tau InsuranceStatus_k \mathrm{x} Losses + \delta X_{ij} + \eta_j + u_{ijk} \tag{36}$$

where $Insurance\ Status_k$ represents the possibilities available described earlier. In order to ascertain whether the effect of higher losses on the partner's generosity changes depending on the type of insurance, we include an interaction term of both factors.

The subsample analysis in Table II.19 reveals more clearly the deterring influence that formal protection wields on risk sharing. Interestingly, the negative effect is almost double when the investor is indemnity insured, indicating that partners deem those protected in this manner less deserving of help. However, no significant differences in transfers received are found when all investors are insured, as shown by the last set of specifications (columns 5 and 6).

The enumerator team implementing the game appeared to have an important bearing in the sharing decision, although their influence fluctuates across the different subsamples, being positive in the first two specifications, negative in (3) and (4), and finally neutral.

## Table II.19: OLS Regressions: Sharing Decision (Subsamples)$^{\Psi}$

| Specification | (1) | (2)$^{\psi}$ | (3) | (4)$^{\psi}$ | (5) | (6)$^{\psi}$ |
|---|---|---|---|---|---|---|
| **Variable** | **Amount Shared** | | | | | |
| Indemnity Insured (*T3*) | -112.6** | -126.1** | | | | |
| (1=Yes, 0=No) | (40.91) | (55.86) | | | | |
| Index Insured (*T1*) | | | -82.4 | -74.79** | -43.2 | -48.67 |
| (1=Yes, 0=No) | | | (59.85) | (32.38) | (117.6) | (94.81) |
| Partner's Losses | | 0.035** | | 0.038*** | | 0.052* |
| | | (0.012) | | (0.009) | | (0.025) |
| Indemnity Insured (*T3*) x Losses | | 0.017 | | | | |
| | | (0.016) | | | | |
| Index Insured (*T1*) x Losses | | | | -0.006 | | -0.02 |
| | | | | (0.012) | | (0.029) |
| Good Weather | | | | -24.35 | | -24.16 |
| | | | | (46.19) | | (45.04) |
| Gender | | 148.8 | | 190.2 | | 188.5* |
| (1=Male) | | (117.5) | | (144) | | (106.9) |
| Age | | -0.339 | | 0.766 | | -0.469 |
| | | (5.475) | | (5.714) | | (3.807) |
| Years of Education | | -1.122 | | -23.89 | | -10.62 |
| | | (24.33) | | (26.1) | | (21.17) |
| Wealth Index | | -5.591 | | 25.7 | | 9.521 |
| | | (21.78) | | (17.03) | | (12.48) |
| Enumerator Team 2 | | 657*** | | -508.1*** | | 62.18 |
| | | (87.2) | | (139.4) | | (55.16) |
| Participant's Risk Preferences | | 37.58 | | -9.24 | | -7.942 |
| | | (72.88) | | (40.4) | | (31.37) |
| Knowledge of Insurance | | -70.5 | | 80.32 | | 9.606 |
| | | (158.4) | | (145.2) | | (119.15) |
| Constant | 614.8*** | -187.3 | 541.4*** | 612.4** | 502.2*** | -38.05 |
| | (111) | (279.8) | (102.5) | (148.6) | (225.8) | (151.2) |
| **Reference** | **Not insured (*T5*)** | **Not insured (*T5*)** | **Not insured (*T5*)** | **Not insured (*T5*)** | **Ind. Insured (*T3*)** | **Ind. Insured (*T3*)** |
| **N** | **1176** | **1176** | **1778** | **1778** | **1772** | **1772** |

Robust standard errors in parenthesis, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

$^{\Psi}$ Details of the variables can be found in Table II.12.

$^{\psi}$ Village dummies included in this specification.

In light of the findings accumulated over the analysis of the risk sharing data we conclude the following.

**Result 3.** *Being insured crowds out informal risk sharing towards investors, especially, when the cover is of the indemnity type.*

# VI Discussion & Conclusion

The primary aim of this paper was to investigate the impact that formal insurance and risk sharing exert on investment in a controlled environment. A line of research pursued against a backdrop of insufficient evidence for the benefits of insurance in the context of agricultural investment (Dercon *et al.*, 2009; Cole *et al.*, 2012; Carter *et al.*, 2014; Cole and Xiong, 2017), and of the widespread reputation of informal risk sharing as a deterrent for investment (Platteau, 2009; Baland *et al.*, 2011; Di Falco and Bulte, 2011).

In the spirit of hypothetico-deductive method, our approach for addressing this enquiry begins by devising a theoretical framework that bears our key predictions. The model features an agent maximising utility by choosing the amount to invest in a risky input, which can result in higher wealth if the investment is successful, but also in the loss of the monetary resources invested in case it fails. Risk sharing was then incorporated to this basic setting, and it was shown to foster risk taking due to its capacity to mitigate the losses in the event of a failed investment. Next, the basic framework was modified to accommodate formal insurance. The protection of a cover that provides a payout when the investment is lost unequivocally encourages risk taking, yet the obligation of paying the premium results in an ambiguous overall effect. Nevertheless, it was shown that investment will be higher—in no uncertain terms—under a compliant insurance, provided the cover is fairly priced and the chances of investment failure are the same (or higher) as for success. This conclusion may not hold for the case of index insurance as, first, the benefits of insurance are diminished by the non-compliance of the cover and, second, its drawbacks become more acute, with the premium being payable despite making losses and receiving no compensation in one of the states of the world. However, informal transfers—which always have a positive effect on investment—can especially improve the appeal of index insurance, as they enable assistance in the worst state, when the cover fails to perform.

With our main hypotheses in place, we developed an empirical test to evaluate them, under the controlled conditions created by the experimental setting implemented. Our design enabled us to restrict the source of variation to our representation of the elements of interest in order to observe their impact on investment behaviour. The elements purposefully varied randomly were, first, the insurance status of the investor—who could be index, indemnity or not insured—and, second, her chance of receiving informal support, which was binary: either permissible or not.

It is important to note that however relevant the two factors under the experimenter control might be for the investment decision—as argued above and in the literature—they are but two aspects among the many that matter for the real-life decision recreated. As a result, the implications of the experimental findings are strictly circumscribed to the behaviour in response to the elements varied, all else equal.

We find that insurance—in any of its forms—is innocuous for investment; a surprising result given our theoretical predictions, but one that, regrettably, is in tune with a sizeable part of the literature. Studies like Giné and Yang (2009), Cole *et al.* (2017) or Cai *et al.* (2014) report little or no effect of formal coverage on risk-taking decisions; in the first study, investment was even higher for the option without insurance. Furthermore, some experimental studies like ours also fail to find any positive behavioural change as a result of introducing formal insurance (Brick and Visser, 2015; Munro, 2015). However, there are notable exceptions to this trend, namely, Karlan *et al.*'s (2014) seminal article, where the availability of insurance leads to higher investment levels than cash grants.

The presence of risk sharing revealed some interesting, albeit faint, patterns in our results. As predicted in the theoretical framework, risk sharing wields a positive influence on investment, in particular, when the investor is uninsured or protected by an indexed cover.[35] The latter finding is significant at conventional levels, and occurs despite the crowding out of informal transfers when the investor is insured (see Table II.17). The result cannot be understated, since, as is well-established in the literature, the presence of basis risk dilutes the benefits of insurance and exacerbates its drawbacks. In line with the theoretical point made earlier, risk sharing is shown to seemingly improve the appeal of the cover and lead to a significant increase in risk taking. It does so by mitigating the inflated losses in the worst state, offsetting, to a certain degree, the disadvantages brought about by the indexed nature of the cover. This benefit was apparent to investors in the experiment who increased the resources committed by an economically large amount—about 30% of the median investment; a rise in risk-taking with respect to the transfer-less scenario which appears to be prompted by the anticipated receipt of informal transfers.

Furthermore, the amount invested in the experiment when the investment was insured as opposed to unprotected was significantly higher for those indemnity rather than index insured in the scenarios characterised by no risk sharing (Table II.15). However, these differences vanish when informal transfers are allowed, indicating that the possibility of sharing losses improve the appeal of investing under the protection of an indexed cover.

[35] The first result arises from the comparative analysis (Table II.14 ), whereas the second was shown in Table II.17 of the econometric analysis.

Sandmo (1971) famously hypothesised that an increase in the riskiness of the returns to production activities reduces the scale of production, and therefore, a reduction of such risk should lead to increased production and risk taking. Yet for this consequence to take place, the tool employed to diminish uncertainty (*i.e.* the insurance product) must be capable of achieving it, and in a meaningful way too; only then the farmer would have an objective reason to change her investment portfolio. In addition, the farmer must trust that the cover will perform and that a payout will be disbursed when it is due. With all these elements in place, one can reasonably expect to observe a behavioural change towards higher risk taking.

In hindsight, our experimental design probably failed to capture at least one of these aspects, as the insurance on offer did not make a meaningful difference across states of the world, nor with respect to the treatments where it was absent. Even though the cover compensated a quarter of the losses (once its cost was factored in), its presence accrued to minimal differences in comparison to investing without protection at the lowest—but most common—levels of investment, with just about a 5% average change in earnings. The situation changed considerably at higher levels of investment, where differences ranged between 25% and 75% of the earnings, yet few participants opted for investing that much. Moreover, insurance in its best performing version reduced variability, measured by the standard deviation of the prospect, 20% across the board, which at low investment levels represented a meagre 7% of the original endowment on average, and in general, it meant that earnings still fluctuated significantly throughout the different states.[36] All these factors weakening the appeal of insurance, especially for prudent investors not taking much risk, were coupled with the low levels of investment recorded in the experiment, where around 75% of participants invested 2,000 Shillings or less, and not investing was the preferred option. Judging by this degree of caution, we can deduce that the investment prospect offering a return of 150% was not sufficiently attractive given the high risk of investment failure, which was as likely as succeeding with the investment. The healthy level of investment reported by D'Exelle and Verschoor (2015) in a similar experiment, averaging just below 4,000 Shillings overall, gives credence to this conjecture. In their game, participants had similar choices, although the return to the amount invested was only double, yet the likelihood of a successful investment was 4 out of 5 chances instead of a 50-50 split, like in our case. The latter feature appears crucial for explaining the cautious stance of investors.

The present paper also investigates the response of informal risk sharing to the decisions of investors under different insurance arrangements.

[36] See Tables II.7 and II.8 displaying the experimental payoffs for contextual information about these calculations. For example, to measure the change in earnings at the maximum level of investment, 6,000 Shillings, we take the difference in earnings, between the scenarios with and without insurance in case of investment failure (3,500-2,000=1,500), and divide it by the earnings the investor obtains when not insured ($1,500/2,000 = 0.75$).

Of key import, when formal insurance is introduced where previously only informal arrangements existed, is the change over risk exposure experienced by the beneficiaries, and how it can affect their standing as recipients of informal assistance. Cettolin and Tausch (2015) hypothesise that individuals exposed to arbitrary risk can be seen as more deserving of help than those in control of their own exposure; their results, and those of Lenel and Steiner (2017) show that indeed the degree of control has some bearing over sharing decisions. Insurance, precisely, allows individuals to reduce their exposure to risk and may alter the partners' perceptions about who is deserving of help. Yet the sensitivity of risk sharing will also depend on the actual ability of the product to control risk exposure. This feature differs between indemnity and index insurance, with the former being the more effective of the two due to the absence of basis risk, and therefore, more capable of controlling the level of risk.

Interestingly, deciding about the degree of exposure to risk is inherent to the act of investing. Consequently, even though benefactors might be more sympathetic towards individuals facing a prospect with a higher variance, committing substantial resources to a volatile investment can be penalised with the withdrawal of assistance. Nevertheless, in a society characterised by risky investment and accustomed to sharing risk, this perception might be diluted, and only arise in levels of risk taking above the social norm.

Our results appear to back this conjecture, as we find that informal transfers are the highest towards uninsured investors, facing the most volatile prospect, and that the level of assistance falls when the partner is insured. Furthermore, the extent of the crowding out almost doubles if the partner is protected by a cover that performs well (*i.e.* of the indemnity type). In sum, the more volatile the investment prospect is, the higher the level risk sharing. However, even though sharing increases with losses and the amount invested, the proportion of losses shared decreases sharply at higher levels of investment.[37]

In sum, like a considerable part of the literature (Dercon *et al.*, 2009; Cole *et al.*, 2012; Carter *et al.*, 2014; Cole and Xiong, 2017), our study fails to find any significant benefits from introducing insurance when it previously did not exist. This finding is explained by the lack of meaningful impact that the availability of formal coverage involved for the investment decision under investigation; an issue that might also be afflicting many of the insurance products that have recently being marketed in developing countries, as the evidence of their positive impact on investment remains scarce.[38] Insurance, in any of its forms, failed to become a useful instrument for risk management, which beneficiaries

[37] For example, whereas transfers towards uninsured investor extend to 60% of the losses when they unsuccessfully invest 1,000 Shillings, those committing the maximum (6,000) receive assistance for less than 13% of the amount lost.

[38] Karlan *et al.* (2014) is the most notable exception rigorously measured, reporting an increase of 13% in investment for insured farmers, who purchase coverage for over 60% of their cultivated acreage when insurance is fairly priced. A rare example, not only because of the welfare gains recorded, but also due to the large proportion of the cultivated land protected, which is typically fairly low for newly set up programmes (Cole *et al.*, 2013).

could rely upon, a prerequisite to bring about change in farmers' investment behaviour. In addition, we learned that risk sharing can be a force for good, fostering investment, in particular, when formal protection is fallible. A finding that underscores the importance of taking pre-existing risk sharing arrangements into account in any initiative to introduce formal coverage in rural areas of developing countries. The more so, considering that the interaction between demand for formal insurance and the adjustment of risk sharing will determine the final effective protection against negative shocks (Pérez-Viana, 2019b), which is of paramount importance to determine the investment response of any such intervention.

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# Appendix A: Kuhn-Tucker Conditions

## A.1 Basic Model

$$\text{Max } EU(x) = \pi u[Y + (r-1)x] + (1-\pi)u[Y - x] \quad \text{s.t.}$$
$$0 \leq x$$
$$0 \leq Y - x$$
$$L(x, \lambda_1) = \pi u[Y + (r-1)x] + (1-\pi)u[Y - x] + \lambda_1[Y - x]$$

(1) $x \geq 0$

(2) $\dfrac{\partial L}{\partial x} = L_x = \pi(r-1)u'[Y + (r-1)x] - (1-\pi)u'[Y - x] - \lambda_1 \leq 0$

(3) $xL_x = 0$

(4) $\lambda_1 \geq 0$

(5) $\dfrac{\partial L}{\partial \lambda_1} = L_{\lambda_1} = Y - x \geq 0$

(6) $\lambda_1 L_{\lambda_1} = 0$

## A.2 Model with Risk Sharing

$$\text{Max } EU(x) = \pi u[Y + (r-1)x] + (1-\pi)u[Y - (1-l)x] \quad \text{s.t.}$$
$$0 \leq x$$
$$0 \leq Y - x$$
$$L(x, \lambda_1) = \pi u[Y + (r-1)x] + (1-\pi)u[Y - (1-l)x] + \lambda_1[Y - x]$$

(1) $x \geq 0$

(2) $\dfrac{\partial L}{\partial x} = L_x = \pi(r-1)u'[Y + (r-1)x] - (1-\pi)(1-l)u'[Y - (1-l)x] - \lambda_1 \leq 0$

(3) $xL_x = 0$

(4) $\lambda_1 \geq 0$

(5) $\dfrac{\partial L}{\partial \lambda_1} = L_{\lambda_1} = Y - x \geq 0$

(6) $\lambda_1 L_{\lambda_1} = 0$

## A.3 Model with Insurance

$$\text{Max } EU(x) = \pi u[Y + (r - p - 1)x] + (1 - \pi)u[Y - (1 + p - \alpha)x] \quad \text{s.t.}$$
$$0 \leq x$$
$$0 \leq Y - (1 + p)x$$
$$L(x, \lambda_1) = \pi u[Y + (r - p - 1)x] + (1 - \pi)u[Y - (1 + p - \alpha)x] + \lambda_1[Y - (1 + p)x]$$

(1) $x \geq 0$

(2) $\frac{\partial L}{\partial x} = L_x = \pi(r - p - 1)u'[Y + (r - p - 1)x] - (1 - \pi)(1 + p - \alpha)u'[Y - (1 + p - \alpha)x]$
$- (1 + p)\lambda_1 \leq 0$

(3) $xL_x = 0$

(4) $\lambda_1 \geq 0$

(5) $\frac{\partial L}{\partial \lambda_1} = L_{\lambda_1} = Y - (1 + p)x \geq 0$

(6) $\lambda_1 L_{\lambda_1} = 0$

## A.4 Model with Non-compliant Insurance

$$
\begin{aligned}
\text{Max } EU(x) =& q\{\pi u[Y + (r-1)x + (\alpha - p)x] + (1-\pi)u[Y - (1+p-\alpha)x]\} \\
&+ (1-q)\{\pi u[Y + (r-p-1)x] + (1-\pi)u[Y - (1+p)x]\} \quad \text{s.t.} \\
&0 \leq x \\
&0 \leq Y - (1+p)x
\end{aligned}
$$

$$
\begin{aligned}
L(x, \lambda_1) =& q\{\pi u[Y + (r-1)x + (\alpha - p)x] + (1-\pi)u[Y - (1+p-\alpha)x]\} \\
&+ (1-q)\{\pi u[Y + (r-p-1)x] + (1-\pi)u[Y - (1+p)x]\} + \lambda_1[Y - (1+p)x]
\end{aligned}
$$

(1) $x \geq 0$

(2)
$$
\begin{aligned}
\frac{\partial L}{\partial x} = L_x = \; & q\Big\{\pi(r-p-1+\alpha)u'[Y + (r-p-1+\alpha)x^*_{ix}] \\
& - \; (1-\pi)(1+p-\alpha)u'[Y - (1+p-\alpha)x^*_{ix}]\Big\} \\
& + \; (1-q)\Big\{\pi(r-p-1)u'[Y + (r-p-1)x^*_{ix}] \\
& - \; (1-\pi)(1+p)u'[Y - (1+p)x^*_{ix}]\Big\} \\
& - (1+p)\lambda_1 \leq 0
\end{aligned}
$$

(3) $xL_x = 0$

(4) $\lambda_1 \geq 0$

(5) $\dfrac{\partial L}{\partial \lambda_1} = L_{\lambda_1} = Y - (1+p)x \geq 0$

(6) $\lambda_1 L_{\lambda_1} = 0$

# Appendix B: Proof Investment under Insurance

We begin the proof that investment is higher under a compliant insurance with equation (13), which we used to compare the outcomes with and without insurance, in case of both investment success and failure, in order to understand the investment response to insurance.

$$\Phi(x^*_{im}) = \pi\big\{(r-1)u'[Y+(r-1)x^*_{im}] \;-\; (r-p-1)u'[Y+(r-p-1)x^*_{im}]\big\} \\ +\;(1-\pi)\big\{(1+p-\alpha)u'[Y-(1+p-\alpha)x^*_{im}] \;-\; u'[Y-x^*_{im}]\big\} \quad \text{(B1)}$$

As with the other versions of the model, if we can show that $\Phi(x^*_{im}) < 0$, it must be that $x^* < x^*_{im}$, which means that investment is higher when protected against failure.

From the logical derivations in section III.3, we concluded that the sign of eq.(13, B1) was ambiguous. However, under certain conditions, it can be shown that $\Phi(x^*_{im}) < 0$.

First, we simplify the notation denoting each outcome of every possible state of the world as follows:

$$Y+(r-1)x^*_{im} = S_{NI} \quad \text{(B2)}$$
$$Y+(r-p-1)x^*_{im} = S_I \quad \text{(B3)}$$
$$Y-(1+p-\alpha)x^*_{im} = F_I \quad \text{(B4)}$$
$$Y-x^*_{im}] = F_{NI} \quad \text{(B5)}$$

As proven in section III.3, we know that:

$$S_{NI} > S_I > F_I > F_{NI} \quad \text{(B6)}$$

Given that, under the assumption of risk aversion, $u'$ decreases with larger values we have that:

$$u'[S_{NI}] < u'[S_I] < u'[F_I] < u'[F_{NI}] \quad \text{(B7)}$$

It therefore follows that:

$$u'[S_{NI}] + u'[F_I] < u'[S_I] + u'[F_{NI}] \quad \text{(B8)}$$

The terms on the LHS of inequality (B8) take a positive sign in equation (13), whereas those in the RHS are negative.

$$\underbrace{u'[S_{NI}] + u'[F_I]}_{(+)} < \underbrace{u'[S_I] + u'[F_{NI}]}_{(-)} \tag{B9}$$

Rewriting eq.(13) with the new notation:

$$\Phi(x^*_{im}) = \underbrace{\pi\big\{(r-1)u'[S_{NI}] \;-\; (r-p-1)u'[S_I]\big\}}_{(+/-)} \\ + \underbrace{(1-\pi)\big\{(1+p-\alpha)u'[F_I] \;-\; u'[F_{NI}]\big\}}_{(-)} \lesseqgtr 0 \tag{B10}$$

Given inequalities (B7) and (B8), equation (B10) could only take a positive sign if:

$$\pi(r-1) - \pi(r-p-1) \;+\; (1-\pi)(1+p-\alpha) - (1-\pi) > 0 \tag{B11}$$

Conversely, we can demonstrated that $\Phi(x^*_{im})$ takes a negative sign if we can show that the absolute size of the first part of the inequality ($\big|\pi(r-1) \;-\; \pi(r-p-1)\big|$) is smaller or equal than the absolute size of the second part ($\big|(1-\pi) \;-\; (1-\pi)(1+p-\alpha)\big|$). We can write such comparison as follows:

$$\big|\pi(r-1) \;-\; \pi(r-p-1)\big| \lesseqgtr \big|(1-\pi) \;-\; (1-\pi)(1+p-\alpha)\big|$$

which can be simplified to:

$$\big|\pi p\big| \lesseqgtr \big|(1-\pi)(p-\alpha)\big|$$

In what follows we distinguish three cases depending on whether $\pi \gtreqless 1-\pi$. First of all, when the chances of investment success and failure are equal, $\pi = 1-\pi$, these probabilities would disappear from the inequality leaving:

$$\big|p\big| \lesseqgtr \big|p-\alpha\big|$$

Assuming that insurance is fairly priced rather than subsidised or sold with a mark-up, we have that $(1-\pi)\alpha = p \;\Rightarrow\; \alpha = p/1-\pi$, as a result:

$$\begin{aligned}
|p| \lesseqgtr |p-\alpha| &= |p| \lesseqgtr |p - \frac{p}{1-\pi}| \\
&= |p| \lesseqgtr |\frac{p(1-\pi)-p}{1-\pi}| \\
&= |p| \lesseqgtr |\frac{-p\pi}{1-\pi}| \\
&= |p| = |-p| \qquad \text{(B12)}
\end{aligned}$$

The latter step is made possible by $\pi = 1 - \pi$.

The fact that the size of both differences is the same, allow us to conclude that the overall sign of $\Phi(x^*_{im})$ is negative, due to the negative differences in the utilities both in the second $(u'[Y + (r-1)x^*_{im}] < u'[Y + (r-p-1)x^*_{im}])$ and in the first part $(u'[Y - (1+p-\alpha)x^*_{im}] < u'[Y - x^*_{im}])$ of eq.(13, B1). $\Phi(x^*_{im}) < 0$ implies that $x^* < x^*_{im}$, which completes the proof.

This conclusion is extended to the case of subsided insurance, since then $|p| < |p-\alpha|$, as it follows from (B12). Likewise, in this second case, when the probability of investment failure is greater than the likelihood of a successful investment, $\pi < 1 - \pi$, then $|\pi p| < |(1-\pi)(p-\alpha)|$; regardless of whether the insurance is actuarially fair or subsidised.

However, in the third case, when the probability of success is greater than that for a failed investment, $\pi > 1 - \pi$, the result no longer holds and the sign of $\Phi(x^*_{im})$ is ambiguous.

# Appendix C: Instructions and Procedures

## C.1 Room Preparation

[When people enter the meeting room, they are asked for their name. We have a list of invited candidates. Their name is marked and they are given a sticker with an identity number, which we ask them to stick on their shirt. It is explained that this identity number is unique and allows us to identify them during the exercise while guaranteeing complete confidentiality. This is important, as they are able to earn real money in the exercise.][39]

[They are asked to take a seat in the experimental room. There are two rows of chairs/benches, placed perpendicular to the instruction table. Participants are seated randomly in each row. Both rows of participants are seated back-to-back. The benches/chairs should be arranged so that no subject can see what another subject is looking at.]

## C.2 Running the Experiment

[The following instructions should be given to all subjects simultaneously while they are seated in the experimental room.]

### C.2.1 Welcome Address

"Welcome. Thank you for taking the time to come today. [Introduce Experimenters and Assistants.] Later, you can ask any of us questions during today's programme. For this raise your hand so that we can come and answer your question in private."

"We have invited you here, today, because we want to learn about how people in this area take decisions. You are going to be asked to take decisions about money. The money that results from your decisions will be yours to keep. The decisions that you take here will not be told to anyone. We will never use your name."

"What you need to do will be explained fully in a few minutes. But first we want to make a couple of things clear."

"First of all, this is not our money. We belong to a university, and this money has been given to us for research."

"Participation is voluntary. You may still choose not to participate in the exercise."

[39] Instructions in square brackets were not read out loud and were directed towards the implementation team. Regular text in quotation marks were the instructions orally explained to participants.

"We also have to make clear that this is research about your decisions. Therefore, you cannot talk with others. This is very important. I'm afraid that if we find you talking with others, we will have to send you home, and you will not be able to earn any money here today. Of course, if you have questions, you can ask one of us. We also ask you to switch off your mobile phones." "Make sure that you listen carefully to us. You will be able to make a good amount of money here today, and it is important that you follow our instructions."

"During today's programme, you will be asked to make one or more choices, which will be explained to you very clearly. Only one of your choices will be selected to determine the money you will be paid. At the end of the exercise, we will randomly select one of your decisions to be paid out. Any money you earn will be paid out to you privately and confidentially after all parts of the exercise are complete." "Now, before we explain what you need to do, it is really important to bear one more thing in mind. You will be asked to take decisions that are not a matter of getting it right or wrong; they are about what you prefer. However, it is important to think seriously about your choices because they will affect how much money you can take home."

"Please bear in mind when you take your decisions, no projects are going to come to this area because of the research that we do here today."

"There are two parts to today's programme. In both parts you will be asked to take decisions. Only one of the decisions will be selected. You will be told which decision that is at the end, and that decision determines how much money you take home. However, you will only find out which decision is selected at the end, so with every decision you take, remember: for all you know, this could be the one that determines how much money you take home."

"Although many of the concepts that we will explain you here today may be familiar from the last time we invited you, bear in mind that the decisions you take in this task are in no way dependent on the decisions you took last time. You should think about this task as a new one, and take into account only the explanations we are about to give you."

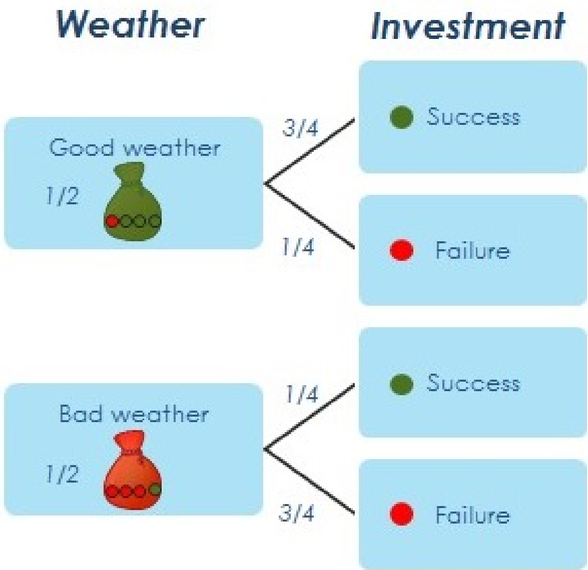
### C.2.2 Part 1 (Treatment 5)

***[The following instructions correspond to the implementation of Game 1A, the instructions for the remaining games (Games 1B, 2C and 2D) are identical apart from those modifications required to implement the treatments featured in each game.]***

**Instructions**

"In the first part of the task you receive 8,000 Shillings, which are yours, and you will be given the chance to invest some part of this amount. You can think about the investment as purchasing fertiliser."

"Whether your investment is successful or not depends on the situation you can see in the poster."




"As I said a moment ago, you can think about the investment as purchasing fertiliser. The common event you could think of as the weather. If the weather is good, it is more likely that your investment in fertiliser pays off and you get a good harvest. By contrast, in case of bad weather, it is less likely the fertiliser is profitable; instead there is a higher chance that the fertiliser doesn't improve your harvest and your investment is lost. However, the weather alone does not determine whether the investment fails or not. One can be lucky and get a better harvest thanks to the fertiliser even if the weather is bad, but also unlucky and not get any profit from the fertiliser with good weather."

"In this task, good weather is represented by a green bag and bad weather by a red bag. If the green bag is drawn everyone gets good weather, in this case there are 3 out 4 chances that your investment is successful, while there is 1 out 4 chances that you lose it. In contrast, if the red bag is selected the likelihood of making a profit goes down to 1 out

4 times, while there is 3 in 4 chances that the investment fails. There are equal chances that the green or the red bag are selected, we will put both bags into a larger bag and ask a volunteer to pick one without looking."

"Whether the investment succeeds depends on the type of token that you draw individually from the green or red bag. If the token is green your investment is successful, however, if it is red, your investment fails. There are 3 green tokens in the green bag for only 1 red token, so 3 out of 4 chances of a successful investment in the green bag for only 1 out 4 chances of losing the investment. As opposed to this, in the red bag there is only 1 green token and there are 3 red tokens, so 1 out of 4 chances of investment success and 3 out 4 chances of a failure."

*Decision*

"As we mentioned, you need to decide how much you wish to invest out of the options available to you. You have seven options: invest 0 Shillings, invest 1,000 Shillings, invest 2,000 Shillings, invest 3,000 Shillings, invest 4,000 Shillings, invest 5,000 Shillings, or invest 6,000 Shillings. If your investment is successful, you get two times and a half what you invested. So for example, if you invest 1,000 and you're successful, then the 1,000 becomes 2,500 shillings. That means you'll make a profit of 1,500: equal to the amount you invested and a half. If your investment fails you lose it, so that you have a loss equal to what you invested."

*Pairing*

"Throughout this task you will be paired with somebody in this room. You don't know who this person is, but it is somebody who is also here now, participating in this workshop."

"One person in the pair is called Person 1, the other is called Person 2. Both persons have an endowment of 8,000 Shillings each, which is theirs to keep. Person 1 will be given chance to invest by choosing one of the options we will explain in a moment. By contrast, Person 2 cannot invest but in this part will have the chance to compensate to compensate Person 1 if her investment fails."

"You are paired with two different people in this part. In one pair you are Person 1 and in another pair you are Person 2."

"We will determine at random later on for whether you are paid for your decision as Person 1 or as Person 2."

[Role play to explain pairing by asking two participants to come forward. One of them takes the role of Person 1 and the other that of Person 2. With the volunteers present we explain:

"Both Person 1 and Person 2 have an endowment of 8,000 Shillings each, which is theirs.

Person 1 will be given chance to invest. Person 2 cannot invest but will be given the opportunity of compensating Person 1 for her losses up to whatever amount she sees fit."

Subsequently, the participant role-playing as Person 1 becomes Person 2 and another participant comes forward to fulfil the role of Person 1.]

"This part has two rounds and each of you will be asked to take a different decision in every round: an investment decision as Person 1 and a sharing decision as Person 2."

"One of us will inform you personally if you are Person 1 or 2 in the round."

**Questions I**

"Please raise your hand if you have any questions." [The experimenter administrator answers participants' questions in front of everybody as clearly and accurately as possible. If necessary, clarify the instructions. Refrain from giving any answers that may influence their decisions.]

**Round 1**

*Choices Person 1*

[Stick the poster of the investment decision card for part 1, and use it to explain the scenarios below.]

"Person 1 has the chance to invest any amount she wishes in fertiliser so that she gets two and a half times the amount invested if successful or loses the investment in case of failure. In addition to this, Person 2 can compensate Person 1 when she makes losses."

"Person 1 will be asked to choose how much she wants to invest. In other words, you as Person 1 are asked to choose between the different investment options."

"The choice is between the different options on the table on display here, where you will record your choice after it is distributed to you. You can choose exactly one of these options."

| **Person 1** | | ID: ____ Part: __1__ Session: ____ | | |
|---|---|---|---|---|
| **Investment** | | **Success** | **Failure** | **Sharing Person 2** |
| ☐ | 0 | ● + 0<br>Earnings: 8,000 | ● - 0<br>Earnings: 8,000 | |
| ☐ | 1,000 | ● + 1,500<br>Earnings: 9,500 | ● - 1000<br>Earnings: 7,000 | + ? |
| ☐ | 2,000 | ● + 3,000<br>Earnings: 11,000 | ● - 2,000<br>Earnings: 6,000 | + ? |
| ☐ | 3,000 | ● + 4,500<br>Earnings: 12,500 | ● - 3,000<br>Earnings: 5,000 | + ? |
| ☐ | 4,000 | ● + 6,000<br>Earnings: 14,000 | ● - 4,000<br>Earnings: 4,000 | + ? |
| ☐ | 5,000 | ● + 7,500<br>Earnings: 15,500 | ● - 5,000<br>Earnings: 3,000 | + ? |
| ☐ | 6,000 | ● + 9,000<br>Earnings: 17,000 | ● - 6,000<br>Earnings: 2,000 | + ? |

"If you don't invest anything, you won't get any additional amount if you draw the green token, nor you will lose any part of your endowment if you draw the red token. Whichever token you draw you will get to keep your endowment of 8,000 Shillings. Person 2 cannot transfer any amount to you since you would not have suffered any losses."

"If you invest 1,000 Shillings and you draw the green token, you will get an additional 1,500 Shillings and your earnings will be of 9,500 Shillings. If instead you draw the red token, you will make a loss of 1,000 Shillings and your earnings will be of 7,000 Shillings. In this case, Person 2 can choose to share any amount from 0 up to the 8,000 Shillings she is endowed with to compensate you for the investment losses."

"If you invest 2,000 Shillings and you draw the green token, you will get an additional 3,000 Shillings and your earnings will be of 11,000 Shillings. If instead you draw the red token, you will make a loss of 2,000 Shillings and your earnings will be of 6,000 Shillings. Person 2 can choose to share any amount of her endowment to compensate you for the investment losses."

"If you invest 3,000 Shillings and you draw the green token, you will get an additional 4,500 Shillings and your earnings will be of 12,500 Shillings. If instead you draw the red token, you will make a loss of 3,000 Shillings and your earnings will be of 5,000 Shillings. Person 2 can choose to share any amount of her endowment to compensate you for the investment losses."

"If you invest 4,000 Shillings and you draw the green token, you will get an additional 6,000 Shillings and your earnings will be of 14,000 Shillings. If instead you draw the red token, you will make a loss of 4,000 Shillings and your earnings will be of 4,000 Shillings. Person 2 can choose to share any amount of her endowment to compensate you for the investment losses."

"If you invest 5,000 Shillings and you draw the green token, you will get an additional 7,500 Shillings and your earnings will be of 15,500 Shillings. If instead you draw the red token, you will make a loss of 5,000 Shillings and your earnings will be of 3,000 Shillings. Person 2 can choose to share any amount of her endowment to compensate you for the investment losses."

"Finally, if you invest 6,000 Shillings and you draw the green token, you will get an additional 9,000 Shillings and your earnings will be of 17,000 Shillings. If instead you draw the red token, you will make a loss of 6,000 Shillings and your earnings will be of 2,000 Shillings. Person 2 can choose to share any amount of her endowment to compensate you for the investment losses."

"Remember that if you draw a green token Person 2 cannot transfer any amount to you since you would not have made any losses and actually got profits."

"After you have made your choice, your earnings will be calculated in the following way. We will ask one of you to come forth and pick one bag from this one [Show the bag], which contains a red and a green bag. Each of these bags contains the number of tokens described before. Whereas the green bag has 3 green tokens, indicating a successful investment, and 1 red tokens, meaning a failed investment, the red bag contains only 1 green token and 3 green ones. Once one of the bags is selected, each one of you will pick one token during the resolution phase, which together with your decision will determine how much money you go home with."

*Decision Card Person 1*

"To make your decision we will use the following decision card. It shows the same 7 options as the ones presented on the table. Out of these 7 options we ask you to select one by ticking the appropriate box." [Show the decision card, and indicate where they can find the different options and how they correspond to the options presented on the table. Explain where they have to indicate their investment decision.]

*Questions II*

"Please raise your hand if you have any questions." [The experimenter administrator answers participants' questions in front of everybody as clearly and accurately as possible. If necessary, clarify the instructions. Refrain from giving any answers that may influence their decisions.]

*Choices Person 2*

"Person 2 cannot invest any part of her endowment, but in this part she will have the chance to compensate Person 1 if her investment fails up to whatever amount she sees fit."

"So you as Person 2 need to decide how much, if any, of Person 1's losses you wish to compensate for every possible investment decision taken by Person 1. The sharing decision you take for the actual investment choice of Person 1 will determine how much you take home."

[Stick posters of the losses-sharing cards for part 2 and use them to explain the scenarios below.]

| **Person 2** | ID: ____ Part: __1__ Session:____ | |
|---|---|---|
| ● - Inv | | |
| **Investment** | **Losses Person 1** | **Sharing** |
| 1,000 | 1,000 | ________ Shillings |
| 2,000 | 2,000 | ________ Shillings |
| 3,000 | 3,000 | ________ Shillings |
| 4,000 | 4,000 | ________ Shillings |
| 5,000 | 5,000 | ________ Shillings |
| 6,000 | 6,000 | ________ Shillings |

"If Person 1 doesn't invest anything she won't lose anything if she draws the red token nor earn anything is she draws the green one. You as Person 2 cannot share any amount with her as she won't make any losses."

"If Person 1 draws a red token and has invested 1,000 Shillings, she will lose this amount. You as Person 2 can choose to share any amount from your endowment to compensate Person 1, from 0 Shillings to 8,000 Shillings."

"If, on the other hand, Person 1 draws a green token she will not suffer any losses as her investment will be successful and she will make a profit. In this case you cannot transfer any amount to her."

"If Person 1 draws a red token and has invested 2,000 Shillings, she will lose this amount. You can choose to share any amount of your endowment to compensate Person 1 for her investment losses, from 0 to 8,000 Shillings."

"If Person 1 draws a red token and has invested 3,000 Shillings, she will lose this amount. You can choose to share any amount of your endowment to compensate Person 1 for her investment losses."

"If Person 1 draws a red token and has invested 4,000 Shillings, she will lose this amount. You can choose to share any amount of your endowment to compensate Person 1 for her investment losses."

"If Person 1 draws a red token and has invested 5,000 Shillings, she will lose this amount. You can choose to share any amount of your endowment to compensate Person 1 for her investment losses."

"Finally, if Person 1 draws a red token and has invested 6,000 Shillings, she will lose this amount. You can choose to share any amount of your endowment to compensate Person 1 for her investment losses."

[Ask two volunteers to come forward and role-play with them using the examples below. Use actual money to simulate the transactions.]

"For instance, if Person 1 invests 3,000 Shillings and you, as Person 2, decide to share 1,000 Shillings because the investment has failed and she has lost the money, Person 1 will end up with 6,000 Shillings and you as Person 2 will take 7,000 Shillings home."

[Tell participants that this is just an example to help them understand the decision they need to make and that they should not guide their decisions based on it.]

"If Person 1 invests 2,000 Shillings and you, as Person 2, decide to share nothing. Person 1 will end up with earnings of 6,000 Shillings and you will take your full endowment of 8,000 Shillings home."

"If Person 1 invests 5,000 Shillings and you, as Person 2, decide to share 1,500 Shillings because the investment has failed and she has lost the money. Person 1 will end up with 4,500 Shillings and you as Person 2 will take 6,500 Shillings home."

[Tell participants that these are just examples to help them understand the decision they need to make and that they should not guide their decisions based on it.]

"Remember that if Person 1 draws a green token, you cannot transfer any amount to her, since Person 1 would have made a profit."

*Decision Card Person 2*

[Use loss-sharing poster to explain.]

"We will use these cards to record the amount that you, as Person 2, wish to share with Person 1. [Show the cards and use it in the explanations.] These cards allow you to express how much of your endowment you wish to share with Person 1 to compensate her for her investment losses. You can share any amount from your endowment of 8,000 Shillings, from 0 to 8,000."

"The cards show the investment Person 1 has made and the amount she has lost. [Point at the card while you explain this.] As Person 2, you will need to decide how much, if any, of your endowment you want to share with Person 1 when her investment fails for every possible amount Person 1 could have invested."

"In other words, you will need to decide how much you want to share with Person 1 if she invests 1,000 Shillings, if she invests 2,000 Shillings, if she invests 3,000 Shillings, if she invests 4,000 Shillings, if she invests 5,000 Shillings, and if she invests 6,000 Shillings." [Indicate the spaces where the amounts they wish to share in every case will be filled.]

"Remember that only the sharing decision you take for the investment decision actually made by Person 1 will have actual consequences. However, you are asked to decide about all possible decision of Person 1 because we don't know yet what Person 1 would choose."

"For example, if Person 1 invests 2,000 Shillings, we will look at how much you decided to share in this case and deduct from your endowment." [Use the posters to illustrate this point.]

*Questions III*

"Please raise your hand if you have any questions." [The experimenter administrator answers participants' questions in front of everybody as clearly and accurately as possible. If necessary, clarify the instructions. Refrain from giving any answers that may influence their decisions.]

*Control Questions*

[Ask participants to turn and explain that they should place the decision card within the wooden structure.]

[The experimenter assistants call each participant one by one. They say the following:

"I am going to ask you some questions to see if you understood the instructions. In this round you are Person 1, you are given the chance to invest any amount of your endowment out of the options available to you."

"You are paired with someone else in this room who is Person 2 who may help you if your investment is not successful."

"You can invest 0 Shillings, 1,000 Shillings, 2,000 Shillings, 3,000 Shillings, 4,000 Shillings, 5,000 Shillings or 6,000 Shillings. Each option changes how much you take home depending on whether the investment fails or succeeds."

Finally, the experimenters ask the following question making reference to the decision cards that they carry with them.]

1. As Person 1, if you chose to invest 2,000, how much would be your profits if you picked a green counter out of the bag? (3,000) How much would you go home with?

(11,000)

2. As Person 1, if you chose to invest 5,000, how much would you lose if you picked a red counter out of the bag? (5,000) How much would you go home with? (3,000)
3. As Person 1, if you decide to invest 3,000 Shillings, how much would you go home with if you picked a red counter out of the bag? (5,000) And how much would you go home with if Person 2 decides to share 2,000? (7,000)

[For each of the questions, record on the control question card whether they answered it correctly. If the participant gave a wrong answer for at least one of the questions, ask her what was not clear. Answer all the remaining questions participants as clearly and accurately as possible. If necessary, clarify the instructions; but not more than once.]

[At the bottom of the page the experimenter should answer the following question:

"Do you think the participant understood the instructions well?" Y=Yes/N=No]

*Decisions Card*

[Before the participant goes back to her seat. The experimenter administering the control question explains how the decision card works by saying the following:]

"As Person 1 you will take the investment decision using the following decision card. It shows the 7 options I mentioned before. Out of these 7 options we ask you to select one by ticking the appropriate box." [Show the decision card, and indicate where they can find the different options. Explain where they have to indicate their investment decision.]

[Before the participant goes back to her seat give her the decision card with the ID are already filled in. Ask the participant to study the decision card, but not to write anything on it until we tell her so. Remind them that if they need help or make a mistake they can ask us for help.]

*Decisions*

[Give each participant a pen.] "If you have no further questions, we will now begin. Please indicate the investment option you choose. Remember, there are no wrong choices."

"We emphasise that it is important that you make your choice in private. Do not show your decision card to the other participants and place it in the wooden structure in front of you. If you need assistance, please raise your hand so that one of us can come to you to assist you. Once you have made your choice, please fold the decision sheet and raise your hand so that we can come and collect your decision card."

"If you are Person 1, select your preferred option by ticking the box."

"If you are Person 2, revise that the answers recorded and make sure you are happy with your choices."

"Take your time to make your decisions since they can affect how much money you take home."

[The participants remain seated. Any questions at this point should be addressed individually. After the participants have made their choice, they fold their decision card, and we collect them. Verify whether participants filled in the decision cards correctly. The central administrator enters the investment decisions in an Excel data sheet. When all participants have made their decision, Round 1 is completed.]

**Round 2**

*Instructions*

"After you have taken your decisions in the first round, you will take your decisions in the second round. A different decision than before."

*Control Questions*

"We will now ask some questions to see whether you understood the instructions and inform you about the decision we ask you to make."

[Ask participants to turn.]

[The experimenter assistants call each participant one by one. They say the following:

"I am going to ask you some questions to see if you understood the instructions. In this round you are Person 2, you are not able to invest. You are paired with someone in this room, Person 1 who has the chance to invest."

"As Person 2, you have the chance of compensating Person 1 for her investment losses for every possible decision she can take. In other words, you will need to decide how much you want to share with Person 1 if she invests 1,000 Shillings, if she invests 2,000 Shillings, if she invests 3,000 Shillings, if she invests 4,000 Shillings, if she invests 5,000 Shillings, and if she invests 6,000 Shillings."

"However, only one of your sharing decisions will have actual consequences. We will only take from you the money you decide to share for the actual investment decision taken by Person 1." [Use an example to make this point employing the decision cards.]

Finally, the experimenters ask the following question making reference to the decision cards that they carry with them.]

1. If Person 1 invests 4,000 Shillings and her investment fails how much would she go home with? (4,000) And if you as Person 2 decide to share 3,000 with her? (7,000) How much will you take home then? (5,000)

[Record on the control question card whether the participant answered the question correctly. If the participant gave a wrong answer, ask him/her what was not clear. Answer all the remaining questions participants as clearly and accurately as possible. If necessary, clarify the instructions; but not more than once.]

[At the bottom of the page the experimenter should answer the following question:

"Do you think the participant understood the instructions well?" Y=Yes/N=No]

*Decisions Cards Person 2*

[Before the participant goes back to her seat. The experimenter explains how the decision card works by saying the following:]

"We will use these cards to record the amount that you, as Person 2, wish to share with Person 1. [Show the cards and use it in the explanations.] These cards allow you to express how much of your endowment you wish to share with Person 1 to compensate her for her investment losses. You can share any amount from your endowment of 8,000 Shillings, from 0 to 8,000."

"The cards show the investment Person 1 has made and the amount she has lost. [Point at the card while you explain this.] As Person 2, you will need to decide how much, if any, of your endowment you want to share with Person 1 when her investment fails for every possible amount Person 1 could have invested."

"In other words, you will need to decide how much you want to share with Person 1 if she invests 1,000 Shillings, if she invests 2,000 Shillings, if she invests 3,000 Shillings, if she invests 4,000 Shillings, if she invests 5,000 Shillings, and if she invests 6,000 Shillings." [Indicate the spaces where the amounts they wish to share in every case will be filled.]

"Remember that only the sharing decision you take for the investment decision actually made by Person 1 will have actual consequences. However, you are asked to decide about all possible decision of Person 1 because we don't know yet what Person 1 would choose."

"For example, if Person 1 invests 2,000 Shillings, we will look at how much you decided to share in this case and deduct from your endowment." [Use the cards to illustrate this point.]

[Ask the participant to think about their decision. Tell them that if they change their minds or make a mistake they can ask us for help.]

*Decisions*

"If you have no further questions, we will now begin. Please indicate clearly your choice. Remember, there are no wrong choices."

"We emphasise that it is important that you make your choice in private. Do not show your decision card to the other participants and place it in the wooden structure in front of you. If you need assistance, please raise your hand so that one of us can come to you to assist you. Once you have made your choice, please fold the decision sheet and raise your hand so that we can come and collect your decision card."

"Take your time to make your decisions since they can affect how much money you take home."

[The participants remain seated. After the participants have made their choices, they fold their decision card, and we collect them. Verify whether the decision cards are filled correctly. When all participants have made their decision, Part 1 is completed.]

### C.2.3 Part 2 (Treatment 1)

*Instructions*

[Remove posters for part 1.]

[Participants remain seated.] "Thank you, you have now all completed the first part of the task. We will now explain the second part."

"During this part you will be again paired with two other people in this room. Different people than before. You don't know who they are, but they are also here now, participating in this workshop."

"Same as in the previous part, in each pair there is again a Person 1 and a Person 2. Both persons have an endowment of 8,000 Shillings each, which is theirs to keep. Person 1 will be again given the opportunity to invest by choosing one of the same options presented before. Person 2 cannot invest but she will again have the chance to compensate Person 1 if her investment fails."

"You are paired with two different people in this part. In one pair you are Person 1 and in another pair you are Person 2."

"We will determine at random later on for whether you are paid for your decision as Person 1 or as Person 2." [Role play to explain pairing by asking two participants to come forward. One of them takes the role of Person 1 and the other that of Person 2. With the volunteers present we explain:

"Both Person 1 and Person 2 have an endowment of 8,000 Shillings each, which is theirs. Person 1 will be given chance to invest. Person 2 is not at risk of losing her harvest and will be given the opportunity of compensating Person 1 for her losses up to whatever amount she sees fit."

[Subsequently, the participant role-playing as Person 1 becomes Person 2 and another participant comes forward to fulfil the role of Person 1.]

"This part has two rounds and each of you will be asked to take a different decision in every round: an investment decision as Person 1 and a sharing decision as Person 2."

"One of us will inform you personally if you are Person 1 or 2 in the round."

**Questions I**

"Please raise your hand if you have any questions." [The experimenter administrator answers participants' questions in front of everybody as clearly and accurately as possible. If necessary, clarify the instructions. Refrain from giving any answers that may influence their decisions.]

## Round 1

*Choices Person 1*

[Stick the poster of the investment decision card for part 1, and use it to explain the scenarios below.]

"Person 1 will be presented with the same investment choices as before, and will be asked to choose one option again. The only difference is that she will be insured against bad weather."

"Insurance is an arrangement that pays out some money when a specified bad event happens, like making a loss due to bad harvest, in return for a cost. In this case the insurance protects you against bad weather, so that if the weather is bad the insurance will pay you an indemnity for half the amount you have invested."

"This insurance has a cost, which is equal to half of the indemnity it pays."

"Insurance is mandatory when you invest. For every additional 1,000 Shillings you invest, you will have to pay 250 Shillings more of insurance, and the insurance will pay you 500 Shillings in case of bad weather."

"Person 1 will be asked to choose how much she wants to invest. In other words, you as Person 1 are asked to choose between the different investment options."

"The choice is between the different options on the table on display here, where you will record your choice after it is distributed to you. You can choose exactly one of these options."

| **Person 1** | | | | ID: ____ Part: __2__ Session: ____ | | |
|---|---|---|---|---|---|---|
| | **Investment** | **Insurance Price** | **Success/Failure** | **Good Weather** | **Bad Weather** | **Sharing Person 2** |
| ☐ | 0 | - 0 | ● + 0<br>● - 0 | + 0<br>● Earnings: 8,000 ● Earnings: 8,000 | + 0<br>● Earnings: 8,000 ● Earnings: 8,000 | |
| ☐ | 1,000 | - 250 | ● + 1,500<br>● - 1,000 | + 0<br>● Earnings: 6,750 ● Earnings: 9,250 | + 500<br>● Earnings: 7,250 ● Earnings: 9,750 | + ? |
| ☐ | 2,000 | - 500 | ● + 3,000<br>● - 2,000 | + 0<br>● Earnings: 5,500 ● Earnings: 10,500 | + 1,000<br>● Earnings: 6,500 ● Earnings: 11,500 | + ? |
| ☐ | 3,000 | - 750 | ● + 4,500<br>● - 3,000 | + 0<br>● Earnings: 4,250 ● Earnings: 11,750 | + 1,500<br>● Earnings: 5,750 ● Earnings: 13,250 | + ? |
| ☐ | 4,000 | - 1,000 | ● + 6,000<br>● - 4,000 | + 0<br>● Earnings: 3,000 ● Earnings: 13,000 | + 2,000<br>● Earnings: 5,000 ● Earnings: 15,000 | + ? |
| ☐ | 5,000 | - 1,250 | ● + 7,500<br>● - 5,000 | + 0<br>● Earnings: 1,750 ● Earnings: 14,250 | + 2,500<br>● Earnings: 4,250 ● Earnings: 16,750 | + ? |
| ☐ | 6,000 | - 1,500 | ● + 9,000<br>● - 6,000 | + 0<br>● Earnings: 500 ● Earnings: 15,500 | + 3,000<br>● Earnings: 3,500 ● Earnings: 18,500 | + ? |

"If you as Person 1 don't invest anything, you will not pay anything for insurance. You will get no additional amount if you draw the green token, nor you will lose any part of your endowment if you draw the red token. Whichever token you draw you will get to keep your endowment of 8,000 Shillings. Person 2 cannot transfer any amount to you since you would not have suffered any losses."

"If you invest 1,000 Shillings, you will pay 250 Shillings for the insurance. Same as before, if you draw the green token, you will get an additional 1,500 Shillings. Your earnings will be of 9,250 Shillings if the weather is good, and of 9,750 if the weather is bad, since then the insurance will pay you 500 Shillings. If instead you draw the red token, you will make a loss of 1,000 Shillings and the insurance will not pay you anything if the weather is good; you will then end up with earnings of 6,750 Shillings (1,250 Shillings less than your initial endowment). However, if you draw the red token and the weather is bad, the insurance will pay you the 500 Shillings and you will get earnings of 7,250 Shillings (750 Shillings less than your initial endowment). In both cases when you draw the red token and make losses, Person 2 can choose to share any amount from 0 up to the 8,000 Shillings she is endowed with to compensate you for your investment losses."

"If you invest 2,000 Shillings, you will pay 500 Shillings for the insurance. If you draw the green token, you will get an additional 3,000 Shillings. Your earnings will be of 10,500 Shillings if the weather is good, and of 11,500 if the weather is bad, since then the insurance will pay you 1,000 Shillings. If instead you draw the red token, you will make a loss of 2,000 Shillings and the insurance will not pay you anything if the weather is good; you will then end up with earnings of 5,500 Shillings (2,500 Shillings less than your initial endowment). However, if you draw the red token and the weather is bad, the insurance will pay you the 1,000 Shillings and you will get earnings of 6,500 Shillings (1,500 Shillings less than your initial endowment). In both cases when you draw the red token and make losses, Person 2 can choose to share any amount from 0 up to the 8,000 Shillings she is endowed with to compensate for your investment losses."

"If you invest 3,000 Shillings, you will pay 750 Shillings for the insurance. If you draw the green token, you will get an additional 4,500 Shillings. Your earnings will be of 11,750 Shillings if the weather is good, and of 13,250 if the weather is bad, since then the insurance will pay you 1,500 Shillings. If instead you draw the red token, you will make a loss of 3,000 Shillings and the insurance will not pay you anything if the weather is good; you will then end up with earnings of 4,250 Shillings (3,750 Shillings less than your initial endowment). However, if you draw the red token and the weather is bad, the insurance will pay you the 1,500 Shillings and you will get earnings of 5,750 Shillings (2,250 Shillings less than your initial endowment). In both cases when you draw the red token and make losses, Person 2 can choose to share any amount of her endowment to compensate you for your investment losses."

"If you invest 4,000 Shillings, you will pay 1,000 Shillings for the insurance. If you draw the green token, you will get an additional 6,000 Shillings. Your earnings will be of 13,000 Shillings if the weather is good, and of 15,000 if the weather is bad, since then the insurance will pay you 2,000 Shillings. If instead you draw the red token, you will make a loss of 4,000 Shillings and the insurance will not pay you anything if the weather is good; you will then end up with earnings of 3,000 Shillings (5,000 Shillings less than your initial endowment). However, if you draw the red token and the weather is bad, the insurance will pay you the 2,000 Shillings and you will get earnings of 5,000 Shillings (3,000 Shillings less than your initial endowment). In both cases when you draw the red token and make losses, Person 2 can choose to share any amount of her endowment to compensate you for your investment losses."

"If you invest 5,000 Shillings, you will pay 1,250 Shillings for the insurance. If you draw the green token, you will get an additional 7,500 Shillings. Your earnings will be of 14,250 Shillings if the weather is good, and of 16,750 if the weather is bad, since then the insurance will pay you 2,500 Shillings. If instead you draw the red token, you will make a loss of 5,000 Shillings and the insurance will not pay you anything if the weather is good; you will then end up with earnings of 1,750 Shillings (6,250 Shillings less than your initial endowment). However, if you draw the red token and the weather is bad, the insurance will pay you the 2,500 Shillings and you will get earnings of 4,250 Shillings (3,750 Shillings less than your initial endowment). In both cases when you draw the red token and make losses, Person 2 can choose to share any amount of her endowment to compensate you for the losses."

"Finally, if you invest 6,000 Shillings, you will pay 1,500 Shillings for the insurance. If you draw the green token, you will get an additional 9,000 Shillings. Your earnings will be of 15,500 Shillings if the weather is good, and of 18,500 if the weather is bad, since then the insurance will pay you 3,000 Shillings. If instead you draw the red token, you will make a loss of 6,000 Shillings and the insurance will not pay you anything if the weather is good; you will then end up with earnings of 500 Shillings (7,500 Shillings less than your initial endowment). However, if you draw the red token and the weather is bad, the insurance will pay you the 3,000 Shillings and you will get earnings of 3,500 Shillings (4,500 Shillings less than your initial endowment). In both cases when you draw the red token and make losses, Person 2 can choose to share any amount of her endowment to compensate you for the losses."

"Remember that if you draw a green token Person 2 cannot transfer any amount to you since you would not have made any losses and actually got profits."

*Decision Card Person 1*

"To make your decision as Person 1 you will use the following decision card. It shows the same 7 options as the ones presented on the table. Out of these 7 options we ask you to select one by ticking the appropriate box."

[Show the decision card, and indicate where they can find the different options and how they correspond to the options presented on the table. Explain where they have to indicate their investment decision.]

*Questions II*

"Please raise your hand if you have any questions." [The experimenter administrator answers participants' questions in front of everybody as clearly and accurately as possible. If necessary, clarify the instructions. Refrain from giving any answers that may influence their decisions.]

*Choices Person 2*

"Person 2 cannot invest any part of her endowment, she will have the chance to compensate Person 1 if her investment fails up to whatever amount she sees fit."

"So you as Person 2 need to decide how much, if any, of Person 1's losses you wish to compensate for every possible investment decision taken by Person 1. The sharing decision you take for the actual investment choice of Person 1 will determine how much you take home."

[Stick posters of the losses-sharing cards for part 2 and use them to explain the scenarios below.]

<table>
<tr><td colspan="3">Person 2</td><td colspan="3">ID: ____ Part: _2_ Session: ____</td></tr>
<tr><td colspan="3"></td><td colspan="3">● - Inv</td></tr>
<tr><td colspan="2">Investment</td><td colspan="2">Losses Person 1</td><td colspan="2">Sharing</td></tr>
<tr><td colspan="2">1,000</td><td colspan="2">1,250</td><td colspan="2">________ Shillings</td></tr>
<tr><td colspan="2">2,000</td><td colspan="2">2,500</td><td colspan="2">________ Shillings</td></tr>
<tr><td colspan="2">3,000</td><td colspan="2">3,750</td><td colspan="2">________ Shillings</td></tr>
<tr><td colspan="2">4,000</td><td colspan="2">5,000</td><td colspan="2">________ Shillings</td></tr>
<tr><td colspan="2">5,000</td><td colspan="2">6,250</td><td colspan="2">________ Shillings</td></tr>
<tr><td colspan="2">5,000</td><td colspan="2">7,500</td><td colspan="2">________ Shillings</td></tr>
</table>

| **Person 2** | | ID: ____ Part: __2__ Session: ____ |
| --- | --- | --- |
|  | | ● - Inv |
| ***Investment*** | ***Losses Person 1*** | ***Sharing*** |
| 1,000 | 750 | ________ Shillings |
| 2,000 | 1,500 | ________ Shillings |
| 3,000 | 2,250 | ________ Shillings |
| 4,000 | 3,000 | ________ Shillings |
| 5,000 | 3,750 | ________ Shillings |
| 6,000 | 4,500 | ________ Shillings |

"If Person 1 doesn't invest anything she won't lose anything if she draws the red token nor earn anything is she draws the green one. You as Person 2 cannot share any amount with her as she won't make any losses."

"If Person 1 draws a red token and has invested 1,000 Shillings, she will lose 1,250 Shillings if the weather is good (1,000 are the investment losses and 250 the cost of the insurance that has not paid out anything) You as Person 2 can choose to share any amount from your endowment to compensate Person 1, from 0 Shillings to 8,000 Shillings. If however Person 1 draws a red token and the weather is bad, she will lose 750 Shillings (1,000 of it are losses and 250 the cost of the insurance that has paid out 500). You can again choose to share any amount of your endowment, from 0 Shillings to 8,000 Shillings, to compensate Person 1 for her investment losses."

"If, on the other hand, Person 1 draws a green token she will not suffer any losses as her investment will be successful and she will make a profit. In this case you cannot transfer any amount to her."

"If Person 1 draws a red token and has invested 2,000 Shillings, she will lose 2,500 Shillings if the weather is good (2,000 are the investment losses and 500 the cost of the insurance that has not paid out anything). If however Person 1 draws a red token and the weather is bad, she will lose 1,500 Shillings (2,000 of it are losses and 500 the cost of the insurance that has paid out 1,000). In both cases when Person 1 draws a red token and makes losses, you as Person 2 can choose to share any amount of your endowment to compensate Person 1 for her investment losses."

"If Person 1 draws a red token and has invested 3,000 Shillings, she will lose 3,750 Shillings if the weather is good (3,000 are the investment losses and 750 the cost of the insurance that has not paid out anything). If however Person 1 draws a red token and the weather is bad, she will lose 2,250 Shillings (3,000 of it are losses and 750 the cost of the insurance that has paid out 1,500). In both cases when Person 1 draws a red token and makes losses, you as Person 2 can choose to share any amount of your endowment to compensate Person 1 for her investment losses."

"If Person 1 draws a red token and has invested 4,000 Shillings, she will lose 5,000 Shillings if the weather is good (4,000 are the investment losses and 1,000 the cost of the insurance that has not paid out anything). If however Person 1 draws a red token and the weather is bad, she will lose 3,000 Shillings (4,000 of it are losses and 1,000 the cost of the insurance that has paid out 2,000). In both cases when Person 1 draws a red token and makes losses, you as Person 2 can choose to share any amount of your endowment to compensate Person 1 for her investment losses."

"If Person 1 draws a red token and has invested 5,000 Shillings, she will lose 6,250 Shillings if the weather is good (5,000 are the investment losses and 1,250 the cost of the insurance that has not paid out anything). If however Person 1 draws a red token and the weather is bad, she will lose 3,750 Shillings (5,000 of it are losses and 1,250 the cost of the insurance that has paid out 2,500). In both cases when Person 1 draws a red token and makes losses, you as Person 2 can choose to share any amount of your endowment to compensate Person 1 for her investment losses."

"Finally, if Person 1 draws a red token and has invested 6,000 Shillings, she will lose 7,500 Shillings if the weather is good (6,000 are the investment losses and 1,500 the cost of the insurance that has not paid out anything). If however Person 1 draws a red token and the weather is bad, she will lose 4,500 Shillings (6,000 of it are losses and 1,500 the cost of the insurance that has paid out 3,000). In both cases when Person 1 draws a red token and makes losses, you as Person 2 can choose to share any amount of your endowment to compensate Person 1 for her investment losses."

"For instance, if Person 1 invests 6,000 Shillings and you, as Person 2, decide to share 5,000 Shillings because the investment has failed and she has lost the money; Person 1 will end up with earnings of 5,500 Shillings if the weather is good, and with 8,500 Shillings if the weather is bad. In either case you will take 3,000 Shillings home."

"If Person 1 invests 3,000 Shillings and you, as Person 2, decide to share 500 Shillings because the investment has failed and she has lost the money; Person 1 will end up with earnings of 4,750 Shillings if the weather is good, and with 6,250 Shillings if the weather is bad. In either case you will take 7,500 Shillings home" [Tell participants that these are just examples to help them understand the decision they need to make and that they should not guide their decisions based on it.]

"Remember that if Person 1 draws a green token, you cannot transfer any amount to her, since Person 1 would have made a profit."

*Decisions Cards Person 2*

[Use loss-sharing posters to explain.]

"We will use these cards to record the amount that you, as Person 2, wish to share with Person 1. [Show the cards and use it in the explanations.] These cards allow you to express how much of your endowment you wish to share with Person 1 to compensate her for the investment losses. You can share any amount from your endowment of 8,000 Shillings, from 0 to 8,000."

"For both the case of good and bad weather, the cards show the investment Person 1 has made and the amount she has lost. [Point at the cards for good and bad weather while you explain this.] As Person 2, you will need to decide how much, if any, of your endowment you want to share with Person 1 when her investment fails for every possible amount Person 1 could have invested, both in the event of good and bad weather"

"In other words, you will need to decide, both in the case of good and bad weather, how much you want to share with Person 1 if she invests 1,000 Shillings, if she invests 2,000 Shillings, if she invests 3,000 Shillings, if she invests 4,000 Shillings, if she invests 5,000 Shillings, and if she invests 6,000 Shillings. [Indicate the spaces where the amounts they wish to share in every case will be filled.]

"Remember that only the sharing decision you take for the investment decision actually made by Person 1 will have actual consequences. However, you are asked to decide about all possible decision of Person 1 because we don't know yet what Person 1 would choose."

"For example, if Person 1 invests 2,000 Shillings, we will look at how much you decided to share in this case and deduct it from your endowment." [Use the posters to illustrate this point.]

*Questions III*

"Please raise your hand if you have any questions." [The experimenter administrator answers participants' questions in front of everybody as clearly and accurately as possible. If necessary, clarify the instructions. Refrain from giving any answers that may influence their decisions.]

*Control Questions*

"We will now ask some questions individually to see whether you understood the instructions and inform you about the decision we ask you to make."

[Ask participants to turn.]

[The experimenter assistants call each participant one by one. They say the following:

"I am going to ask you some questions to see if you understood the instructions. In this round you are Person 1, you are given the chance to invest any amount of your endowment out of the options available to you. This time your investment is insured against bad weather, the insurance pays half the amount invested if the weather is bad. The more you invest, the more you pay for insurance, but also the more the insurance pays to you in case of bad weather."

"You are paired with someone else in this room who is Person 2 who may help you if your investment is not successful."

"You can invest 0 Shillings, 1,000 Shillings, 2,000 Shillings, 3,000 Shillings, 4,000 Shillings, 5,000 Shillings or 6,000 Shillings. Each option changes how much you take home depending on whether the investment fails or succeeds, and if the weather is good or bad."

Finally, the experimenters ask the following question making reference to the decision cards that they carry with them.]

1. As Person 1, if you chose to invest 3,000, how much would be your profits if you picked a green counter out of the bag? (4,500) How much would you go home with if the weather is good? (11,750)
2. As Person 1, if you chose to invest 6,000, how much would you lose if you picked a red counter out of the bag? (6,000) How much would you go home with if the weather is bad? (3,500)
3. As Person 1, if you decide to invest 4,000 Shillings, how much would you go home with if you picked a red counter with good weather? (3,000) And how much would you would home with if Person 2 decides to share 1,500? (4,500)

[For each of the questions, record on the control question card whether they answered it correctly. If the participant gave a wrong answer for at least one of the questions, ask him/her what was not clear. Answer all the remaining questions participants as clearly and accurately as possible. If necessary, clarify the instructions; but not more than once.]

[At the bottom of the page the experimenter should answer the following question:

"Do you think the participant understood the instructions well?" Y=Yes/N=No]

*Decisions Cards Person 1*

[Before the participant goes back to her seat. The experimenter explains how the decision card works by saying the following:]

"As Person 1 you will take the investment decision using the following decision card. It shows the 7 options I mentioned before. Out of these 7 options we ask you to select one by ticking the appropriate box." [Show the decision card, and indicate where they can find the different options. Explain where they have to indicate their investment decision.]

[Before the participant goes back to her seat give her the decision card with the ID are already filled in. Ask the participant to study the decision card, but not to write anything on it until we tell her so. Remind them that if they need help or make a mistake they can ask us for help.]

*Decisions*

"If you have no further questions, we will now begin. Please indicate clearly your choice. Remember, there are no wrong choices."

"We emphasise that it is important that you make your choice in private. Do not show your decision card to the other participants and place it in the wooden structure in front of you. If you need assistance, please raise your hand so that one of us can come to you to assist you. Once you have made your choice, please fold the decision sheet and raise your hand so that we can come and collect your decision card."

"Take your time to make your decisions since they can affect how much money you take home." [The participants remain seated. Any questions at this point should be addressed individually. After the participants have made their choice, they fold their decision card, and we collect them. Verify whether participants filled in the decision cards correctly. The central administrator enters the investment decisions in an Excel data sheet. When all participants have made their decision, Round 1 is completed.]

**Round 2**

*Instructions*

"After you have taken your decisions in the first round of this part, you will take your decisions in the second round. A different decision than before."

*Control Questions*

"We will now ask some questions to see whether you understood the instructions and inform you about the decision we ask you to make."

[Ask participants to turn.]

[The experimenter assistants call each participant one by one. They say the following:

"I am going to ask you some questions to see if you understood the instructions. In this round you are Person 2, you are not able to invest. You are paired with someone in this room, Person 1 who has the chance to invest. This time the investment of Person 1 is insured against bad weather, which pays half the amount invested if the weather is bad."

"As Person 2, you have the chance of compensating Person 1 for her investment losses for every possible decision she can take. In other words, you will need to decide, both in the case of good and bad weather, how much you want to share with Person 1 if she invests 1,000 Shillings, if she invests 2,000 Shillings, if she invests 3,000 Shillings, if she invests 4,000 Shillings, if she invests 5,000 Shillings, and if she invests 6,000 Shillings."

"However, only one of your sharing decisions will have actual consequences. We will only take from you the money you decide to share for the actual investment decision taken by Person 1." [Use an example to make this point employing the decision cards.]

Finally, the experimenters ask the following question making reference to the decision cards that they carry with them.]

1. If Person 1 invests 4,000 Shillings and her investment fails with bad weather how much would she go home with? (5,000) And if you as Person 2 decide to share 5,000 with her? (10,000) How much will you take home then? (3,000)

[Record on the control question card whether the participant answered the question correctly. If the participant gave a wrong answer, ask him/her what was not clear. Answer all the remaining questions participants as clearly and accurately as possible. If necessary, clarify the instructions; but not more than once.]

[At the bottom of the page the experimenter should answer the following question:

"Do you think the participant understood the instructions well?" Y=Yes/N=No]

*Decisions Cards Person 2*

[Before the participant goes back to her seat. The experimenter explains how the decision card works by saying the following:]

"We will use these cards to record the amount that you, as Person 2, wish to share with Person 1. [Show the cards and use it in the explanations.] These cards allow you to express how much of your endowment you wish to share with Person 1 to compensate her for her investment losses. You can share any amount from your endowment of 8,000 Shillings, from 0 to 8,000."

"For both the case of good and bad weather, the cards show the investment Person 1 has made and the amount she has lost. [Point at the cards for good and bad weather while you explain this.] As Person 2, you will need to decide how much, if any, of your endowment you want to share with Person 1 when her investment fails for every possible amount Person 1 could have invested, both in the event of good and bad weather"

"In other words, you will need to decide, both in the case of good and bad weather, how much you want to share with Person 1 if she invests 1,000 Shillings, if she invests 2,000 Shillings, if she invests 3,000 Shillings, if she invests 4,000 Shillings, if she invests 5,000 Shillings, and if she invests 6,000 Shillings. [Indicate the spaces where the amounts they wish to share in every case will be filled.]

“Remember that only the sharing decision you take for the investment decision actually made by Person 1 will have actual consequences. However, you are asked to decide about all possible decision of Person 1 because we don’t know yet what Person 1 would choose.”

“For example, if Person 1 invests 2,000 Shillings, we will look at how much you decided to share in this case and deduct from your endowment.” [Use the cards to illustrate this point.]

[Ask the participant to think about their decision. Tell them that if they change their minds or make a mistake they can ask us for help.]

*Decisions*

“If you have no further questions, we will now begin. Please indicate clearly your choice. Remember, there are no wrong choices.”

“We emphasise that it is important that you make your choice in private. Do not show your decision card to the other participants and place it in the wooden structure in front of you. If you need assistance, please raise your hand so that one of us can come to you to assist you. Once you have made your choice, please fold the decision sheet and raise your hand so that we can come and collect your decision card.”

“Take your time to make your decisions since they can affect how much money you take home.”

[The participants remain seated. After the participants have made their choices, they fold their decision card, and we collect them. Verify whether participants filled in the decision cards correctly. When all participants have made their decision, Part 2 is completed and we proceed to the resolution stage.]

## Resolution

"Thank you, you have now completed all parts of the task. Your earnings from your decisions will now be determined."

"In order to do so, we first need to select which of the two parts of the task will be used to determine your earnings, part 1 or part 2. For this, we put two cards with numbers 1 and 2 on them in a bag, and pick out one card without looking. The number on the card that is picked out determines the decision which will be used to calculate your earnings. [Ask one volunteer to pick out a card.]"

[Whichever number is drawn say:] "In this part you played both as Person 1 and Person 2, so we need to decide which decision will determine your earnings. We will do as follows, we will put two cards with the numbers 1 and 2 on this bag. If number 1 is selected those with IDs 1 to 5 will be paid for their decision as Person 1 and IDs 6 to 10 for their decision as Person 2. In contrast, if number 2 is drawn, those with IDs 6 to 10 will be paid for their decision as Person 1 and IDs 1 to 5 for their decision as Person 2." [Ask one volunteer to pick out a card.]

[For everyone] "Before we proceed to determine the individual earnings, we need to know what the common weather conditions are, that is, the chances of getting a red or a green token. Remember that a green bag contains 3 green tokens for 1 red one, so if this bag is picked, there is a 3 in 4 chances that Person 1's investment is successful. If however the red bag, containing 3 red and 1 green tokens, is selected there is a 1 in 4 chances that Person 1's is successful."

[Ask one volunteer to pick out the bag.]

"We now invite you to come forward, one by one, to determine your earnings."

[If type 1 pairs were selected, IDs 1 to 5 are called first in one by one to pick out a counter from the bag selected. We explain them what their decision was in that pair as well as the decision of the person they were paired with, so that they understand how their earnings were calculated.]

[After IDs 1 to 5 have received their payment, IDs 6 to 10 are called in one by one. We explain them what their decision was in the selected pair as well as the decision of the person they were paired with, so that they understand how their earnings were calculated.]

[If type 2 pairs are selected, we follow the opposite order; with IDs 6 to 10 coming forward first to pick out the counter, followed by IDs 1 to 5.]

[After the session, put all decision cards in one big envelope, and write on it date, time and code of session. Close and seal the envelope.]

# Appendix D: Further Balancing Tests

We conduct the same tests as in Table II.10 between, first, Games 1A and 1B, which comprise the 'index' subsample; and, second, Games 2C and 2D, which make up the 'indemnity' group.

**Table II.D1: Balancing Tests Within Subsamples**

| Variable | Mean (Standard Deviation) Index | | t-stat | Mean (Standard Deviation) Indemnity | | t-stat |
|---|---|---|---|---|---|---|
| | Game 1A (N=100) | Game 1B (N=100) | | Game 2C (N=99) | Game 2D (N=97) | |
| Gender (1=Male) | 0.51 | 0.52 | -0.141 | 0.357 | 0.443 | -1.226 |
| | (0.502) | (0.502) | | (0.482) | (0.499) | |
| Age | 39.63 | 39.17 | 0.24 | 37.55 | 38.33 | -0.419 |
| | (14.18) | (12.9) | | (13.19) | (13.03) | |
| Married | 0.78 | 0.74 | 0.66 | 0.869 | 0.773 | 1.75* |
| | (0.416) | (0.441) | | (0.34) | (0.421) | |
| Household size | 5.53 | 5.65 | -0.332 | 5.576 | 5.753 | -0.458 |
| | (2.468) | (2.641) | | (2.512) | ( 2.883) | |
| Years of Education | 5.67 | 6.09 | -0.893 | 5.768 | 5.625 | 0.304 |
| | (3.408) | (3.238) | | (3.232) | (3.332) | |
| Bagisu Tribe | 0.96 | 0.98 | -0.826 | 0.97 | 0.979 | 0.669 |
| | (0.197) | (0.141) | | (0.172) | (0.143) | |
| Protestant | 0.59 | 0.64 | -0.724 | 0.616 | 0.567 | 0.487 |
| | (0.494) | (0.482) | | (0.489) | (0.498) | |
| Land Holdings | 1.362 | 1.271 | 0.528 | 1.188 | 1.338 | -0.904 |
| | (1.192) | (1.237) | | (1.005) | (1.294) | |
| Wealth Index | 0.109 | -0.216 | 0.98 | 0.035 | -0.003 | 0.105 |
| | (2.405) | (2.282) | | (2.806) | (2.178) | |
| Participant's Risk Preferences | 2.24 | 2.2 | 0.194 | 2.051 | 2.422 | -1.774 |
| | (1.478) | (1.443) | | (1.373) | (1.56) | |
| Knowledge of Insurance | 0.31 | 0.19 | 1.969* | 0.212 | 0.217 | -0.074 |
| | (0.465) | (0.394) | | (0.411) | (0.414) | |
| Experience with Shocks | 0.32 | 0.42 | -1.465 | 0.394 | 0.361 | 0.476 |
| | (0.469) | (0.496) | | (0.491) | (0.483) | |

Stars denote significance levels: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

As we can see, the within-subsample tests yield no significant differences at the conventional 5% level.

# Risk and Development: Are Risk Preferences all that Important in Explaining Agricultural Investment?

**Abstract**

The notion that poverty perpetuates itself due to the influence it wields on the risk attitudes of the poor is an old and influential narrative in development economics. With the aim of examining how cogent this account of poverty is, we investigate whether, and to what extent, risk preferences matter for investment in agricultural technology adoption by a representative sample of 1,803 households. This exercise was carried out through the study of the main correlates of investing in two meaningful examples of this phenomenon, purchasing fertiliser and growing cash crops with the recommended inputs. Risk preferences were elicited experimentally and comprise aversion to risk and the heterogeneous weighting of probabilities. The main lesson from the analysis is that risk aversion plays a non-trivial role in investment decisions. However, its importance pales in comparison to that of having the means to invest, which calls into question the validity of the prevailing narrative and points to the risk environment rather than preferences towards it as the main barrier for investment.

# I Introduction

In spite of the success of the Green Revolution in vastly increasing crop production in developing countries, agricultural productivity has failed to rise meaningfully in Sub-Saharan Africa over the last fifty years (Evenson and Gollin, 2003). This is seen as one of the central reasons for the region's poor economic growth performance and the prevalence of poverty (Bold *et al.*, 2017). Furthermore, the lack of productivity gains compromises the objectives of food security in the face of rising populations in the continent (UN, 2017).

As a result of the pressing need to close the productivity gap, interventions aimed at increasing productivity in agriculture are commonplace in developing countries (World Bank, 2002). Many of them focus on incentivising the adoption of modern technologies, especially agricultural inputs. An effort that stems from the consensus among agricultural experts about the key role of modern inputs, in particular fertiliser, in raising agricultural productivity. In fact, it has been argued that the dramatic growth in yields in Asia and the stagnation in Africa can be largely explained by the increased fertiliser use in the former continent and the continued low use in the latter (Morris *et al.*, 2007).

However, the actual reasons behind these low levels of adoption remain shrouded in mystery, although many potential explanations have been offered (Bold *et al.*, 2017). They range, *inter alia*, from low and heterogeneous returns (Suri, 2011; Bold *et al.*, 2017), to risk and missing insurance markets (Fafchamps, 2003; Karlan *et al.*, 2014), credit constraints (Croppenstedt *et al.*, 2003), impediments to learning (Munshi, 2004; Conley and Udry, 2010) and behavioural factors (Duflo *et al.*, 2011). None of these is seen as the chief element determining adoption, even though they all seem to weigh heavily in the decision depending on the circumstances.

In contrast to this uncertainty, a narrative with a strong pedigree in development economics is that poverty perpetuates itself due to the influence it exerts on the attitudes of those who suffer from it towards risk. Lipton (1968) illustrated this idea formulating the peasant's *survival algorithm*, by which the farmer prioritises keeping the livelihood of the farm intact, while sacrificing efficiency in the resource allocation—an attempt to explain why inputs of production were not used at the level of their marginal product. The poorer the household, Lipton argued, the more urgent the need to protect against risk (Mosley and Verschoor, 2005). The notion that the poorest must be the most risk averse—and that this informs their financial decisions—has prevailed undeterred and left its mark beyond academic discussions; the World Bank's Development Report (2000:145) stated that "as households move closer to extreme poverty and destitution, they become very risk averse: any drop in income could push them below the survival point." More recently, in a review article in *Science*, Haushofer and Fehr (2014) claim that risk aversion is part of the psychology of those in poverty. They argue that material hardship increases the stress levels of the poor, instilling in them a sense of short-sightedness and aversion to risk in the decisions they take. All these accounts suggest that poor people living in rural areas are risk averse, which leads them to take conservative decisions about the financial prospects they face.

This paper intends to put this narrative under the microscope and assess the extent to which risk attitudes matter for investment in technology adoption. To this end, we undertake the study of the main correlates of investing in two meaningful examples of adoption, purchase of fertiliser and growing cash crops with the recommended inputs. In order to carry out the proposed research and make a meaningful contribution, we have at our disposal a large and unique dataset from a representative sample of 1,803 households from a rural region in eastern Uganda. The data was collected through a tailor-made questionnaire to study investment decisions, which includes a measure of risk aversion elicited through a hypothetical question. In addition to this, the study employs data on risk preferences obtained through incentivised experimental games for sub-samples of participants.

Due to the scope of our enquiry and data limitations, the paper does not address other important related questions which have preoccupied the literature on development economics, and it focuses exclusively on the relationship between risk preferences and investment. In particular, we do not investigate whether risk preferences are endogenous—*i.e.* whether they are determined by socio-economic factors like destitution, which is the thesis put forward by Haushofer and Fehr (2014). Similarly, our cross-sectional data does not allow us to look at the stability of the attitudes towards risk, and therefore we are unable to shed any light on the matter.

The present work builds on the research by Verschoor, D'Exelle and Pérez-Viana (2016), who investigate how well risk preferences measured experimentally capture real-life risk attitudes in agricultural investment. The aim of the article was considerably different from the purpose of this paper, namely, the former was concerned with the external validity of economic experiments, whereas ours seeks to explain agricultural investment decisions and to what extent risk preferences correlate with them. As such, we engage primarily with the literature on the determinants of investment in technology adoption and intend to contribute to it. To this end, we put forward a distinct conceptual framework, consisting of a theoretical model, adapted from Karlan *et al.* (2014), and devise a suitable empirical framework to test the predictions derived from it. In addition, we extend the analysis to other domains of risk preferences, namely, heterogeneity in probability weighting.

The chapter is organised as follows, section II reviews the literature on investment in technology adoption, with special attention to the most recent research, particularly, in relation to the aim of this inquiry. Section III lays down the theoretical framework to show the role that risk, wealth and risk preferences plays in the decision to invest in technology adoption. In Section IV, the empirical framework is developed to test the predictions arising from the model in the earlier section. Section V provides contextual information about the area where the research was carried out, describes the data and justifies the variables used in the analysis in Section VI. The latter part presents the results from the econometric analysis of the investment decisions investigated. After discussing these results, we carry out an extension of the original analysis to account for differences in the weighting of probabilities, which appears in Section VII. Finally, section VIII concludes.

# II Literature Review

## II.1 Correlates of Agricultural Investment

The adoption of technological innovations in agriculture has attracted enormous attention due to its potential to dramatically improve the lives of large swathes of the population in developing countries, who live in rural areas and for whom agriculture is, in general, the first source of income (World Bank, 2007). Part of this attention can also be explained by the fact that, despite its seemingly obvious benefits, the record of success in adoption differs greatly across settings. This is the case with agricultural input use, considered key to raising agricultural productivity.

In a recent survey on technology adoption, Foster and Rosenzweig (2010:1) define adoption as meaning both "new mappings about inputs and outputs and allocations of inputs that exploit new mappings," that is, both the use of new technologies themselves as well as new allocations of inputs needed to exploit new technologies, with the latter being the main focus of our investigation.

The authors highlight some of the principal determinants of investing in adoption commonly identified in the literature. As they note, most studies find that larger and wealthier farmers are more likely to invest in new technologies than poorer households. Another common finding is that adoption and education level are positively correlated, even when accounting for wealth. Lastly, individual farmer's adoption behaviour tends to be positively correlated with that of their neighbours.

Some of these findings echo the descriptive conclusions reported in a seminal survey of agricultural technology adoption in developing countries undertaken by Feder *et al.* (1985) more than 30 years ago. For example, these authors emphasised the importance of farm size, suggesting that size of the land holdings was a surrogate for a large number of potentially important factors such as credit, capacity to bear risks, access to scarce inputs, wealth or access to information. Human capital was also taken back then as a salient factor for investing in technology. Feder and his co-authors summarised the literature stating that "the results suggest that farmers with better education are earlier adopters of modern technologies and apply modern inputs more efficiently throughout the adoption process" (*ibid.*:276). The authors also reported consensus around the view that differential access to capital is an aspect that explains diverging rates of investment in indivisible technologies. Subjective (affecting the individual farmer) and objective risks (affecting everyone involved in farming) were mentioned as important elements for adoption. However, as the authors admit, these factors had been rarely treated in empirical studies at the time, because of the difficulty in their measurement. Particularly, in regard to the subjective kind, they concluded that "most of the empirical work on subjective risk aversion is not yet rigorous enough to allow validation or refutation of available theoretical work" (*ibid.*:276).

Notwithstanding some common conclusions, studies written in the last three decades have make substantial advances in the understanding of the process of investing in technology adoption, by employing new theoretical frameworks, data and empirical methods. What follows concentrates on exploring this recent research, especially, in relation to the stated purpose of the enquiry, which intends to investigate whether risk attitudes substantially influence investment in technology adoption.

For reasons of scope and space limitations, this review does not account for macroeconomic level factors that can influence the adoption decision. Despite this omission, it is worth mentioning that these considerations can exert substantial weight in the demand for new technologies, mainly through their impact on costs. As Morris *et al.* (2007) note, modern input prices in Africa are higher than in any other part of the world; coincidentally, the region is home to the lowest adoption rates. The authors discuss several potential causes that could explain this situation at the regional level, like small market size, a weak private sector, unfavourable business climate, uncertain policy environment and weak regulatory and institutional systems. We take into account the role of prices through their effect on the returns to adoption of agricultural technologies.

### II.1.1 Returns

Probably the first consideration that comes to mind when deciding whether to undertake any investment is its estimated return. Investing in agricultural technologies is no exception, yet the role of returns is still hotly debated today due to the difficulty of measuring the profitability of investments by small-scale farm enterprises in rural developing country settings. Many studies simply assume positive returns to inputs and technologies allegedly underinvested, with fertiliser as the most common exponent. This tendency is partially justified by the substantially high returns that the input achieves in experimental farms, and the high correlations registered between agricultural productivity and fertiliser uptake across countries (Morris *et al.*, 2007).

Duflo *et al.* (2008a) take a novel approach to address the returns question in the context of rural Kenya. They employ field experiments in which treatment and control plots are randomly allocated within—also randomly selected—farms to compare the yields over six growing seasons. For the typical farmer fertiliser is highly profitable, with average returns of 36 percent per season and 69.5 percent annually. However, the authors show that not all levels of fertiliser tried are equally profitable, or even advantageous at all. For example, the official recommendations of the Kenyan Ministry of Agriculture would leave the average farmer facing losses. Despite the rigour of their design, Foster and Rosenzweig (2010) call into question the validity of their profitability calculations because of the failure to capture all relevant costs, namely labour-related, and to investigate possible heterogeneity in the returns, due to differences in soil fertility or other unobserved factors.

Suri (2011) addresses precisely the issue of return heterogeneity, deploying a new econometric approach borrowed from the literature studying comparative advantage in labour markets, a generalised Roy model inspired in the work of Heckman and Vytlacil (1998). The author hypothesises that the benefits and costs of technologies are heterogeneous, so that farmers with low net returns do not adopt the new technology. She tests her thesis for the adoption of a new hybrid maize by a representative sample of maize-growing Kenyan farmers over an eight-year period. The results strongly support the existence of heterogeneity in the returns of hybrid maize, leading the author to conclude that despite the high average returns to the new variety, marginal returns are low, and, given the infrastructure constraints faced by farmers, adoption decisions are on the whole rational.

A late addition to the lively literature on returns to inputs is the paper by Bold *et al.* (2017) on input quality. The authors postulate that the low quality of the modern technologies, like fertiliser and improved seeds, is at the heart of the lack of productivity improvements observed in the African region. The study, conducted in Uganda, combines experimental trials to assess the quality of the available inputs, and simulations—employing the results of the trials—to test the ability of farmers to learn about the properties of these technologies and their willingness to pay for them. On average, retail fertiliser contains 31% less nutrients than authentic products and only about half of the seeds sold as improved are genuine, a deficit which severely cripples the profitability that can be obtained from these inputs. Even though the extent of these practices is widespread and the downgrade is substantial, the authors show through simulations based on a Bayesian learning model that detection of low-quality inputs is a challenge for farmers. Quality is heterogeneous and rarely as extreme as to be easily noticeable by the buyer through experimentation. This uncertainty about the returns negatively affects the willingness to pay for high-quality inputs, estimated to be low and insensitive to changes in quality in further simulations. The latter result partly explains why vendors lack the incentives to enhance their offerings, all of which is conductive to the low adoption equilibrium observed in the Ugandan market. The authors conclude that only a long-term commitment by vendors to the provision of quality inputs could change farmer's perceptions and lead to an increase in adoption rates, and, thereby, in productivity.

### II.1.2 Capital constraints

In most instances, investing in technology entails high up-front cost prior to the realisation of the gains, which requires availability of funds by the farmer. If credit markets were complete, the decision to invest would depend exclusively on the returns to investment, rather than on collateral or any other measure of access to capital, which would be guaranteed by the availability of credit (Foster and Rosenzweig, 2010).

Differential access to financial resources has long been thought as one of the main determinants of technology adoption. Feder *et al.* (1985) reported widespread agreement around this view for the case of indivisible technologies. Moreover, they noted that contrary to some theoretical postulations (Von Pischke, 1978), which argued that lack of credit alone did not inhibit investing in innovations that were scale neutral (such as high yield varieties or fertiliser), growing evidence suggested that lack of credit did also significantly limit the adoption of technologies where fixed costs were not large (Wills, 1972).

The study of the effects of capital constrains is partly hindered by its high correlation with other relevant factors for adoption. For example, wealth and capacity to borrow are in most cases correlated with the scale of the farm, which in turn, affects returns. Consequently, even if all farmers faced similar loan rates, their capacity to take on these loans would differ as the returns accrued from them would vary from farmer to farmer. Hence, the study of credit constraints cannot rely fully on self-reported measures of lack of access, which complicates substantially the task of identifying its role (Foster and Rosenzweig, 2010).

To overcome this problem, Croppenstedt *et al.* (2003) deploy a double-hurdle model due to Cragg (1971) in their study of fertiliser demand in Ethiopia. This estimation method assumes that access to and demand for fertiliser are two separate phenomena. The model of fertiliser demand estimated is conditional on access to the supply of the input, determined by another model. Limited credit availability is among the key elements predicted to grant access to fertiliser, and it is measured by whether the peasant association the farmer belongs to engages in lending. The authors indeed find evidence that lack of credit availability is a major constraint to fertiliser adoption for the farmers in the area.

Some recent research, reviewed below, has challenged the traditional views about the vital role of credit constraints in favour of alternative explanations, like psychological factors (Duflo *et al.*, 2008b, 2011) or the risk environment (Karlan *et al.*, 2014).

### II.1.3 Learning

Underinvestment in an input or a new technology could arise even when returns are high, due to ignorance about the actual extent of the returns or about how to manage the new technology. Both instances are more likely to occur in a setting where the technology is new and relatively complex (Foster and Rosenzweig, 2010), a paradigmatic example in this strand of the literature is the adoption of high-yielding varieties (HYVs).

The primary focus of the learning literature has been on whether and, if so how much, farmers can learn from their peers. Foster and Rosenzweig (1995) investigate, using a nationally representative dataset of Indian farmers, the adoption and profitability of HYVs associated with the Green Revolution. They concentrate on estimating the effects for adoption of farmers learning from their experience or acquiring knowledge externally from observing their neighbours. They show that imperfect knowledge about the management of new seeds is a significant barrier to adoption, and that experimentation both by oneself and one's neighbours increase the rate of investment. In addition, the authors establish that the profitability of the new technology is increasing in the farmer's own and their neighbours' experience at a decreasing rate.

In the context of the Indian Green Revolution too, Munshi (2004) continues to pursue this line of research with some important advances. Her contribution lies in showing that social learning is weaker in a heterogeneous context, which she achieves by comparing adoption of HYVs for two different crops: rice and wheat. Whereas wheat growers respond strongly to neighbours' experiences, rice farmers (operating in regions with greater heterogeneity in agro-ecological conditions) do not, and opt instead for further self-experimentation with the crop.

In a more recent study, Conley and Udry (2010) test an innovative proposition for the adoption of pineapple by Ghanaian farmers, a new crop in this context, grown with a commercial orientation (exports to European markets). They surmise that when learning about a new technology, farmers follow the behaviour of those who are unexpectedly successful, that is, neighbouring farmers who garner high profits, even after considering other observables that influence profitability. Unlike previous work, which made use of large nationally representative datasets, where village characteristics provided an important source of variation (Foster and Rosenzweig, 1995; Munshi, 2004), the study gather detailed data on the network structure of a small number of villages. The findings are supportive of the authors' hypothesis, and individuals are shown to learn more from the experience of their surprisingly successful peers. Moreover, farmers also adjust their input use (*e.g.* fertiliser employed) towards those who are successful and away from those who appear to fail.

A common finding in the agricultural technology adoption literature is that more educated farmers tend to adopt new technologies earlier and more effectively (Foster and Rosenzweig, 2010).

Foster and Rosenzweig (1996) assess whether returns to investment are higher in areas of India where advances in agricultural technology were more pronounced in the onset of the Green Revolution. Their results indicate that profit differentials for educated farmers with respect to illiterate ones rise fourfold between the period before the Revolution and some years later.

In a study conducted in a similar Kenyan setting as their well-known fertiliser returns paper, Duflo *et al.* (2008b) search for determinants of fertiliser adoption through an experimental design with several treatment arms; including one providing training on the use and profitability of fertiliser. As opposed to the previous literature, they find no effect of the farmer and being better educated in handling fertiliser on its uptake. Furthermore, very small learning effects arise from interactions between untreated farmers and those who have received the training. Foster and Rosenzweig (2010) attribute these results to the longevity of fertiliser as a technology in this setting, already well-known to the locals, pointing out that learning effects are not expected to play a major role in this situation.

### II.1.4 Behavioural Explanations

As a result of the prominence that theories of risky choice deviating from standard economic behaviour have (*e.g.* Prospect Theory [PT] developed by Kahneman and Tversky [1979]), and the mounting evidence that decision makers not always behave rationally (Thaler and Sunstein, 2009; Kahneman, 2011), a few studies have tested alternative behavioural explanations to describe the process of adoption or its absence.

A landmark example of this line of research, and one of the scarce studies applied to investment in agriculture is the investigation by Duflo *et al.* (2011) on fertiliser uptake in Uganda. Given their previous research demonstrating the high potential profitability of investing in fertiliser (Duflo *et al.*, 2008a), the authors hypothesise that, at least in part, lack of investment may not arise from rational decision making. Their hypothesis is further motivated by the notion that some farmers do not acquire fertiliser, even though they have means (after the harvest) and they consider it a good investment. Instead, farmers postpone the decision and end up being impatient in the last period in which buying is possible, eventually failing to investment altogether. Their impatience is explained by the combined utility cost of buying fertiliser (at a time when capital is likely in short supply), going to the shop, and obtaining the required information to make a decision about the type and amount of fertiliser needed. To test their theory and new incentivising strategies that could be more efficient than standard subsidies to promote uptake, they employ an experimental design to examine the efficacy of a commitment device. The treatment consists on small, time-limited, discounts to help present-biased farmers overcome procrastination problems, while minimally distorting the investment decisions of farmers who do not suffer from such problems. In spite of the probable naiveté of their premise about procrastination being a major barrier for investment, the substantial increase in fertiliser use as a consequence of the discount seem to provide some support for their story.

### II.1.5 Risk

Risk is an ever-present element in the context of agricultural activities in developing countries (Fafchamps, 2003). Its pervasive presence, alongside the inherent variability in the returns to new technologies and the absence of insurance markets, have made risk long been considered an important determinant for adoption.

Despite the large body of empirical literature indicating incompleteness of insurance in rural setting of low-income countries, and of solid theoretical work demonstrating how risk can affect decision making in agricultural investment (Feder, 1980; Binswanger, 1981; Antle, 1983), the empirical literature assessing the role of risk as a deterrent for adoption is scarce (Foster and Rosenzweig, 2010).

An early representative of this kind of literature is the article by Rosenzweig and Binswanger (1993). Using a panel dataset from rural India spanning ten years, they show that less well-off farmers facing increased rainfall variability hold asset portfolios that are less influenced by rain but also less profitable. By contrast, wealthy farmers exposed to an equivalent variation in rainfall risk do not display changing asset portfolios.

More recently, Lamb (2003) employ the same dataset (with some additional periods) to study the role of off-farm employment in smoothing consumption and, thereby, allowing farmers to invest more in fertiliser. Prior to investigating the matter empirically, the author develops a two-period theoretical model that formalises the use of the proceeds from off-farm employment by risk-averse households to buffer the effects of production shocks *ex post*, leading to a more efficient allocation of inputs for production *ex ante*, in an environment where returns to agricultural activity are uncertain. The results of the empirical test indicate that, controlling for exogenous weather risk, (assumed to be risk averse) farmers use more fertiliser, the lower the unemployment rate is in the area and the higher the proportion of off-farm labour (unrelated to agriculture) is among members of the household.[1]

In a similar fashion to Lamb (2003), Dercon and Christiaensen (2011) continue looking at the deterring effect of consumption risk on the uptake of risky production technologies with a four-round panel dataset from rural Ethiopia. They start off by devising a theoretical model of risky input choice in which capital constraints on input adoption are distinguished from barriers preventing the household from buffering negative consumption shocks. Deploying a fixed effects estimator to accounts for household and community time-invariant factors, Dercon and Christiaensen find that downside risk in consumption—measured as the predicted conditional expectation of consumption when rains are poor—reduces fertiliser uptake significantly. The result was obtained controlling for working capital constraints, proxied, rather disputably, by only livestock and land holdings.

[1] The source of weather risk is the variability in rainfall, particularly, during the rainy season.

On the basis of their results, the authors argue that the link between consumption risk and lack of investment in modern inputs is suggestive of a poverty-trap mechanism causing the perpetuation of deprivation.

As of late, a burgeoning literature has explored the impact of insurance on investment decisions in agricultural investment. This body of research has arisen in light of the growing hope that (weather) index insurance, a new form of insurance product, could be a suitable instrument to feasibly deliver insurance in the developing world. This type of insurance protects against losses from adverse weather events across specific geographical areas, disbursing payouts depending on predetermined patterns of an index based on weather indicators. Its particular features seemingly overcome the serious informational and enforcement problems which have hampered the development of other insurance markets (*e.g.* crop insurance) in low-income countries. Although the focus of the literature has been placed on studying the demand for the product (*inter alia*, Giné *et al.*, 2008; Cole *et al.*, 2013; Cole *et al.*, 2014; Dercon *et al.*, 2014), some papers have extended the investigation to the effect of index insurance on economic activity and, in particular, on behavioural changes in agricultural investment.[2]

The greatest exponent of this line of enquiry is Karlan *et al.* (2014), one of the few published studies investigating the impact of incomplete insurance and credit markets on technology adoption employing a rigorous identification strategy. The authors conduct several experiments in northern Ghana in which farmers are randomly assigned to receive cash grants, opportunities to obtain rainfall index insurance or a combination of the two. They, firstly, lay down a model predicting farmer investment behaviour under different scenarios conditional on which market fails: insurance, capital or both. On the basis of these predictions, they work out the implications of relaxing the constraints associated with inefficiencies in those markets. The emerging key hypothesis is that only when insurance markets are imperfect and credit markets operate efficiently, insurance provision can increase investment in risky ventures. The analysis of the experimental data shows that insurance significantly increases investment and leads to riskier productive choices. In tune with the theory, but in stark contrast to common perception, the authors find that credit constraints are not binding for investment, which is much more affected by uninsured risk. Despite providing important insights on how risk matters for investment and the tools to help farmers overcome it, some important issues remain open. Interestingly, the authors state that for no treatment group they can reject that the higher value of output after the intervention is equal to the increase in costs; in other words, beneficiary farmers in their study did not necessarily increase their profits on average.

[2] See Pérez-Viana (2019b) for a complete review of this literature.

As part of their pioneering research on index insurance in India, Mobarak and Rosenzweig (2012, 2013) study the impact that formal insurance may exert on risk taking among farmers. Their working hypotheses are based on a cooperative risk-sharing framework adapted from Arnott and Stiglitz (1991), whose main implication for investment is that groups with a higher degree of individual loss sharing may decrease risk taking, particularly in the aftermath of a shock, because of their compensation duties. On account of this situation, the availability of formal insurance should mitigate the need of applying risk reduction strategies and favour *ex-ante* risk taking in agriculture. The predictions are validated to a large extent by the empirical work undertaken by the authors. First off, their results reveal that among households experiencing a shock, those who are members of sub-caste groups or *jatis* with a higher degree of idiosyncratic loss indemnification are significantly more likely to embark in risk-reduction strategies. Secondly, making index insurance randomly available to farmers increases the cultivation of more profitable (but presumably less resilient) rice varieties, and reduces the production of rice types deemed more drought resilient (but seemingly less lucrative). These effects are indeed more pronounced, albeit only marginally, for farmers involved in arrangements with a higher degree of risk sharing (Mobarak and Rosenzweig, 2012). The authors also report that farm output rises especially when insurance is offered in areas with higher levels of rainfall, associated with more favourable conditions for the growing of rice, under which investment in modern inputs pays larger dividends (Mobarak and Rosenzweig, 2013).

## II.2 Risk Attitudes and Real-life Agricultural Investment Behaviour

The relationship between wealth and attitudes towards risk is central to many fields of economics under conditions of uncertainty (Guiso and Paiella, 2008). Kenneth Arrow, one of the most prominent risk theorist, eloquently made this point almost 50 years ago arguing that "the behaviour of these measures [risk attitudes] as wealth varies is of the greatest importance for prediction of economic reactions in the presence of uncertainty" (1970:35).

Risk aversion is the defining characteristic of the agent's attitudes in most economic applications about decisions under risk, since the utility function is assumed to be concave (Kahneman and Tversky, 1979). The consensus view is that this aversion to risk should decline with wealth, based on the fundamental economic intuition that greater asset holdings should be associated with a higher tolerance to risk.

The intuition has indeed found significant empirical support in western countries (Donkers *et al.*, 2001; Dohmen *et al.*, 2011b), although, according to Vieider *et al.* (2018), the evidence is less clear-cut than it is often understood.

The degree of aversion has long been considered especially acute in the case of poor inhabitants of developing countries, to the extent that their lack of appetite for risk is seen as both cause and consequence of poverty. In a recent article in *Science*, Haushofer and Fehr (2014) go as far as to claim that risk aversion is embedded in the psychology of those in dire material need. The authors reason that by increasing the level of stress among those suffering from it, poverty leads to short-sighted and risk-averse decision making. The article epitomises a long tradition in development economics dating all the way back to Lipton's (1968) *survival algorithm*—a decision rule which maximises the chances of keeping the livelihood of the farm household intact, while sacrificing efficiency in resource allocation in the process (Mosley and Verschoor, 2005).

The evidence in support of these considerations is far from unanimous, however. In a seminal paper, which marks one of the earliest attempts to identify risk preferences employing experimental methods with real payoffs, Binswanger (1980) famously found no significant association between risk averison and low income. Mosley and Verschoor (2005) find little relationship between risk aversion and income too, but a strong association with low assets levels and returns. Yesuf and Bluffstone (2009) report that risk aversion decreases in the availability of cash in Ethiopia. Liebenehm and Waibel (2014) find risk aversion of cattle farmers in Burkina Faso and Mali to decrease in income. By contrast, Cardenas and Carpenter (2013) do not observe any correlation between risk preferences and a measure of economic well-being (an aggregate comprising several wealth indicators) in an experiment conducted in six Latin American countries.

Aside from validating established economic theory, the study of the correlates of risk preferences is also part of the quest to explore whether these attitudes relate to prosperity or lack of it, as argued by Haushofer and Fehr (2014), in an attempt to elucidate if economic success is linked to basic features of human preferences.

A strand of this literature takes as a measure of prosperity the extent to which individuals make the most of potentially profitable opportunities, like investing in technology. As argued by Liu (2013), there are several reasons why it is crucial to take risk preferences into account when explaining adoption of new technologies. First of all, risk preferences have long featured in the theoretical literature of adoption as an important factor in the adoption decision-making process (Feder *et al.*, 1985). Thus, omitting risk attitudes from an empirical model of adoption can bias the coefficients of those variables correlated with them. Second, as mentioned above, some of the evidence indicates that risk preferences are correlated with wealth, and that it plays a role in asset accumulation and income growth (McInish *et al.*, 1993; Shaw, 1996). Third, studies like Dohmen *et al.* (2011a) have found intergenerational correlation of risk attitudes. Lastly, and perhaps more importantly, given the pervasive presence of risk and how significantly it can influence adoption, as seen above, risk preferences are likely to play an important role, since they define how individuals perceive and are affected by risk during the process of making investment decisions.

One of the first studies examining the role of risk attitudes directly on technology adoption is that of Knight *et al.* (2003) in Ethiopia. Using data from the Ethiopian Rural Household Survey and a purposively designed sample for surveying risk attitudes and educational attainment, they investigate the relationship between education and attitudes toward risk, and the effects of these two factors on innovative behaviour. The rationale for their enquiry stems from the notion that farmer's capacity to absorb risk partly depends upon their risk attitudes, and that education can affect these by reducing the riskiness of agricultural activities. According to the authors, education can lessen uncertainty by improving the farmer's ability to process information through better numeracy and literacy skills. It can also affect attitudes and habits in a way conductive to enhance farmers' willingness to take risks. Likewise, education can help increasing farm productivity and the capacity of the farmer to obtain income from other sources, thereby, improving access to credit and providing a buffer when investments fail. Despite its interesting premise, the paper suffers from a number of shortcomings preventing it from fully accomplishing the aims of its conceptual framework. First, the authors infer their findings from a small sample size, containing only 257 observations. Second, in the analysis, their dependent variable is just a binary variable set equal to 1 if a farmer has adopted at least one new agricultural input (*e.g.* fertiliser, pesticide, etc.) and one new crop, which can be a misleading indicator of investment if not supported by a strong justification grounded in the local reality, which they do not seem to have. Third, the authors do not employ any measure of wealth, even though they cite previous studies showcasing how much it seems to matter (Dercon, 1998). Finally, despite hypothesising that education also affects adoption through its influence on risk preferences, their empirical model is not set up to capture this expected interaction, and this important insight of their conceptual framework goes untested.

Another study looking at the role of risk preferences in farmers' agricultural economic decisions is Vargas Hill's (2009) investigation of short-term labour allocation choices by coffee-producing households in Uganda. The author builds on the premise, founded on previous research of short-term agricultural decisions (Morduch, 1991; Dercon, 1996), that households with less capacity to smooth consumption are less able to produce high-risk, high-return crops in the face of uncertainty. Yet previous work had identified the impact of uncertainty through wealth alone, which is problematic since it is not entirely possible to address the endogeneity issues involved in identifying the relationship between wealth and production decisions. Vargas argues that unobserved risk preferences may affect past production choices and therefore the wealth accumulated by the household (as higher returns are expected from riskier activities), causing the household's ability to deal with risk to be endogenous to production choices. The author elicits risk preferences through a set of hypothetical lottery choices, in the manner of Binswanger (1980), framed in a farming context—each option consisted in a scenario varying in the level of coffee prices (the risky crop), and the yield of the coffee and matooke trees (the safe crop). Her empirical model features the measure both in parametrical (as an estimate of the Coefficient of Risk Aversion [CRRA]) and in ordinal form. Vargas Hill finds that risk averse households are less likely to allocate labour to coffee production, but that the effect of risk preferences on this production decision was minimal for the richest households. The hypothetical nature of the parametrical measure calls into question its quality as a proxy for the coefficient of risk aversion, and hence, the extent to which the endogeneity problem pointed out by the author is mitigated. Furthermore, the indicator of wealth only comprises land and liquid wealth, leaving out other durable goods deemed important to construct a robust measure of wealth (Filmer and Pritchett, 2001).

Probably the best known example of the empirical literature on risk preferences and technology adoption in developing countries is Liu's (2013) study in rural China. In this article, the author examines the role of individual risk attitudes in the decision to adopt the genetically modified *Bacillus thuringiensis* (Bt) cotton variety, a new form of agricultural biotechnology in her area of study. Liu uses the innovative Tanaka *et al.* (2010) experimental design, which elicits three parameters—coefficient of risk aversion, loss aversion and non-linear probability weighting—allowing the estimation of empirical specifications that nest both Expected Utility Theory (EUT) and Prospect Theory (PT). The technique lets then that the results determine which theory better fits the data. Using this method, Liu links the timing of Bt cotton adoption among farmers, taking place during the decade spanning from the introduction of this variety (1993) until the universal adoption of the technology (2004), to their currently observed (2006) risk preferences. She finds that farmers who are more risk or loss averse adopt Bt cotton later, and that those overweighting small probabilities adopt the crop earlier.

Despite its pioneering approach to the measurement of risk preferences, the adoption decision studied by Liu (2013) can only be described as an unambiguous advance from the previous technology, and therefore not necessarily affected by attitudes towards risk. Bt cotton results in higher and less volatile yields on average, and in lower productions costs than traditional cotton, as noted by the author. As a result, the cumulative distribution function of profits for Bt cotton first-order stochastically dominates that of traditional cotton, making the decision of adopting Bt cotton less risky than growing the traditional type. Farmers simply need to be persuaded of the superiority of the technology, and therefore the adoption decision does not depend on risk aversion, but rather on a combination of the ability of farmers to learn about the benefits of the new technology and their uncertainty aversion about whether they are correct in judging it superior (Verschoor *et al.*, 2016).

A recent addition to the literature is the article by Khor *et al.* (2018) investigating the impact of risk aversion on fertiliser use among maize farmers in Vietnam. The authors regard the uncertainty involved in the use of fertiliser, especially due to the wide spread of substandard varieties, as a deterrent for its adoption. Without explicitly mentioning it, they appear to assume that the heightened level of uncertainty leads to lower uptake via risk aversion, which they presume higher among the poorest farmers. They formalise these considerations in a theoretical framework which yields overly complicated and seemingly contradictory predictions in light of their narrative. Whereas their premise is that poor farmers, who allegedly are the most risk averse, would be the most affected by the abundance of fake inputs, their theory predicts that wealthy farmers are more likely to be negatively affected by risk aversion when fertiliser is perceived as ineffective. Despite these apparent contradictions, they proceed to test their premise by estimating the relationship between fertiliser intensity use (*i.e.* weight of fertiliser applied per hectare) and risk preferences for a small sample size of 243 farmers. They control for a large number of factors, including input and output prices, as well as wealth rigorously measured. Risk preferences are elicited through an incentivised experiment (employing the Holt and Laury [2002] method), and also by means of a self-assessment scale. The results indicate that the marginal effect of risk aversion on fertiliser depends on the farmer's level of wealth; higher risk aversion leads to lower use intensity only for farmers in the low-wealth group, comprising 32% of the sample. The reduction in the uptake of fertiliser ranges from negligible, a 3% drop, to pretty substantial for the truly poor, with a fall of 32%; even though the number of households in these groups appears to be small. These findings are robust to a varied choice of dependent variables and wealth indicators. Disconcertingly, neither risk aversion nor wealth are significant in the specifications where the two terms are not interacted, an aspect that the authors fail to discuss.

The present paper builds on the work of Verschoor *et al.* (2016), who investigate the link between risk preferences observed in economic experiments and real-life risky choice behaviour, represented by the pursuit of farming strategies with both higher expected profits and greater variance in them. Similarly to ours, they employ a representative sample of a rural region in eastern Uganda to conduct their enquiry. Controlling for other covariates of risk-taking in agriculture, they find that risky choice behaviour in the experiment is correlated with real-life risky decisions in one domain, the purchase of fertiliser, but not in the other domains, like cultivating cash crops and selling produce to the market. In order to interpret these findings, they base their theoretical framework on the notion of choice bracketing developed by Read *et al.* (1999) and refined by Rabin and Weizsacker (2009). Choice bracketing refers to the group of choices whose consequences are considered together or separately by the decision maker, a concept embedded in two of the main economic theories of risky choice: PT and Reference Dependent Utility Theory (RDUT). For valid comparisons between experimental and real-world choices, both decisions should be narrowly bracketed, that is, the individual needs to consider both the real-world and the experimental decision in isolation. The reason why narrow bracketing applies to the purchase of fertiliser but not to the other decisions studied is that it is pondered separately from the other farming and livelihood decisions. By contrast, embracing market participation, as opposed to sticking to traditional semi-subsistence agriculture, involves a radical change, thus, a decision more likely to be broadly bracketed, appraised as part of an overall livelihood strategy. Fertiliser purchase—like risk-taking in the experimental investment game—is a straightforward investment that can be applied at a modest scale; in both cases is easy to see that a higher return is expected in exchange of a larger variance. The authors conclude that an experiment may be good at capturing risky choice behaviour in those domains in life that are similar to it, *i.e.* where narrow bracketing is to be expected, but not in those which involve a much more complex set of choices.

As noted above, the aim of the article was substantially different from the purpose of the current paper. Whereas the former is concerned with the external validity of economic experiments, the latter seeks to achieve a better understanding of agricultural investment decisions. Consequently, the review has been concerned primarily with the literature on the determinants of investment in technology adoption, and strives to contribute to it. Our aim is to determine whether attitudes toward risk substantially matter for investing in technology adoption. The current literature does not address adequately the research question motivating our enquiry, first, because of the scarcity of studies addressing the issue and, second, due to the limitations of the existing ones, as argued above. With our stated purpose in mind, we put forward a distinct conceptual framework, consisting of a model adapted from Karlan *et al.* (2014), and a suitable set of empirical models to test the predictions derived from the theory. In addition, we go beyond the majority of the literature by accounting for other domains of risk preferences, namely, the heterogeneous weighting of probabilities. Despite the conceptual differences, several elements employed by Verschoor *et al.* (2016), such as some of the analytical tools and data, are adopted and adapted for the distinct objective of the present research.

To the best of our knowledge, no study has attempted to quantify the relative importance of risk preferences for the investment decision with respect to other factors. To carry out this novel investigation, this paper boasts better more abundant data and measures that most of the related literature. Furthermore, extending the analysis to domains of risk preferences is a rare feat that has seldom been carried out in the current body of work on the topic.

# III Theoretical Framework

## III.1 Theories of Risky Choice

Given that we seek to examine the importance of risk preferences in an instance of a decision under risk, *i.e.* investment in agricultural technologies, it seems appropriate to briefly review the main theories attempting to describe how individuals form their preferences when they face risky choices.

Risk preferences can be defined as an individual's acceptability over a given gamble featuring different states of the world with specified probabilities (Kahneman and Tversky, 1984). The paradigmatic example is a gamble that yields monetary outcomes, although risk attitudes have also been studied in other domains (Dohmen *et al.*, 2011b).

### III.1.1 Expected Utility Theory

Despite the consensus on the definition of risk attitudes, there is a lively ongoing debate about the primacy of the existing theories explaining decision making under risk. Expected Utility Theory (EUT) has been the dominant framework since it was fully developed by von Neumann and Morgenstern (1944). They showed that expected utility could be derived from an appealing set of axioms of preference (Starmer, 2000).[3]

In order to outline the basic characteristics of EUT, as described by Kahneman and Tversky (1979), let us define a gamble or prospect $g$ as $(x_1, p_1; ...; x_n, p_n)$, which is a contract that yields outcome $x_i$, the level of the individual's wealth associated with the outcome of the prospect, with $p_i$, where $\sum_{i=1}^{n} p_i = 1$.

The first of the main tenets of EUT is expectation, which means that the overall utility of the prospect, denoted $U(g)$, is the expected utility of the outcomes. Let $u(\cdot)$ be the individual's Von-Neumann-Morgenstern (VNM) utility function, then $U(g)$ can be written as:[4]

$$U(g) = \sum_{i=1}^{n} p_i u(x_i) \tag{1}$$

If we now define the expected value of the prospect as $E(g) = \sum_{i=1}^{n} p_i x_i$, we can represent the utility of the prospect's expected value as:

[3] The origin of EUT can be traced back to Bernulli (1738, cited in Starmer, 2000), who first posited it as a solution to the so-called St. Petersburg paradox. Bernulli tried to explain the willingness of people to pay only small amounts of money to enter a game with an infinite expected monetary payoff. His theory assumed the existence of a cardinal utility scale, and because of this, it was dismissed by most economists until the mid-twentieth century and the irruption of von Neumann and Morgenstern (Starmer, 2000).

[4] See Jehle and Reny (2011) for a definition and the axioms required for its existence.

$$U(E[g]) = U(\sum_{i=1}^{n} p_i x_i) \tag{2}$$

Supposing that an individual is given the choice between accepting the gamble $g$ or receiving with certainty the expected value of $g$, we can use their preference over these two alternatives to classify the individual according to her attitudes towards risk: a person is risk averse at $g$ if $U(E[g]) > U(g)$, risk neutral if $U(E[g]) = U(g)$ and risk loving if $U(E[g]) < U(g)$. In words, a person is, for example, risk averse if she prefers the certain prospect $E[g]$ over the risky prospect $g$.

Most economic applications of EUT assume that individuals are risk averse, which, within this theory, is also equivalent to the assumption of concavity of the utility function with respect to wealth, $w$ (Kahneman and Tversky, 1979). The concavity of the VNM utlity function implies that the second derivative of the function is negative. Even though this is informative of the individual's aversion to risk, it does not provide any insight into how averse she is. To this effect, Pratt (1964) and Arrow (1970) developed two measures of the degree of risk aversion. The first of which is the Arrow-Pratt measure of absolute risk aversion:

$$A(w) = \frac{-u''(w)}{u'(w)} \tag{3}$$

The sign of the measure indicates the basic attitudes towards risk of the individual, and any positive affine transformation would leave it unchanged. $A(w)$ is however a local measure of risk aversion, which may change depending on the level of wealth. To overcome this issue, Arrow (1970) proposed a classification of VNM utility functions according to how $A(w)$ varies with wealth. He determined that a utility function displays decreasing, constant or increasing absolute risk aversion over some wealth domain, when over that interval, $A(w)$ remains constant, decreases or increases.

This feature is embedded in a second measure of the Arrow-Pratt family, the coefficient of relative risk aversion (CRRA):

$$R(w) = \frac{-u''(w)w}{u'(w)} \tag{4}$$

This measure gives the elasticity of the marginal utility of wealth with respect to wealth itself. Relative risk aversion can be decreasing, increasing or constant. In the latter case, changes in the responsiveness of utility to wealth remain the same across levels of wealth.

The last important tenet of EUT is asset integration, by which individuals make decisions based on their total wealth. This means that an individual will accept a prospect if the utility resulting from integrating it with her wealth exceeds the utility of the original amount of wealth held:

$$U(w + x_1, p_1; ...; w + x_n, p_n) > u(w) \tag{5}$$

Consequently, the domain of the utility function is final states, rather than gains and losses (Kahneman and Tversky, 1979).

### III.1.2 Alternative Theories

EUT was not seriously challenged until Daniel Kahneman and Amos Tversky published a series of seminal papers (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992) introducing Prospect Theory (PT). The new theory was an attempt to address some of the observed inconsistencies of EUT (*e.g.* Allais [1953] paradox) and to incorporate insights from the psychology literature in order to explain risky decision making. The most salient features of PT are, first, that risk preferences are defined in the domain of gains and losses, rather than total wealth; and, second, that the utility derived from each possible outcome of a prospect is multiplied by a decision weight, not by additive probability as in EUT (*i.e.* equations [1] and [2]).

To see these differences, let us characterise formally PT, following the notation and assumptions of its most refined version: Cumulative Prospect Theory or CPT (Tversky and Kahneman, 1992). Under CPT, individuals maximise $v : X \to \mathbb{R}$, where $X$ is a set of monetary outcomes, with 0 representing the neutral outcome, positive numbers denoting gains relative to the neutral outcome and negative ones representing losses. Let $S$ be a finite set of states of the world, only one is assumed to take place, which is unknown to the decision maker. An uncertain prospect $f$ is a function from $S$ to $X$ that assigns to each state $s \in S$ a consequence $f(s) = x$ in $X$. The outcomes $x_i$ of the prospect are arranged in ascending order, $x_{-m}, \ldots, x_0, \ldots, x_n$, where outcomes indexed $-m$ to $-1$ denote losses, 0 is the neutral outcome, and 1 to $n$ represent gains. All positive outcomes, comprised in $f^+$, are multiplied by the decisions weights $\pi^+(f^+) = (\pi_0^+, \ldots, \pi_n^+)$; which, in essence, indicate the likelihood of a particular outcome for the decision maker. Analogously, all negative outcomes in $f^-$ multiply the corresponding decision weights $\pi^-(f^-) = (\pi_{-m}^-, \ldots, \pi_0^-)$.[5]

The additivity of the value function for both gains and losses allows us to write it as follows:

$$V(f) = V(f^+) + V(f^-) = \sum_{i=0}^{n} \pi_i^+ v(x_i) \;+\; \sum_{i=-m}^{0} \pi_i^- v(x_i) \tag{6}$$

[5] $\pi_0^+$ and $\pi_0^-$ are in fact redundant since $v(x_0) = v(0) = 0$.

In the case of risky prospects governed by a probability distribution $p_i$, decision weights can be defined in the following way:

$$\pi_n^+ = w^+(p_n), \tag{7}$$

$$\pi_{-m}^- = w^-(p_{-m}), \tag{8}$$

$$\pi_i^+ = w^+(p_i + \ldots + p_n) \; - \; w^+(p_{i+1} + \ldots + p_n), \quad 0 \le i \le n-1, \tag{9}$$

$$\pi_i^- = w^-(p_{-m} + \ldots + p_i) \; - \; w^-(p_{-m} + \ldots + p_{i-1}), \quad 0 \le i \le n-1 \tag{10}$$

The strictly increasing function $w$ transforms probabilities $0 \le p_i \le 1$ into weighted probabilities $w^+(p_i)$ and $w^-(p_i)$, satisfying $w^+(0) = w^-(0) = 0$ and $w^+(1) = w^-(1) = 1$ (Verschoor and D'Exelle, 2018). The weighted probabilities ultimately become decision weights following the process described by the equations above, which shows that the decision weight $\pi_i^+$ is the difference between the weighted probabilities that the outcome is as good as $x_i$ and that it is better than $x_i$ (eq.[9]). The rule applies to all positive outcomes save for the best one, which is simply equal to its own weighted probability, $w^+(p_n)$. Likewise, the decision weights for a negative outcome—with the exception of the lowest (eq.[8])—are the product of a difference, in this instance between the weighted probabilities that the outcome is as low as $x_i$ and that it is lower than that (eq.[10]).

A broad description of individual's behaviour under PT is that risk aversion is prevalent for gambles involving gains, as in EUT, but not for losses, where people tend to be risk seeking (Kahneman and Tversky, 1984). In other words, the value function is concave for gains but convex for losses. In addition, the function is steeper for losses than for gains, indicating that losses loom larger than gains. The second salient behavioural pattern arising from PT is that the transformation of the probabilities described above results in individuals overweighting small probabilities and underweighting moderate to high probabilities (Kahneman and Tversky, 1979).

Paraphrasing the title of Starmer's (2000) review on the topic, the 'hunt' for a descriptive theory of choice under risk is yet to be completed, despite the abundance of alternative explanations. The empirical literature has not been able to tip the scales in favour of any particular theory. In a multi-country study, Harrison *et al.* (2010) conduct an analysis of experimental evidence collected from risky choice experiments with poor subjects in Ethiopia, India and Uganda. They report that over half of their sample behaves in accordance to EUT and the rest subjectively weight probability according to PT. Their results are robust to the use of different estimation models accommodating both theories. The authors take on these findings is that both theories might be correct: some people behave according to EUT, while others decide consistently with PT.

More recently, Kőszegi and Rabin (2006, 2007) have proposed reference dependent utility theory (RDUT), which attempts to marry EUT and PT, where utility is derived both from changes to and from levels of wealth. The theory conforms with PT the more gain-loss utility matters for decision making compared with wealth utility, which would lead, in contrast, to a pattern of behaviour that follows the principles of EUT.

Although not the primary concern of our enquiry, in the face of such theoretical diversity, empirical tests of the kind proposed here can shed some light over the debate; testing under which theory preferences matter for actual risk-taking decisions. In our case, given the underlying assumption of narrow bracketing (Verschoor *et al.*, 2016), which involves that decisions are taken in isolation and not in combination, statistical validation of the partial correlation between risky choice and preferences elicited experimentally can be interpreted as evidence in support of the postulations of PT or RDUT; as these theories nest choice bracketing, as opposed to EUT.

## III.2 Model

In this section, a model of farming household behaviour is developed to assess the importance of wealth and risk in agricultural investment, and how risk preferences play a role in determining the extent of the latter factor. This theoretical representation of the decision making process of investment is a simplified version of the model devised by Karlan *et al.* (2014). It includes two periods, production, risk and the insurance market.

### III.2.1 Basic Setting: Perfect Risk Pooling

The model starts with a perfect insurance market and then shuts it down to evaluate how lack of resources and uninsured risk alters investment behaviour. Subsequently, it will be demonstrated how investment decisions are more affected for those who exhibit a higher degree of risk aversion.

Household's preferences over consumption are defined as follows:

$$V = u(c^0) + \theta \sum_{s \in S} \pi_s u(c^1_s),\ \theta > 0 \tag{11}$$

where $u(c^0)$ and $u(c^1)$ represent household consumption in the first and in the different states of the world that can occur in the second period, respectively; $\pi_s$ is the probability of state s to occur, and $\theta$ is the time preference. The household has access to a market in which it can exchange a risk-free asset, $a$, that earns (or pays) an interest rate $R$ equal to $1/\theta$.

We start by assuming perfect *ex-post* risk pooling through an informal insurance arrangement, which operates in a way that every household consumes the expected value of its second period consumption in any realised second period state.

The farmer produces with technology characterised by the function $f_s(\boldsymbol{x})$, assumed to be strictly concave and to satisfy the Inada conditions, which provides a second period output in state $s$ given the farmer's input choices in the first period, represented by vector $\boldsymbol{x}$.[6]

There are only two states of the world, good and bad ($s \in G, B$), and two types of inputs, a risky input (*e.g.* fertiliser) and a hedging input, such that the marginal return of the risky input ($x_r$) is lower in state $B$ than in $G$, whereas the opposite is true for the hedging input ($x_h$). Both inputs cost the same, 1 unit. In order to simplify matters and show more clearly the difference between the two inputs, let us assume that the marginal return to $x_r$ is naught in state $B$ and similarly for $x_h$ in $G$, that is, $f_G(\boldsymbol{x}) = A_G f(x_r)$ and $f_B(\boldsymbol{x}) = A_B f(x_h)$, with $A_G > A_B$, where $A_s$ is the marginal productivity of the investment decisions in each state.

The per period budget constraints are given by:

$$\begin{aligned} c^0 &= Y - x_r - x_h - a \\ c^1_G = c^1_B = c^1 &= \sum_{s \in S} \pi_s (f_s(\boldsymbol{x}) + Ra) \end{aligned} \tag{12}$$

where $\boldsymbol{x} \geq 0$ and $Y$ is the exogenous amount of wealth the household starts off in the first period.

As noted, we are assuming perfect risk pooling, which operates as a transfer system, where, if she suffers the bad state of the world, the farmer receives:

$$[\pi_G f_G(\boldsymbol{x}) + \pi_B f_B(\boldsymbol{x})] - f_B(\boldsymbol{x}) \tag{13}$$

and when she enjoys the good state, she makes a transfer to the pool equal to:

$$f_G(\boldsymbol{x}) - [\pi_G f_G(\boldsymbol{x}) + \pi_B f_B(\boldsymbol{x})] \tag{14}$$

Under this assumption, the household maximises equation (11) subject to (12) choosing the optimal amount of inputs $x_s$, so that farm investment satisfies:[7]

[6] The conditions for the production function are: $f_s(\boldsymbol{x}) = y$, $f_s'(\cdot) > 0$, $f_s''(\cdot) < 0$ and $f_s(0) = 0$, $f_s'(0) = \infty$, $f_s'(\infty) = 0$.

[7] See Appendix A for the derivation of expression (15).

$$\pi_G A_G \frac{\partial f(\boldsymbol{x})}{\partial f(\boldsymbol{x_r})} = \pi_B A_B \frac{\partial f(\boldsymbol{x})}{\partial f(\boldsymbol{x_h})} = 1 \tag{15}$$

The equation shows that farmer's production satisfies that marginal productivity is equal to marginal cost. Therefore, with full risk-pooling, farm investment is independent of resources ($Y$) and consumption preferences, being fully determined only by the characteristics of the production function and the price of the inputs.

### III.2.2 No Risk Pooling

Let us now drop the assumption of perfect informal insurance, and assume the opposite, that there is none; so that $c_s^1 = f_s(x) + Ra$. The household chooses the amount of the risky input $x_r$ such that:[8]

$$R\left[\frac{\pi_B}{\pi_G}\frac{u'(c_B^1)}{u'(c_G^1)} + 1\right] = \frac{\partial f_G(\boldsymbol{x})}{\partial x_r} \tag{16}$$

The amount of the safe input $x_h$ so that:

$$R\left[\frac{\pi_G}{\pi_B}\frac{u'(c_G^1)}{u'(c_B^1)} + 1\right] = \frac{\partial f_B(\boldsymbol{x})}{\partial x_h} \tag{17}$$

And the risk-free asset $a$ to hold so that:

$$u'(c_0) = \pi_B u'(c_B^1) + \pi_G u'(c_G^1) \tag{18}$$

When insurance is absent and $f_G(\boldsymbol{x}) > f_B(\boldsymbol{x})$:

$$\pi_G \frac{\partial f_G(\boldsymbol{x})}{\partial x_r} > R > \pi_B \frac{\partial f_B(\boldsymbol{x})}{\partial x_h} \tag{19}$$

The reason for this is that $u(c_G^1) > u(c_B^1)$ given that $f_G(\boldsymbol{x}) > f_B(\boldsymbol{x})$; as a result, $u'(c_G^1) < u'(c_B^1)$, which makes $\frac{u'(c_B^1)}{u'(c_G^1)} > 1$ and $\frac{u'(c_G^1)}{u'(c_B^1)} < 1$.

Therefore, in comparison with perfect risk pooling, there is overinvestment in the hedging input and underinvestment in the risky input with respect to the profit maximising amount. The reason for this is that the marginal product of the risky input $x_r$ is greater than the return to the risk-free asset $R$ and the marginal product of the safe input $x_h$, a sign that the riskier input is not being used as much as it should for profit maximisation.

[8] See Appendix A for the first-order conditions for the three inputs.

### III.2.3 Interventions: Capital and Insurance

To ascertain the role of wealth and risk preferences, let us suppose that farmers are subject to two distinct interventions simultaneously. They enjoy an exogenous increase in wealth (*e.g.* are given a grant), $k$, and obtain a formal insurance policy that partially compensates them for their losses if the bad state occurs with a payout $k_B$. The household will maximise eq.(11) now subject to:

$$c^0 = Y - x_r - x_h - a + k \tag{20}$$

$$c^1 = \sum_{s \in S} \pi_s (f_s(\boldsymbol{x}) + Ra + k_s) \tag{21}$$

The inclusion of the two interventions in the model does not alter the conclusions about investment with perfect risk pooling, since none of the interventions will have an effect on investment (see Eq.[15]):

$$\frac{dx_r}{dk} = \frac{dx_r}{dk_s} = \frac{dx_h}{dk} = \frac{dx_r}{dk_s} = 0 \tag{22}$$

However, the situation changes with incomplete insurance, yet only when the farmer's utility function displays decreasing absolute risk aversion (DARA), by which individuals show greater risk aversion at lower levels of wealth.

Let us first assume that $u(\cdot)$ conforms with Constant Absolute Risk Aversion (CARA). We call $\{a^*, x_r^*, x_h^*\}$ the values of the endogenous variables that solve eqs.(16), (17) and (18) when $k = 0$. As shown by Karlan *et al.* (2014), if $u(\cdot)$ is CARA then the investment in either the risky input $x_r$ or the hedging input $x_h$ is invariant with respect to the capital grant; however, the amount invested in the risk-free asset ($a$) increases with the capital grant $k$, that is, $a^{*k} > a^*$. The solutions $\{a^{*k}, x_r^*, x_h^*\}$ are optimal when $k > 0$ because the difference between consumption in the good and bad state at the optimal solution is:

$$c_G^1 - c_B^1 = f_G(\boldsymbol{x}^*) - f_B(\boldsymbol{x}^*) - k_B \tag{23}$$

Therefore, the ratio of utilities in equations (16) and (17) is not affected by $k$. Conversely, an increase in the payout in the bad state ($k_B$) increases investment in the risky input. This follows from the fact that there is a greater difference between $c_G^1 - c_B^1$ with than without $k_B$, which, in turn, decreases the left hand side (LHS) in eq.(16) through its negative effect on the ratio of the marginal utilities of consumption in the good and bad states, $\frac{u'(c_B^1)}{u'(c_G^1)}$.[9] The decrease in the LHS of eq.(16) leads similarly to a reduction in the

[9] As a result of the fall in the difference between $c_G^1$ and $c_B^1$:

RHS ($\frac{\partial f_G(\boldsymbol{x})}{\partial x_r} = f'_G(x_r^{*,\,k_B}) < 0$). This result implies that the marginal product of the risky input is smaller with than without partial formal insurance: $f'_G(x_r^{*,\,k_B}) < f_G(x_r^*)$, which means that $x_r^{*,\,k_B} > x_r^*$, due to the concavity of the production function. Therefore, we have that the presence of insurance encourages risky investment, $\frac{dx_r}{dk_B} > 0$, yet an increase in wealth has no effect with CARA preferences, $\frac{dx_r}{dk} = 0$.

By contrast, under DARA, values $\{a^{*k}, x_r^{*k}, x_h^{*k}\}$, with $x_r^{*k} > x_r^*$ and $x_h^{*k} < x_h^*$, solve eq.(16)-(18). The increase in investment in the risky input and the drop in the hedging input follows from the fall in the absolute degree of risk aversion as consumption in the bad state ($c_B^1$) increases (and $c_B^1$ increases with $a^{*k}$). Consequently, under imperfect insurance and DARA we have:

$$\frac{dx_r}{dk}, \frac{dx_r}{dk_B} > 0 \tag{24}$$

Different mechanisms underlie the positive effect of the cash grant and the insurance payout on risky investment. The grant increases available cash, enabling higher savings in the safe asset and thus consumption in either state of the second period. With decreasing risk aversion, this means higher investment in the risky input. As for insurance, it increases consumption in the bad state of the second period, which implies greater investment in the risky input. We can therefore conclude that higher consumption in the second period—made possible by both interventions—enables greater investment in the risky input, given that, under DARA, higher guaranteed consumption means a reduction in risk aversion and a better disposition towards risky investment.

The measure of risk aversion used in the analysis is derived assuming that farmers risk preferences are characterised by a power Constant Relative Risk Aversion (CRRA) utility function, by which the elasticity of the marginal utility of wealth with respect to wealth itself is constant. As it follows from standard utility theory, a constant relative utility function implies decreasing absolute risk aversion (Pratt, 1964), the necessary assumption in the above proof.

The model has therefore demonstrated that farmers operating under risk—with imperfect insurance markets—underinvest in risky enterprises. It has also shown that an exogenous increase in wealth or the provision of insurance can, to some extent, reverse this behaviour; yet only if the agent's are risk averse and their aversion decreases with wealth. The extent of these effects will vary depending on the degree of risk aversion, which therefore matters in the investment decision making process.

With the theoretical underpinnings of this investigation in place, we can now devise the empirical strategy to examine how our variables of interest affect the risky decision phenomenon we seek to explain.

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$\downarrow c_G^1 - c_B^1 \Longrightarrow \downarrow u'(c_B^1) - u'(c_G^1) \Longrightarrow \downarrow \frac{u'(c_B^1)}{u'(c_G^1)}$.

# IV Data

## IV.1 Area of Study

The analysis in this paper employs a representative sample of 1,803 individuals, most of them farmers, from a rural region in Eastern Uganda. This region, located in the Greater Mbale area, comprises the districts of Sironko and Lower Bulambuli, formerly known as Sironko District.[10] The area is close to the Kenyan border, and benefits from substantial, bimodal rainfall, determining the two cropping seasons around which farmers organise their activities (Humphrey and Verschoor, 2004a). The first, and main season, spans approximately from the beginning of March until the end of the first half of the year, whereas the second goes from the end of July until the end of November. The area is estimated to be inhabited by around 300,000 people, with a large majority of the population having a Bagisu ethnical background and professing some form of Christianity (UBOS, 2014; Verschoor *et al.*, 2016).

Table III.1 below shows descriptive statistics from the representative sample of the area.

**Table III.1: General Descriptives$^{\Psi}$**

| Variable | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| Gender (1=Male) | 0.51 | 0.5 | 0 | 1 |
| Age | 40 | 14 | 18 | 73 |
| Education (years) | 6 | 3 | 0 | 13 |
| Married | 0.8 | 0.4 | 0 | 1 |
| Size Households | 5.85 | 2.73 | 1 | 19 |
| Bagisu Ethnicity | 0.95 | 0.22 | 0 | 1 |
| Christian | 0.91 | 0.28 | 0 | 1 |
| Farmer | 0.82 | 0.39 | 0 | 1 |
| Land holdings | 1.72 | 3.3 | 0 | 75 |

$^{\Psi}$ Sample weights employed.
Sample size: 1,802 households.
Source: Authors' calculations (2012).

Most people are married and scarcely educated, with barely 5 years of formal education. Household size averages almost six members, and half of them are estimated to be dependents. People in this area are primarily farmers of their own land, 98 percent of households cultivate some land and 82 percent report working on the household farm as their primary activity. The remainder of the population typically grows crops as a secondary activity alongside running their own businesses. However, land holdings are small, at around 1.7 acres on average, with few big farmers living in the area.

[10] A map of the area can be found in Appendix A of Pérez-Viana (2019a).

## IV.2 Sample Selection and Fieldwork Implementation

The selection of the study sample, carried out between July and August of 2012, followed a multi-stage cluster sampling strategy to obtain a representative sample of the population in the study area. A total of 10 sub-counties were randomly selected from the 21 eligible in the former Sironko district area. Within this 10 sub-counties, 10 villages were selected out of the total number of villages in each sub-county (with an overall pool of 648 villages). As a result of this process, a total of a 100 villages were randomly chosen. In each of these villages, a list of all adults (18+) by household was compiled and up to 20 adults, provided they belonged to different households, were randomly drawn from the list.[11] Given this sampling design, the probability of a household being selected for the study can be written as:

$$p_i j = \frac{s}{S} \times \frac{v_i}{V_i} \times \frac{h_{ij}}{H_{ij}} \tag{25}$$

where $s/S$ is the ratio of the sub-counties in our sample to the total number of sub-counties in the representative area, $v_i/V_i$ is the ratio of the villages from sub-county $i$ in our sample to the total number of villages in sub-county $i$, and $h_{ij}/H_{ij}$ is the ratio of the households in our sample from village $j$ in sub-county $i$ to the number of households in that village $j$ in sub-county $i$. The probability of selection was used in generating the weights that reflect the sampling method described, which were employed to produce the general descriptives above (Table III.1) and the summary statistics (Table III.3) describing the variables featured in the econometric analysis presented below. On account of this sampling process, all the summary statistics presented are unbiased estimates of the population statistics in the study area.

Data collection took place between September and December of 2012.[12] Every week the survey team visited all the participants in the sub-county to administer the household survey; subsequently, at the end of the week, risk preferences were elicited from all participants through experimental games held at a central location. Attrition was low, with more than 90% of the selected participants taking part in the study.

[11] Villages with fewer than 20 eligible adults were fully sampled.

[12] The candidate supervised the fieldwork and collaborated in the design and implementation of the sampling strategy.

## IV.3 Study variables

### IV.3.1 Investment

The literature on technology adoption in agriculture boasts a wide variety of measures to capture investment. However, use of modern inputs and adoption of new crops are the proxies that feature most heavily in the empirical research reviewed earlier. For several studies the embodiment of investing in adoption is the purchase and cultivation of a new crop mostly for commercial purposes. For example, Conley and Udry (2010) study the adoption of pineapple in Ghana, and Bandiera and Rasul (2006) follow suit with sunflower in Mozambique. Other studies look at the adoption of new (high yielding) varieties, like Suri (2011) with hybrid maize in Kenya, and Munshi (2004) focusing on the diffusion of new varieties of rice and wheat during the Green Revolution in India. Similarly, a host of studies investigate fertiliser uptake in different regions of sub-Saharan Africa where its use is low, making fertiliser the most studied single input in the literature (*inter alia*, Croppenstedt *et al.*, 2003; Duflo *et al.*, 2008b; Dercon and Christiaensen, 2011; Karlan *et al.*, 2014).

The literature relating risk preferences with adoption follows a similar pattern. Liu (2013) employs the adoption of a modern crop variety as their dependent variable; although, as noted above, labelling this decision as a risky choice can be called into question. Knight *et al.* (2003) select as their regressand whether the farmer uses any modern input or crop. However, the experts consulted in this research project advised against choosing such indicator. They argued that occasional adoption of modern inputs was a behaviour often displayed by traditional farmers engaged to a large extent in semi-subsistence agriculture, but who still try out new possibilities at a very small scale.

Due to the wide variety of depictions of investment and the importance of the local context, we sought to obtain a meaningful measure of risky investment in technology adoption for our area of study to avoid being misled by representations that may not reflect the phenomenon studied. To this end, 29 local experts were interviewed and asked to identify investments that would help farmers improve the income and productivity of their farms, but which also entailed the possibility of a severe negative outcome if the investment failed.[13] One of the salient categories highlighted by the experts was the growing of cash crops, which they limited to a specific list of crops grown in the area: coffee, tomatoes, onions, cabbage and egg plants (*i.e.* aubergine). Additionally, each of these crops should be farmed in combination with a specific set of inputs to truly deem the farmer as a market-oriented investor. As such, coffee should be grown using either fertiliser or hiring extra labour, and the rest of the crops require a combination of

[13] The group of experts comprised members of farmer associations, local officials and, especially, agricultural extension officers (AEOs) at the district and sub-county level.

improved seeds and use of fertiliser and pesticides. Farmers who grow any of these crops with the recommended inputs where considered by the experts as commercially-minded investors.

Given the representation of adoption in the literature and the insights of the classification of farmers provided by the experts, we decided to use two different variables in the analysis: purchase of fertiliser and growing cash crops (*i.e.* those who grow any of the above-mentioned crops in combination with purchasing the right inputs). Both variables capture risky investment decisions, the essence of the behaviour the analysis intends to elucidate. These choices are profitable on average but can potentially leave the farmer worse-off than before embarking on them under some scenarios.

Verschoor *et al.* (2016) report detailed profitability calculations for the area of study backing these claims, which will not be reproduced here. They collected data on the extra investment required for each of the farming strategies implied by the second proposed dependent variable (*i.e.* growing selected crops plus inputs), as well as price and yield fluctuations for the crops involved, in order to calculate the expected value and variance of profits. Their results show the existence of worse-worst and better-best outcomes, confirming the higher expected value and variance of the investment returns.

As for the purchase of fertiliser, this input has long been considered an iconic example of risky investment in the literature. Although profitable on average, in some circumstances such as low output prices or a harvest failure, it may leave the farmer worse off than without buying it (Duflo *et al.*, 2008a). The same conclusion holds true in our area, as shown by the profitability calculations in Verschoor *et al.* (2016), where losses can amount to as much as 30% of what an average household needs in order to subsist.

### IV.3.2 Risk Preferences

The key variable of interest in our study are risk preferences and, consequently, the method chosen to elicit them becomes of great import. A wide variety of methods are employed to elicit attitudes towards risks in experimental economics (see Harrison and Rutström [2008] for a comprehensive review), each with its virtues and shortcomings. For example, Liu (2013) employs the Tanaka *et al.* (2010) adaptation of the multiple price list (MPL) method developed by Holt and Laury (2002), which allows for the elicitation of three parameters, nesting both EU and PT theories of risky decision making. MPL involves presenting the participant with an ordered array of paired lotteries or gambles, and asking the subject to pick one of the gambles on offer in each case; subsequently, the experimenter randomly selects and plays one of the gambles out for the subject to be rewarded (Harrison and Rutström, 2008).

The use of this method has been heavily criticised in the context of lab-in-the field experiments in developing countries (Charness *et al.*, 2013). The main critique stems from the distinct possibility that risk preferences elicited in experiments employing complex methods with scarcely educated participants may be unreliable, due to lack of understanding. Charness *et al.* (2013) provide evidence that subjects in these contexts commonly make inconsistent choices that compromise parameter estimation. They equally criticise the alternative addressing this issue, consisting in enforcing a unique switching point between the binary options of the lotteries (employed by Tanaka *et al.* [2010] and Liu [2013]). The authors maintain that having a single switch point not only imposes added assumptions on preferences (which may or may not hold), but also permits that confused individuals, who would have made inconsistent choices if they were permitted to switch freely, are seen as having chosen consistently, making the data even more noisy.

Another well-known elicitation method is the ordered lottery selection design developed by Binswanger (1980, 1981). Here each subject is presented with a choice of several lotteries and asked to pick one. The first available choice is a safe option, offering a certain amount, and all other choices increase the average payoff but with increasing variance (Harrison and Rutström, 2008). An adapted variant of this method was used by Vargas Hill (2009). However, this elicitation tool does not accommodate as large an array of choices as the method chosen for this paper and, therefore, it does not provide such a precise estimate of risk aversion.

In the present study, risk preferences were elicited through the Gneezy and Potters (1997) method. Participants were endowed with 20 counters, representing 400 Shillings each, making up a total amount of 8,000 Shillings, equivalent to twice average daily earnings in the area.[14] Participants could choose to invest $k$ counters, where $k \in \{0, 1,..., 20\}$, in the lottery (0.5, 8,000-400$k$; 0.5, 8,000 + 800$k$), in such a way that their investment was tripled if they won or was lost when they were not successful, an outcome determined by the toss of a coin.[15] In order to calculate the risk aversion parameter that characterise the subjects' choices, a CRRA utility function is assumed over earnings from the game $x$:

$$U(x_i) = \frac{x_i^{1-r}}{1-r} \tag{26}$$

where $r$ is the CRRA coefficient, whose range is estimated by computing for indifference between investing $k$ and $k$-1, on the one hand, and $k$ and $k$+1 counters, on the other. The value of the coefficient at each boundary is, therefore, that which makes equal the value function for investing $k$ and $k$-1 or $k$+1 counters, respectively. The value function at the bound ($q_i$) is defined as:

[14] The Ugandan Shilling (UGX) is the official currency of the Republic of Uganda. At the time of the study $1 could be exchanged for approximately 2,600 UGX.

[15] Experimental instructions can be found in Appendix A of Verschoor *et al.* (2016).

$$V(q_i) = \sum p_j \times U(x_i) \tag{27}$$

Following Binswanger (1980), the geometrical mean of the range was used as the parametrical measure of risk aversion.

Among the benefits of this elicitation method with respect to others are its simplicity, and the narrower range of risk aversion corresponding to each choice. Its main disadvantage is that it can only elicit one parameter of risk preferences (*i.e.* risk aversion), and that it does not involve losses unlike real-life investments; drawbacks shared with most of the elicitation methods applied in the literature.[16] Nevertheless, investing in the game is still riskier than not investing, similarly to our dependent variables of investment in adoption. Also, the incentivised measure of risk aversion was only obtained for a subsample of the total number of participants in the study.

With the aim of overcoming the mentioned issues, a hypothetical measure of risk preferences is also included in the analysis. This additional gauge of risk preferences was obtained through an investment question in which subjects were asked how much of an endowment of 100,000 UGX they were willing to invest, $y \in \{ 0; 20{,}000; 40{,}000; 60{,}000; 80{,}000; 100{,}000\}$, in an asset that yielded a return of 100 percent if successful and minus 50 percent in case of failure. The resulting measure was given an ordinal treatment, with 1 representing the riskiest choice and 6 the safest one.

### IV.3.3 Other Variables

In order to investigate the relationship between risk preferences and agricultural investment we need to control for all those factors that might be associated with the investment decision. Some of these covariates may correlate with risk preferences and, consequently, their omission would prevent us from obtaining unbiased estimates of the link between risk preferences and adoption, all else equal.

Among the key covariates, wealth stands out. It is well established that larger and wealthier farmers are more likely to invest in new technologies than poorer households in developing countries (Foster and Rosenzweig, 2010). Vargas Hill (2009) argues, in the context of Uganda, that when credit and insurance markets are incomplete, wealth determines the household's ability to deal with income fluctuations and access to the limited credit that might be available, which is likely to be heavily collateralised. Her measure of wealth, however, only comprises liquid and land wealth, leaving out many significant assets. In spite of its patent endogeneity, Liu (2013) uses an ex-post measure

[16] Even though losses could not occur in the game, participants were given a voucher, which entitled them to receive 8,000 Shillings three weeks prior to the experimental day. The aim was that participants considered the endowment as part of their own wealth and internalised the losses.

of durable goods collected some years after the beginning of the adoption process of the technology. The measure used in the econometric analysis below is based on a principal components analysis (PCA) of a comprehensive list of household assets reported by the participants in the study, a method for wealth estimation based on the seminal work of Filmer and Pritchett (2001). Details of the methodology employed and results of the analysis can be found in Appendix B.

A closely related covariate of investment in adoption is access to credit, given the likely up-front costs agents have to face. Thus, we would expect that farmers who have access to the credit market invest more. The measure of access we employ is whether the farmer was unable to borrow despite expressing a wish to do so in the last two years. This is a self-reported indicator of credit access and suffers from the likely shortcomings mentioned while reviewing the literature. Liu (2013) and Vargas Hill (2009) also include a measure of access to credit, although the former does not specify which and the latter proxies it by how many people the farmer can ask for help.

Education is also included in the empirical models estimated for the reasons outlined earlier, which have led to the common finding that more educated farmers are more likely to invest and adopt new technologies (Foster and Rosenzweig, 2010). It is measured as total number of years of formal education of the decision maker interviewed.

Other personal characteristics are controlled for too. With regard to gender, a number of studies find that men are less averse to financial risk than women (Binswanger, 1980; Tanaka *et al.*, 2010). Age is another factor commonly featured in empirical models as it is hypothesised to be correlated with risk taking behaviour (Vargas Hill, 2009), although the sign of its effect is unclear. Some think that older farmers may be expected to be more risk averse than younger farmers (Knight *et al.*, 2003), while others consider that more experienced farmers may display a better attitude to trying new treatments on their farms (Feinerman and Finkelshtain, 1996).

Household characteristics are similarly taken into account. The empirical model includes a proxy for available labour in the farm, measured as the size of the household workforce. Liu (2013) employs this indicator under the hypothesis that households who have a smaller workforce are more likely to adopt the new technology. Contrarily to Liu's hypothesis, Knight *et al.* (2003) consider that households with a bigger workforce are less risk averse, and therefore more inclined to invest. Whether the household has any member working in non-agricultural related activities is also a covariate in the model, its inclusion is due to Lamb's (2003) finding that households with members having off-farm employment use more fertiliser in their farms.

The related literature on small-holder market participation highlights some important factors that are also being taken on board, since market orientation is an important aspect of the technology adoption phenomenon studied. Key *et al.* (2000) introduce a distinction between fixed or lump sum transaction costs, on the one hand, and variable or per-unit transaction costs on the other. They show that both fixed and variable transaction costs influence the market participation decision. As Heltberg and Tarp (2002) state, transaction cost are, at best, only partially observable. These authors proxy fixed transaction costs by variables that represent ability to process information, like ownership of information assets (e.g. radio, TV or telephone). As for the variable transaction costs, they are represented by indicators capturing transport costs like ownership of transport assets. All these variables are included in the analysis.

In line with the latter covariates, an infrastructure variable is added in the shape of distance from the market. Suri (2011) finds strong correlation between farmer's heterogenous returns for the technology studied (*i.e.* hybrid maize) and infrastructure variables, among them, distance to a motorable road. The model estimated here employs a measure of the distance in minutes to the nearest daily market.

A further variable added to capture the full extent of access to information available to farmers in the area is contact with agricultural extension officers (AEOs). Agricultural research organisations and extension agents carry out controlled experiments with new seeds and can then determine with considerable precision the maximal possible yields (Foster and Rosenzweig, 1996). This is very useful information, which can help a farmer to become aware of the full potential for profitability of the investment options available.

Given the weight of the evidence about the risks to which small-holding farmers are subject in developing countries, several variables representing different types of shocks affecting the community where the farmers live are included. However, these measures of environmental risk may not be sufficiently informative, as they do not capture the intensity of the shocks undergone by the household.

Finally, location dummies are used to capture any remaining heterogeneity at the village level.

Brief descriptions of all the variables employed are presented in Table III.2.

**Table III.2: Variables Description**

| Variable | Abbreviation | Description |
|---|---|---|
| Fertiliser Purchased | *fertiliser* | Household (HH) purchased fertiliser in last 5 years (dummy) |
| Cash crops grown | *cash crops* | Farmers who grow cash crops with the necessary inputs (dummy) |
| Risk aversion (hypothetical) | *risk aver. (hypo.)* | Hypothetical willingness to invest measured in an ordinal scale (1 least risk averse to 6 most averse) |
| Risk aversion (experimental) | *risk aver. (exp.)* | CRRA coefficient of risk aversion, measure inferred from investment experiment |
| Wealth index | *wealth* | First principal component in a PCA of the HH's assets$^{\psi}$ |
| Credit constrained | *credit cons.* | HH did not borrow in last 2 years despite wanting to |
| Gender (female) | *female* | Participant is female (dummy) |
| Education (years) | *yeduc* | Participant's years of formal education |
| Age | age | Participant's age |
| Farm workforce | *workforce* | Number of HH members between 15 and 69 working at HH farm |
| Off-farm employment | *off-farm* | Any member of the HH has non-farm paid employment |
| Contact AES | *contact aes* | Participant had contact with any agricultural extension services in past 2 years (dummy) |
| Information assets | *info asset* | HH possesses assets for gathering market information (dummy) |
| Distance to market | *distance market* | Distance to the nearest daily market in hours |
| Transport assets | *transport assets* | HH possesses transport assets (dummy) |

$^{\psi}$ See details in Appendix B.

# V Empirical Framework

The main hypotheses put forward in the previous section can be tested through the following empirical model of investment in the fashion of Knight *et al.* (2003):

$$U_i(y) = \boldsymbol{X}_i\boldsymbol{\beta} + e_i \tag{28}$$

where $U_i$ is the net utility gain from making an investment $y$ in equation (28). $\boldsymbol{X}_i$ is a vector comprising those factors shown to matter in the theoretical model: risk preferences and asset wealth, and additionally, human capital endowments, farm and household characteristics, infrastructure, access to credit and information, shocks undergone by the household and location variables. $\boldsymbol{\beta}$ is the parameter vector, and $e_i$ is an independently and identically distributed household specific *ex-ante* shock. If $U_i > 0$, the household decides to invest, conversely, when $U_i \leq 0$ the household does not invest. Consequently, the probability of investment conditional on the vector of explanatory variables is:

$$P(y_i = 1|\boldsymbol{X}_i) = P(U_i > 0) \tag{29}$$

where $y_i$ is a binary indicator of investment, which equals one when the household decides to invest and zero otherwise. Equation (29) can, in turn, be written as:

$$P(y_i = 1|\boldsymbol{X}_i) = P(e_i > -\boldsymbol{X}_i\boldsymbol{\beta}|\boldsymbol{X}_i) \tag{30}$$

Assuming that $e_i$ is independent of $X_i$ and that it has a standard normal distribution, it follows, that $e_i$ is symmetrically distributed about zero, which means that $1 - \Phi(-z) = \Phi(z)$ for all real numbers $z$. Under the assumptions made, we can derive from (30) the response probability model for $y_i$:

$$\begin{aligned} P(y_i = 1|\boldsymbol{X_i}) &= 1 - \Phi(\boldsymbol{X}_i\boldsymbol{\beta}) \\ &= \Phi(\boldsymbol{X}_i\boldsymbol{\beta}) \end{aligned} \tag{31}$$

In order to estimate the probit model outlined in equation (31), it is necessary to employ maximum likelihood estimation (MLE), which readily accounts for the heteroskedasticity of the variance of $y_i$, given $X_i$, present in all limited dependent variable models (Wooldridge, 2013). To obtain the maximum likelihood estimator, we need the density function of investment, $y_i$, given $\Phi(\boldsymbol{X}_i)$, which can be written as:

$$f(y_i = 1|\boldsymbol{X}_i) = [\Phi(\boldsymbol{X}_i\boldsymbol{\beta})]^y[1 - \Phi(\boldsymbol{X}_i\boldsymbol{\beta})]^{1-y} \tag{32}$$

The likelihood function is defined as the product of the densities, however, for ease of computation the log-likelikehood function is employed, defined as follows:

$$lnL(\boldsymbol{\beta} = \sum_{i \in S} ln[\Phi(\boldsymbol{X}_i\boldsymbol{\beta})] + \sum_{i \notin S} ln[1 - \Phi(\boldsymbol{X}_i\boldsymbol{\beta})] \tag{33}$$

# VI Base Econometric Analysis

After providing the rationale for the variables employed in the analysis that follows and obtaining a better understanding of the data, this section tests the main hypotheses arising from the theoretical model. We do so by applying the empirical framework outlined above for the econometric analysis. Let us start, however, by examining some suggestive summary statistics.

## VI.1 Summary Statistics

### VI.1.1 Descriptives

Table III.3 presents summary statistics for the variables employed, computed using sample weights.

**Table III.3: Descriptives$^{\Psi}$**

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Fertiliser Purchased | 1776 | 0.647 | 0.478 | 0 | 1 |
| Cash crops grown | 1776 | 0.314 | 0.464 | 0 | 1 |
| Risk aversion (hypo.) | 1803 | 2.373 | 1.516 | 1 | 6 |
| Risk aversion (exp.) | 872 | 1.705 | 2.685 | 0.135 | 14.97 |
| Wealth Index | 1803 | -0.028 | 2.199 | -2.693 | 20.12 |
| Credit constrained | 1776 | 0.550 | 0.498 | 0 | 1 |
| Gender (female) | 1803 | 0.494 | 0.5 | 0 | 1 |
| Education (years) | 1803 | 6 | 3.431 | 0 | 13 |
| Age | 1803 | 40 | 13.74 | 18 | 73 |
| Farm workforce | 1803 | 2 | 1.205 | 0 | 8 |
| Off-farm employment | 1803 | 0.18 | 0.385 | 0 | 1 |
| Contact AES | 1803 | 0.386 | 0.487 | 0 | 1 |
| Information assets | 1803 | 0.766 | 0.423 | 0 | 1 |
| Distance to market (hrs) | 1803 | 0.394 | 0.612 | 0 | 3 |
| Transport assets | 1803 | 0.163 | 0.37 | 0 | 1 |

$^{\Psi}$ Sample weights employed.

$^{\Psi}$ Details of the variables can be found in Table III.2.

Source: Author's calculations.

In regard to our regressands, fertiliser was reportedly purchased by 65 percent of the population in the last 5 years, while only 31 percent grew cash crops with the recommended inputs, indicating that the latter is a stricter indicator of risky investment in agricultural technology.

The descriptives for the covariates provide some interesting insights, with perhaps the exception of the wealth indicator. Due to its indexed nature, our measure of asset holdings is not directly interpretable, the reader is compelled to look at Appendix B for detailed descriptives and commentary of the variables used to build the index.

The results for the risk aversion measure are by contrast very telling, with participants displaying a much higher risk aversion in the experimental setting rather than when faced with the hypothetical question. The mean CRRA coefficient is 1.70 in the game compared to just an estimated 1.06 for the survey question.[17]

More than half of the households in the area appear to be credit constrained. Ownership of information assets is high, but having contact with extension services is relatively rare. Households have a little more than two members working in the farm, and a low percentage (18%) of members are employed in non-farm related activities.

The correlation matrix between the dependent variables and the key variables of interest yield some revealing patterns (Table III.4). The regressands are significantly correlated among them, and both present an equally significant degree of correlation with wealth and risk aversion in ordinal form. By contrast, risk aversion experimentally measured is uncorrelated with any other variable; especially noteworthy is the lack of correlation between the two risk aversion measures.

**Table III.4: Correlation Matrix**$^{\Psi}$

| **Variable** | **Fertiliser** | **Cash crops** | **Risk aversion (hypo.)** | **Risk aversion (exp.)** | **Wealth** |
|---|---|---|---|---|---|
| Fertiliser | 1 | | | | |
| Cash crops | 0.4152* | 1 | | | |
| Risk aversion (hypo.) | -0.065* | -0.082* | 1 | | |
| Risk aversion (exp.) | -0.05 | -0.02 | -0.001 | 1 | |
| Wealth | 0.239* | 0.279* | -0.024 | 0.014 | 1 |

$^{\Psi}$ Sample weights employed.

* indicates significance at 5% level.

Both this matrix and the econometric analysis that follows are presented for the subsample (n=1,747) of participants who affirm making agricultural investment decisions in the

[17] The figure reported in Table III.3 corresponds to the ordinal version of the variable. For comparison purposes, we estimated the CRRA coefficient for the hypothetical question utilising the same methodology as for the experimental gauge.

household. Conversely, the summary statistics above were computed for the whole sample and are representative of the population studied.

### VI.1.2 Farmers Groups Descriptives

With the aim of improving the understanding of farming practices in the region of study, and shedding light on how farmers who invest in agricultural technology differ from those who do not, summary statistics for several relevant variables are presented for representative groups of farmers.

The general view of the agricultural experts consulted is that farmers can be broadly divided into two categories: those who stick to traditional semi-subsistence agriculture, and those who have become more market-oriented. The former category is characterised by solely growing maize intercropped with beans, and in same cases, coffee and cooking bananas on a very small scale.[18] The latter group is constituted by growers of crops that are cultivated for commercial purposes: coffee, tomatoes, onions, cabbages and aubergines.

In order to define meaningful groups of farmers to study, they should be grounded in the insights described above. Consequently, the first group (commercial 1 [C1]), representing the category of commercially-oriented farmers, is formed by all those who invest in cash crops (growing at least one of them). A second group (C2), more restrictively defined, grows cash crops, excluding coffee, since this crop is also cultivated by some traditional farmers at a small scale. Finally, the semi-subsistence category is made up of farmers (traditional [T]) who grow maize and beans intercropped and, perhaps by not necessarily, coffee and/or bananas.

With farmers classified in locally meaningful categories, let us examine some relevant statistics to obtain a clearer picture about the differences between commercial and traditional farmers in the area looking at Table III.5 below.

[18] Intercropping is a practice against which the experts advise.

**Table III.5: Farmers Groups**$^{\Psi}$

| **Farmer Group** | **C1** | **C2** | **T** |
|---|---|---|---|
| Improved seeds purchase | 0.88 | 0.96 | 0.66 |
| Fertiliser purchase | 0.73 | 0.9 | 0.39 |
| Pesticides purchase | 0.62 | 0.94 | 0.17 |
| Hiring labour | 0.54 | 0.62 | 0.32 |
| Cultivated land | 2.27 | 2.31 | 1.47 |
| Land holdings | 2.04 | 1.98 | 1.32 |
| Wealth index | 0.43 | 0.44 | -0.53 |
| Credit constraints | 0.52 | 0.49 | 0.61 |
| Female | 0.4 | 0.33 | 0.55 |
| Education | 6.15 | 6.21 | 4.88 |
| Age | 38.9 | 35.8 | 41.7 |
| Contact AES | 0.44 | 0.49 | 0.32 |
| Food insecure | 0.27 | 0.28 | 0.44 |
| **Observations** | **860** | **457** | **637** |

$^{\Psi}$ Sample weights employed.

The results in Table III.5 are suggestive. Those who grow crops likely to be sold rather consumed overwhelmingly exhibit higher rates of expenditure on the main inputs needed for production. This is particularly clear for group C2, which excludes coffee growers, a crop occasionally cultivated by traditional farmers. Almost the whole cohort of farmers purchase fertiliser, improved seeds and pesticides, and they hire labour to a much greater extent than any other group. These statistics indicate that farmers specialised in the growing of pure cash crops are real investors, as opposed to gamblers trying their luck; precisely, what we wish to capture through the composite dependent variable, growing cash groups with the recommended inputs. The findings coincide with the warning from the experts about the high risk of harvest failure when the mentioned cash crops are cultivated without inputs. By contrast, traditional farmers purchase modern inputs only marginally, as the crops they grow do not require such an intense use of these products (although they would still improve greatly their productivity).

The three categories of farmers described also differ in other basic characteristics: traditional farmers cultivate less land, report being more credit constrained, and are generally poorer. They are also more likely to have suffered from food insecurity at some point in the last two years.

All these descriptive results set the scene for the econometric analysis in the next section, aimed at establishing *ceteris paribus* relationships between investment in technology adoption and its hypothesised covariates.

## VI.2 Base Analysis

The following analysis presents results for two different kinds of models fitted utilising the empirical framework outlined above. The first type estimates the probability of purchasing fertiliser (Table III.6), whereas the second attempts to predict the likelihood of growing cash crops employing the right inputs (Table III.7).

For each of these models six different specifications are estimated (1 to 6). In the first two (1 and 2) the key independent variables are wealth and risk aversion measured parametrically according to behaviour in the investment experiment; however, participants in the game are only a sub-sample of the total sample. The first of these specifications (1) features only the key variables of interest, while the second (2) includes all the relevant covariates of investment controlled for. The two subsequent sets of specifications (3-4 and 5-6) follow the same pattern.

The second group of econometric models specified (3 and 4) utilises the hypothetical measure of risk aversion described earlier, instead of the experimental type. This measure originates from the hypothetical investment scenario previously described and is expressed in ordinal terms, taking a value from 1 to 6, with 6 denoting the highest degree of risk aversion.

Finally, the third set (5 and 6) continues to represent risk aversion with the hypothetico-ordinal measure, but these models are estimated only with the sub-sample of individuals who also participated in the experimental games. This is done to ensure that the results obtained for the previous two specifications are not merely an artefact of the sample size. All models control for village-level effects.

Specifications (1), (3) and (5) for the two types of models estimated can be expressed in equation form as:

$$y_{ij} = \alpha + \beta risk\ aver_{ij} + \theta wealth_{ij} + \eta_j + \varepsilon_{ij} \tag{34}$$

where $y_{ij}$ denotes either fertiliser purchase (Table III.6) or growing cash crops with the recommended inputs (Table III.7), and $\eta_j$ are the location dummies.

In turn, specifications (2), (4) and (6) can be written as:

$$y_{ij} = \alpha + \beta risk\ aver_{ij} + \theta wealth_{ij} + \boldsymbol{\delta X}_{ij} + \eta_j + \varepsilon_{ij} \tag{35}$$

where $\boldsymbol{X}_{ij}$ includes the covariates described in the data section: personal characteristics (gender, age, years of education), household features (workforce and off-farm employment), transaction costs (ownership of information and transport assets), access to credit (*i.e.* being credit constrained or not), distance to the market and shocks experienced.

Throughout the analysis, we implement a heteroskedasticity-robust estimator of the variance-covariance matrix.

The coefficient reported in Tables III.6 and III.7 are the estimated marginal effects at the means for each of the explanatory variables.

**Table III.6: Probit Regressions: Fertiliser Purchase$^{\Psi}$**

| **Specification** | **(1)** | **(2)$^{\psi}$** | **(3)** | **(4)$^{\psi}$** | **(5)** | **(6)$^{\psi}$** |
|---|---|---|---|---|---|---|
| Risk aversion (exp.) | -0.0145*** | -0.0138*** | | | | |
| | (0.0051) | (0.0047) | | | | |
| Risk aversion (hypo.) | | | -0.0291*** | -0.0173** | -0.0346*** | -0.0212** |
| | | | (0.0069) | (0.0069) | (0.0095) | (0.0096) |
| Wealth index | 0.0652*** | 0.0412*** | 0.0584*** | 0.035*** | 0.0628*** | 0.0397*** |
| | (0.0091) | (0.0106) | (0.00636) | (0.00710) | (0.00894) | (0.0104) |
| Credit constrained | | -0.0659** | | -0.0708*** | | -0.0622** |
| | | (0.0296) | | (0.0215) | | (0.0292) |
| Gender (1=female) | | -0.0264 | | -0.0296 | | -0.0215 |
| | | (0.0315) | | (0.0218) | | (0.0313) |
| Education (years) | | 0.0035 | | 0.0005 | | 0.0035 |
| | | (0.005) | | (0.0035) | | (0.005) |
| Age | | -0.0045*** | | -0.0035*** | | -0.0042*** |
| | | (0.0011) | | (0.0008) | | (0.0011) |
| Farm workforce | | 0.0153 | | 0.0108 | | 0.0141 |
| | | (0.0122) | | (0.0091) | | (0.0123) |
| Off-farm employment | | -0.0245 | | -0.0494* | | -0.0213 |
| | | (0.0404) | | (0.0284) | | (0.0403) |
| Contact AES | | 0.0696** | | 0.0737*** | | 0.0618** |
| | | (0.0308) | | (0.0223) | | (0.0309) |
| Information Assets | | 0.107*** | | 0.117*** | | 0.117*** |
| | | (0.0368) | | (0.0269) | | (0.0366) |
| Distance to market | | 0.454** | | 0.28* | | 0.399* |
| | | (0.215) | | (0.145) | | (0.219) |
| Transport Assets | | 0.0167 | | 0.0421 | | 0.0177 |
| | | (0.0435) | | (0.0319) | | (0.0428) |
| **N** | 830 | 816 | 1582 | 1561 | 830 | 816 |
| **Pseudo $R^2$** | 0.22 | 0.26 | 0.22 | 0.26 | 0.22 | 0.26 |

$^{\Psi}$ Marginal probability effects estimated at the means reported.
$^{\Psi}$ Details of the variables can be found in Table III.2.
$^{\Psi}$ Heteroskedasticity-robust standard errors reported in parentheses, $^{*}\ p < 0.1$, $^{**}p < 0.05$, $^{***}\ p < 0.01$
Dummies for village included but not reported in all specifications.
$^{\psi}$ Dummies for recent shocks included but not reported in specification.

**Table III.7: Probit Regressions: Growing Cash Crops with Recommended Inputs$^{\Psi}$**

| **Specification** | **(1)** | **(2)$^{\psi}$** | **(3)** | **(4)$^{\psi}$** | **(5)** | **(6)$^{\psi}$** |
|---|---|---|---|---|---|---|
| Risk aversion (exp.) | -0.0002 | 0.0011 | | | | |
| | (0.0052) | (0.0052) | | | | |
| Risk aversion (hypo.) | | | -0.0265*** | -0.0142** | -0.0278*** | -0.0173* |
| | | | (0.0069) | (0.007) | (0.0098) | (0.0099) |
| Wealth index | 0.0593*** | 0.0507*** | 0.0547*** | 0.0384*** | 0.0582*** | 0.0481*** |
| | (0.0074) | (0.0087) | (0.0057) | (0.0068) | (0.0075) | (0.0088) |
| Credit constrained | | 0.0296 | | -0.0131 | | 0.0274 |
| | | (0.0294) | | (0.0206) | | (0.0294) |
| Gender (1=female) | | -0.143*** | | -0.119*** | | -0.133*** |
| | | (0.0285) | | (0.0199) | | (0.0286) |
| Education (years) | | 0.0031 | | 0.0041 | | 0.00360 |
| | | (0.005) | | (0.0035) | | (0.005) |
| Age | | -0.0044*** | | -0.0036*** | | -0.0038*** |
| | | (0.0011) | | (0.0008) | | (0.0011) |
| Farm workforce | | -0.0023 | | 0.0027 | | -0.0039 |
| | | (0.013) | | (0.0089) | | (0.0129) |
| Off-farm employment | | 0.0025 | | -0.0147 | | 0.0023 |
| | | (0.0382) | | (0.0272) | | (0.0379) |
| Contact AES | | 0.024 | | 0.0439** | | 0.0214 |
| | | (0.0299) | | (0.0206) | | (0.03) |
| Information Assets | | 0.112*** | | 0.106*** | | 0.120*** |
| | | (0.0426) | | (0.0293) | | (0.0430) |
| Distance to market | | 0.178 | | -0.775** | | 0.161 |
| | | (0.160) | | (0.365) | | (0.162) |
| Transport Assets | | -0.0258 | | 0.0259 | | -0.0246 |
| | | (0.0398) | | (0.0301) | | (0.0398) |
| **N** | 780 | 768 | 1673 | 1650 | 780 | 779 |
| **Pseudo $R^2$** | 0.18 | 0.25 | 0.19 | 0.24 | 0.18 | 0.24 |

$^{\Psi}$ Marginal probability effects estimated at the means reported.
Details of the variables can be found in Table III.2.
$^{\Psi}$ Heteroskedasticity-robust standard errors reported in parentheses, $^{*}$ $p < 0.1$, $^{**}p < 0.05$,$^{***}$ $p < 0.01$
$^{\Psi}$ Dummies for village included but not reported in all specifications.
$^{\psi}$ Dummies for recent shocks included but not reported in specification.

The estimation results show that, somewhat surprisingly, risk aversion measured experimentally is only significant for the fertiliser purchase decision at conventional levels. By contrast, the hypothetical measure of risk aversion successfully predicts investment behaviour however measured and regardless of the sample size used.

This important result conforms with recent studies validating the capacity of survey or hypothetical measures of risk aversion to predict real-life risky behaviour (Dohmen *et al.*, 2011b; Hardeweg *et al.*, 2013). Verschoor, D'Exelle and Pérez-Viana (2016) rationalise this finding with a conceptual framework built around the notion of choice bracketing (Read *et al.*, 1999; Rabin and Weizsacker, 2009). The main thrust of their argument is that "the decision to buy fertiliser is a straightforward investment decision that raises both the expected profit and the spread of possible profits within an existing livelihoods strategy (...), which resembles the one-dimensional investment decision subjects are asked to take in the laboratory. Decisions to grow cash crops or to grow for the market more broadly, on the other hand, are complex, multi-dimensional decisions that invoke not only risk preferences but also the nebulous notion of entrepreneurship" (Verchoor *et al.*, 2016: 14). The latter notion can be better predicted by an all-around risk aversion measure like the hypothetical question. The authors argue that this can be explained by assuming that farmers narrowly bracket the decision of purchasing fertiliser, assimilating it to the experimental choice, but not other agricultural investment decisions considerably more complex.

Moreover, such difficult decisions—like growing cash crops—contain a strategic element which relates to the individual's entrepreneurial spirit, whose relationship with risk preferences has proven elusive. Elston *et al.* (2005) find that part-time entrepreneurs are more risk averse (experimentally measured) than non-entrepreneurs, while full-time time entrepreneurs were less risk averse than either, which suggests that heterogeneity in risk preferences among entrepreneurs may cloud its relationship with strategic investment decisions (Verschoor *et al.*, 2016). In addition, Verschoor *et al.* (2016) point out that risk-taking can be domain-specific, and that attitudes displayed in one domain may not necessarily correspond to those exhibited in every domain. Entrepreneurs could seek risks in strategic decisions yet be relatively cautious in operational ones, which resemble the experimental game more closely. Evidence of this heterogeneous behaviour was found by Hanoch *et al.* (2006), who showed that individuals engaging in gambling do not necessarily take more risk in other domains. Similarly, Dohmen *et al.* (2011b) find that a general willingness to take risks question is a better all-around predictor than more context-specific measures, which only correlate strongly with behaviour in the domain they relate to. Overall, we can conclude that the experimental measure is appropriate for capturing risky choice in those domains that are quite like it, where narrow bracketing can be expected (Verschoor *et al.*, 2016).

The discrepancy between the insignificant raw correlation coefficient of the investment measures and the risk aversion elicited experimentally, on the one hand, and the significant regression coefficient for fertiliser purchase in the econometric analysis, on the other, is testimony to the importance of devising empirical models where the relevant covariates of the phenomenon studied are accounted for. Asset wealth is a prime example of this.

Wealth is highly significant across the board, which is a clear indication of the crucial role it plays in the investment decisions studied. Its importance as a buffer when investment are unsuccessful is likely magnified by the absence of credit and insurance markets in rural Uganda, making it the main proxy for the farmer's capacity to undertake risky investments (*cf.* Vargas Hill, 2009; Foster and Rosenzweig, 2010).

Wealth's consistent statistical and economic relevance as opposed to risk aversion merits further investigation. In the next section, its predictive capacity of risky investment decisions is scrutinised and compared to that of risk preferences.

Even after controlling for wealth, credit constraints matter, at least, for the purchase of fertiliser.

Personal characteristics of the decision maker seem to have some weight in the decision of investing. The results obtained from age are consistent with Knight *et al.* (2003) hypothesis that older farmers are less likely to risk investing. They also indicate that household represented by female decision makers are less likely to make complex risky choices as predicted by Binswanger (1980) and Tanaka *et al.* (2010). In the Ugandan context, domestic responsibilities and limited access to networks have been highlighted as factors hampering women's capacity to engage in lucrative agricultural enterprises (FOWODE, 2012). This is certainly the case for the strategic household decision of growing cash crops, where gender is strongly associated with lack of investment.

Contrarily to the common finding in the literature on learning and technology adoption, education does not matter for investment in adoption. This result does not come as a complete surprise, as it has also been reported by Duflo *et al.* (2008b). As argued by Foster and Rosenzweig (2010), the lack of an effect is likely due to the fact that, like in our setting, the technology studied is widely known and thus the returns to schooling are lower. For example, there is no new information about the technology to decode, an aspect in which formal education can make a substantial difference.

By contrast, access to information, proxying for lower transaction cost, appears to be highly correlated with investment. Owning information assets, stripped of the wealth effect, turns out to be highly significant, echoing the findings of Heltberg and Tarp (2002) for market orientation. The information obtained through these assets may not relate to the technology *per se*, but perhaps to the market conditions which may determine the success of the investment. Having contact with agricultural extension services (AES) is another meaningful source of information in the analysis. As pointed out, its relevance is likely due to the useful knowledge regarding investment profitability which AES agents can share with farmers (Foster and Rosenzweig, 1996).

None of the other hypothesised covariates of investment seem to matter in our setting, while several of the village dummies show that location heterogeneity is still relevant.

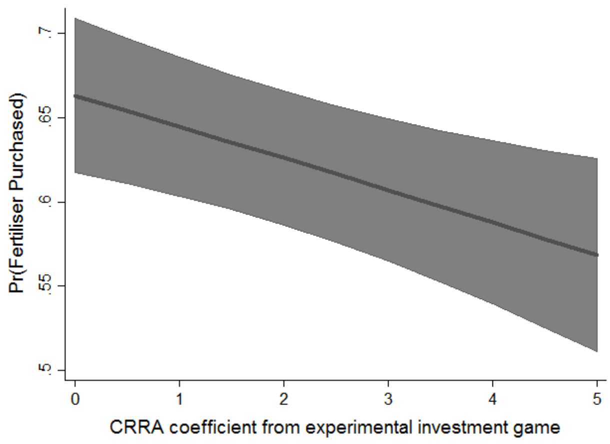
## VI.3 Predicted Probability Analysis

In this section, we study the quantitative importance of risk preferences with respect to asset wealth, the most impactful and consistent covariate found in the analysis. This predictive probability analysis is restricted to representative specifications where risk preferences, measured either experimentally or through the survey question, appear to be statistically associated with the investment decisions investigated.

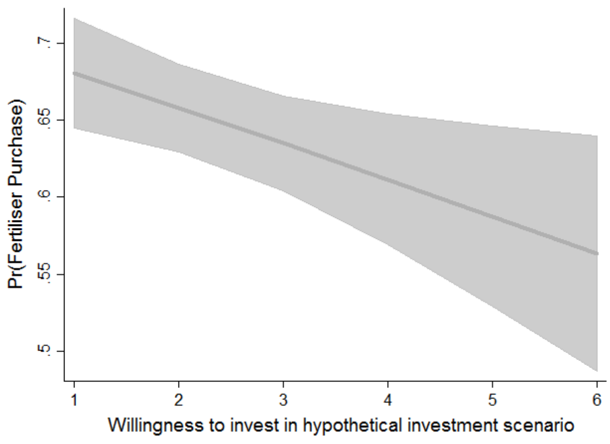
Let us start by evaluating the change in the probability of fertiliser purchase along the range of values taken by the key variables of interest. In this model, risk aversion was significant for all specifications however elicited, therefore, we depict the predictive power plot for each of the measures in turn. Figure III.1 (a) depicts the likelihood of purchasing fertiliser for the range of possible CRRA coefficient values that participants display in the experiment. These probabilities are obtained from specification (2) in Table III.6, holding all the other relevant covariates fixed at their means. As we can see, the probability of purchase goes from 66 percent—for those least averse to risk—to 56 percent—in cases where farmers exhibit the highest degree of aversion; a change of just ten percentage points.[19]

The plot in Figure III.1 (b) presents a similar story when risk aversion is represented by the hypothetical willingness to invest. Given the estimates from specification (4), probability of purchase goes from 68 to 56 percent for those least willing to risk losing the hypothetical endowment.

**Figure III.1: Predicted Probability of Fertiliser Purchase by Level of Risk Aversion**




***(a)***




***(b)***

[19] These figures correspond to the point estimates laying on the thick line crossing through the middle of the graph. The shaded area represents the range of the 95% confidence intervals for every level of risk aversion at which the probabilities were evaluated. The same applies to the rest of the figures.

The picture changes radically when assessing the evolution of the probability of purchase across the range of wealth levels. Figure III.2, utilising specification (4) too, depicts this scenario. The likelihood of having purchased fertiliser in the last five years goes from a fifty-fifty chance to complete certainty along the interval of values of the wealth index. The probability spread for wealth is several times larger than for any of the risk aversion measures, which speaks to the vast differences in the importance of each of these factors for the investment decision.

**Figure III.2: Predicted Probability of Fertiliser Purchase by Wealth Level**


If we turn to examining the variation in probability of growing cash crops with the recommended inputs at different levels of the key variables, the situation is similar, yet the difference in magnitude of the predictive capacity of risk aversion with respect to asset wealth is even more striking. Figures III.3 and III.4 show the probability of growing the most marketable crops with the necessary modern inputs by risk aversion elicited though the hypothetical question, and by asset levels, respectively, all else fixed at average levels.[20]

[20] Risk aversion was only significant when elicited through the hypothetical willingness to invest question in the specifications presented in Table III.7.

**Figure III.3: Predicted Probability of Growing Cash Crops with Right Inputs by Level of Risk Aversion**

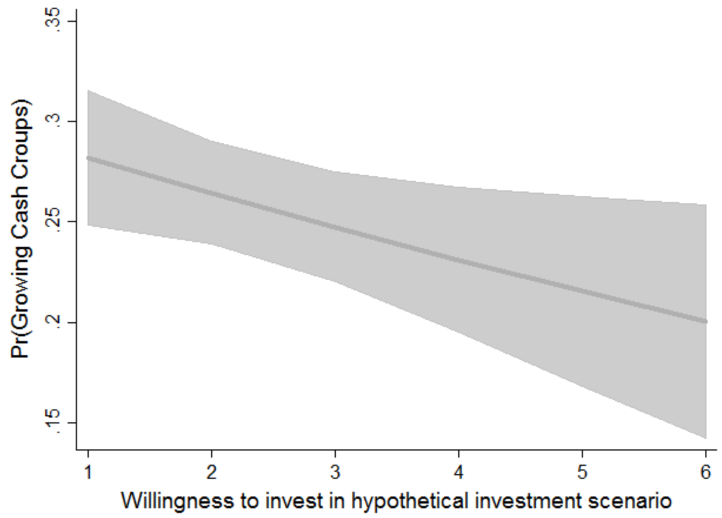



**Figure III.4: Predicted Probability of Growing Cash Crops with Right Inputs by Wealth Level**


Whereas the probability of the phenomenon studied ranges from 28 to 20 percent as risk aversion increases, the different values of wealth describe almost the whole spectrum of probabilities that a farmer grows cash crops adequately; from barely 10% for the poorest households, to full certainty for those better-off.

In the next section we take stock of what we have learned through the analysis and introduce the next step in our enquiry.

## VI.4 Commentary

The differential analysis of predicted probabilities has clearly shown that while risk aversion plays a non-trivial role in investing in technology adoption, its importance pales in comparison to being in an adequate financial position to invest, which for the most complex decision investigated almost separates with total accuracy investors from non-investors. The relevance of wealth may come as no surprise, given the weight of the evidence highlighting its prominence as a determinant of technology adoption in low-income countries in general (Foster and Rosenzweig, 2010), and, specifically, close to our geographical area of study (Vargas Hill, 2009). However, standard theory states that for profit maximising firms operating in perfect markets, wealth should not matter when deciding upon adoption (Karlan *et al.*, 2014). Consequently, the further this assumption is from describing reality, the more asset holdings seem to gain in relevance, since they reflect more accurately the household's ability to self-finance, obtain credit and smooth consumption.

An alternative explanation for the relatively inconsequential role of risk preferences is that they have not been adequately depicted in the study. The representation of the attitudes towards risk so far has been limited to risk aversion. This exclusive focus would seem tantamount to implicitly assuming that individuals follow Expected Utility Theory (EUT) in their decisions under risk. However, under the assumption of narrow bracketing, this is not the case, as we only expect to observe correlation between risk aversion and real-life risk-taking decisions that are similar to the experimental task, and therefore, narrowly bracketed (*i.e.* fertiliser purchase). In EUT, risk aversion captured by the concavity of the utility function of wealth would not be detected by conventional elicitation measures, as the stakes are too small to mimic actual wealth states (Rabin, 2000). By contrast, in Prospect Theory (PT) which only considers changes to wealth relative to the reference level, correspondence between the experimental and real-life domains is expected as long as both are narrowly bracketed (Thaler, 1999). The same correspondence follows partly for RDUT, which combines the previous two theories, the more so, both decisions are perceived as changes from a given level of wealth, *i.e.* gains and losses, rather than to the level of wealth (Verschoor *et al.*, 2016).

Even though our results conform with PT or RDUT, rather than EUT, we have not accounted for all the dimensions that characterise risk preferences according to the former theories. An important omission is that people may weight probabilities subjectively and in different ways. Interestingly, the bulk of the experimental evidence obtained in Western laboratories finds that people place excessive importance on small risks, yet small farmers in poor countries exhibit the exact opposite tendency: they tend to downplay the importance of adverse events that occur with low-to-medium frequency (Humphrey and Verschoor, 2004a; Harrison *et al.*, 2010). It would appear that they have developed attitudes towards risk adapted to operating in endemically insecure environments: risk that is not excessive must be ignored. Risk avoidance would then take place when dealing with higher-frequency risk of significant intensity.

Both these conjectures and some of the most prominent theories of risky choice, PT and RDUT, indicate that the heterogeneous weighting of probabilities is likely to play a role in risk-taking decisions in agriculture like those which are the object of this paper. A test we perform in the next section.

# VII Probability Weighting

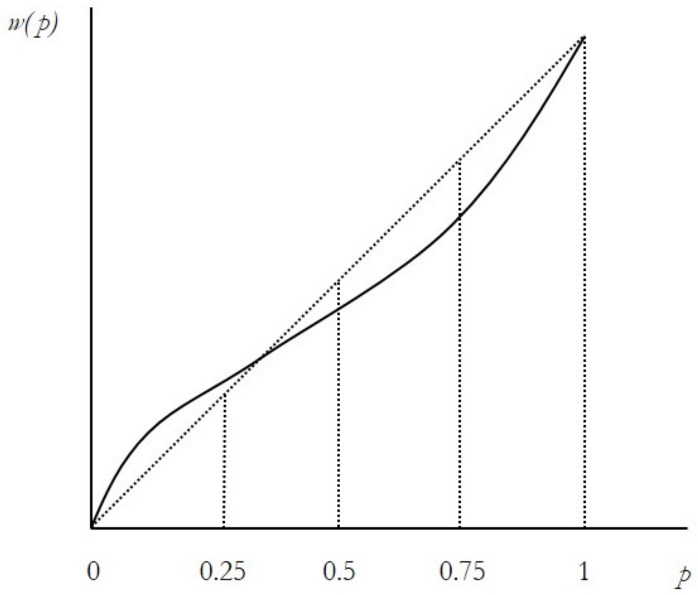
In this part of the paper, we introduce probability weighting in our analysis of agricultural investment decisions. We employ the same dataset as Verschoor and D'Exelle (2018), and by extension the same elicitation methods of risk preferences. However, our purpose is starkly different, whereas we investigate the relationship between probability weighting and investment behaviour, they strived to track the shape of the probability weighting function for a non-standard pool of subjects, and contrast it with evidence obtained elsewhere, namely, in Western laboratories.

We begin by giving an intuitive explanation of the relationship between probability weighting and farmer behaviour. Next, the theoretical foundation for common consequence effects, the key notion to elicit probability weighting in our study, is put forward. This part is followed by a detailed description of the experimental design and its implementation. Finally, we present the results of the extended analysis, comprising the probability weighting patterns of interest.

## VII.1 Probability Weighting and Farmer Behaviour

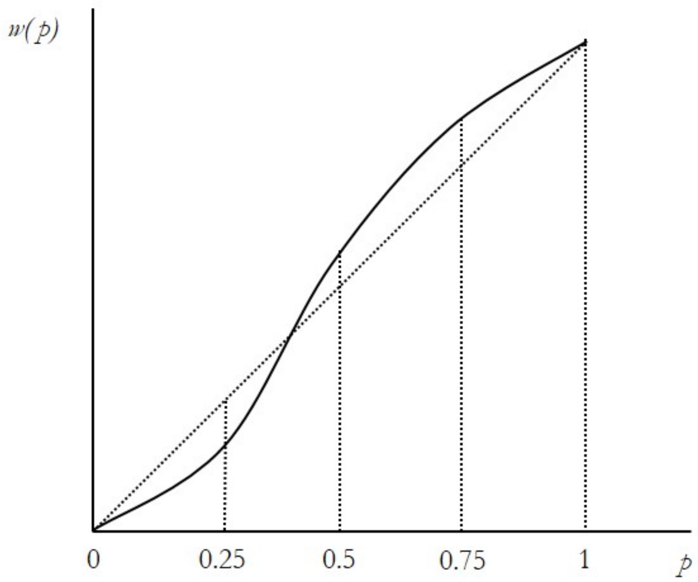
The probability weighting function (PWF) in the original formulation of Cumulative Prospect Theory (Tversky and Kahneman, 1992) is characterised by an inverse S-shape, as described by the graphic depicted in Figure III.5. The psychological foundation for this shape is based on the principle of diminishing sensitivity; the notion that people are more sensitive to changes in probability close to their reference point, and that their sensitivity decreases the further away the change occurs from that point. The two endpoints in the probability domain, 0 and 1, serve as reference, in the sense that zero represents the impossibility of an event's occurrence and one the complete certainty (Gonzalez and Wu, 1999). In terms of the behaviour of a farmer contemplating an investment, it means that the value of the prospect would be more affected if, for example, the probability of a loss changes from 5 to 10 percent rather than from 30 to 35 percent. Similarly, the farmer would mind more a drop in the probability of investment success from near certainty (*e.g.* 95 to 90), than an equal drop around the middle of the probability spectrum, like from 60 to 55 chance (Verschoor and D'Exelle, 2018). Experimental evidence from western labs has turned the inverse S-shape into an stylised fact about the PWF, although there are exceptions (listed in Blavatsky [2006] cited in Verschoor and D'Exelle [2018]).

**Figure III.5: Inverse S-shaped Probability Weighting Function**




By contrast, the evidence from developing countries is mixed, in some cases consistent with the inverse S-shape (Tanaka *et al.*, 2010; Liu, 2013; Vieider *et al.*, 2018), yet in other studies the PWF has been found to be S-shaped (Humphrey and Verschoor, 2004a,b). This pattern (Figure III.6) entails that changes in the middle of the probability interval are felt more acutely than changes at the endpoints. For a farmer considering to invest, it means that, for example, an increase in the chance of obtaining gains from 45 to 55 percent is more valuable than a rise from 70 to 80 percent. Likewise, a fall in the probability of a loss from 50 to 40 percent is more impactful than an equivalent decrease from a 20 percent probability.

**Figure III.6: S-shaped Probability Weighting Function**



As explained by Verschoor and D'Exelle (2018), the psychological intuition for a S-shape pattern with a reference point in between the extremes of the domain could be the awareness of the pervasive presence of risk in developing countries. Assuming that the reference points are formed through experience considering the relative frequencies of outcomes, then on particularly hazardous environments, where the chance of suffering a negative shock is far from 0 and that any endeavour—especially, related to agriculture—seldom can be deemed certain to succeed, a reference probability (or several) in between the endpoints is plausible. This reference probability $p^*$, $0 < p^* < 1$, would give rise to a S-shaped PWF which is convex below $p^*$ and concave above it, characterised by a relatively steep curvature near $p^*$ and relative flatness in the vicinity of the extremes (Figure III.6). The behaviour underpinning such shape would make the investor more resilient to small probabilities of making a loss and pull through even when the probability of success is not certain. As a result, a farmer weighting probability in such way would be more likely to invest in agricultural technologies under the hazardous conditions for agriculture found in developing countries.

## VII.2 Common Consequence Effects

### VII.2.1 Gains Domain

In order to derive the curvature of the PWF, we employ common consequence effects. We follow the formal demonstration of the link between effects and curvature by Verschoor and D'Exelle (2018), based on work of Wu and Gonzalez (1998) and others.

To illustrate the procedure we limit the number of outcomes to three since this is the number used in the experimental design. The prospects considered are of the form $(p, x; q, y; r, z)$, where $x$ is the best outcome with probability $p$, $y$ is the intermediate outcome which occurs with a chance of $q$, and $z$ is the worst (and neutral) outcome with the remainder of the probability $r = 1 - p - q$. [21]

The value function under CPT for the prospect in the gains domain can be expressed as:

$$V(f^+) = \pi_x^+ v(x) + \pi_y^+ v(y) + \pi_z^+ v(z) \tag{36}$$

From equations (7) and (9) in section III.1.2 we have that $\pi_x^+ = w^+(p)$ and $\pi_y^+ = w^+(p + q) - w^+(p)$. Taking also into account that the neutral outcome has no value ($v(z) = 0$), the value function can be rewritten as:

[21] For ease of visualisation the notation has been changed with respect to section III.1.2. However, The prospect depicted above is equivalent to $(p_2, x_2; p_1, x_1; p_0, x_0)$ using the previous notation.

$$V = w^{+}(p)v(x) + \big(w^{+}(p+q) - w^{+}(p)\big)v(y) \tag{37}$$

Let us imagine a choice between two prospects with similar outcomes but diverging in their probabilities. We denote the first prospect safe $S$, whose associated probability pair is $(p^{'}, q^{'})$, and the second one risky $R$ characterised by $(p, q)$. $R$ differs from $S$ in having both a higher probability of the best outcome $(p > p^{'})$ and a higher chance of the worst outcome $(1 - p - q > 1 - p^{'} - q^{'})$. Consider next another set of prospects $S_{\varepsilon}$ and $R_{\varepsilon}$ constructed from $S$ and $R$ by shifting probability mass $\varepsilon$ from the worst to the intermediate outcome, so that $S_{\varepsilon}$ is characterised by $(p^{'}, q^{'} + \varepsilon)$ and $R_{\varepsilon}$ by $(p, q + \varepsilon)$. A set of prospects derived along these lines are referred to as a common consequence ladder (CCL), each prospect in the ladder is linked to every other by a shift of probability mass between the same two outcomes. As noted, all outcomes ($x$, $y$ and $z$) are held constant to control for other features of the value function while deriving the common consequence conditions for the curvature of the PWF.

The curvature of the function can be inferred from preference reversals (or the lack of them) as a result of a common consequence shift. An example of a preference reversal occurs when $R \prec S$ while $R_{\varepsilon} \succ S_{\varepsilon}$, so the safe prospect is preferred prior to the common consequence $\varepsilon$ $(\varepsilon > 0)$, and the risky one afterwards. This instance, known as a common consequence effect, implies that the value of the risky prospect has risen more than the value of the safe option as a consequence of the common consequence shift, or $\Delta V = V_{\varepsilon} - V > \Delta V^{'} = V_{\varepsilon}^{'} - V^{'}$. The shift in preferences leads, in turn, to a change in the curvature of the PWF which is described by:[22]

$$w^{+}(p+q+\varepsilon) - w^{+}(p+q) \; > \; w^{+}(p^{'}+q^{'}+\varepsilon) - w^{+}(p^{'}+q^{'}) \tag{38}$$

The inequality indicates that, in light of the preference reversal $R \prec S$ while $R_{\varepsilon} \succ S_{\varepsilon}$, the PWF is steeper in the interval $[p+q,\, p+q+\varepsilon]$ than in the interval $[p^{'}+q^{'},\, p^{'}+q^{'}+\varepsilon]$, which would be consistent with strict concavity of $w^{+}(\cdot)$ in the interval $[p+q,\, p^{'}+q^{'}+\varepsilon]$.[23]

In a similar fashion, a preference reversal $R \succ S$ while $R_{\varepsilon} \prec S_{\varepsilon}$ implies:

$$w^{+}(p+q+\varepsilon) - w^{+}(p+q) \; < \; w^{+}(p^{'}+q^{'}+\varepsilon) - w^{+}(p^{'}+q^{'}) \tag{39}$$

which states that the PWF is steeper in the interval $[p^{'}+q^{'},\, p^{'}+q^{'}+\varepsilon]$ than in the interval $[p+q,\, p+q+\varepsilon]$.

[22] See Verschoor and D'Exelle (2018) for a formal demonstration of the equivalence between $\Delta V > \Delta V^{'}$ and equation (38).

[23] While strict concavity would be a sufficient condition for inequality (38) to hold, additional requirements are needed for it to be also necessary.

### VII.2.2 Losses Domain

To derive the common consequence conditions for the domain of losses we follow a similar procedure as in the previous section, based on the theoretical work of Verschoor and D'Exelle (2018). Let us consider again a three-outcome prospect characterised by $(p, x; q, y; r, z)$ in which the worst outcome $x$ is associated with a probability $p$, the intermediate outcome $y$ with a probability $q$, and the neutral (and best) outcome $z$ has a probability $r = 1 - p - q$ of occurring. In the present case, therefore, $x < y < z$ and $v(z) = 0$.

The value function for such a prospect in the losses domain can be expressed as:

$$V(f^-) = \pi_x^- v(x) + \pi_y^- v(y) + \pi_z^- v(z) \tag{40}$$

From equations (8) and (10) we have that $\pi_x^- = w_p^-$ and $\pi_y^- = w_p^-(p+q) - w_p^-$, and given that $v(z) = 0$, we have that:

$$V = w_p^- v(x) + \big(w_p^-(p+q) - w_p^-\big)v(y) \tag{41}$$

Same as before, we are faced with a choice between a risky prospect $R$, $(p, x;\ q, y)$, and a safe prospect $S$, $(p^{'}, x;\ q^{'}, y)$, however, in the present case the probability that both the worst and the best outcome occur is lower in $S$ than in $R$, or $p^{'} < p$ and $1-p^{'}-q^{'} < 1-p-q$.

To derive the curvature of the PWF for losses, we employ once more common consequence shifts of probability that eventually form a ladder. In the domain of losses, the ladders consists of shifts of probability mass from the worst outcome to the intermidiate outcome to form new prospects like $S_\varepsilon$, characterised by $(p^{'} - \varepsilon,\ q^{'} + \varepsilon)$, and $R_\varepsilon$, by $(p - \varepsilon,\ q + \varepsilon)$.

Consider the preference reversal $R \prec S$ while $R_\varepsilon \succ S_\varepsilon$ resulting from the common consequence shift $\varepsilon > 0$. The reversal implies that the value of the risky prospect has increased further than the value of the safe prospect following the shift, that is, $\Delta V = V_\varepsilon - V > \Delta V^{'} = V_\varepsilon^{'} - V^{'}$. The common consequence condition derived from this reversal is:[24]

$$w^-(p) - w^-(p - \varepsilon) > w^-(p^{'}) - w^-(p^{'} - \varepsilon) \tag{42}$$

From it, we can conclude that, as a result of the preference reversal, $w^-$ is steeper in the interval $[p - \varepsilon,\ p]$ than in $[p^{'} - \varepsilon,\ p^{'}]$.[25]

[24] See Verschoor and D'Exelle (2018) for the full derivation of the condition.

[25] Strict convexity of $w^-(\cdot)$ is a sufficient but not a necessary condition for the inequality to hold.

Likewise, the preference reversal $R \succ S$ while $R_\varepsilon \prec S_\varepsilon$ yields the common consequence condition:

$$w^-(p) - w^-(p-\varepsilon) < w^-(p') - w^-(p'-\varepsilon) \tag{43}$$

which implies that the PWF for losses is steeper in the interval $[p'-\varepsilon, p']$ than in $[p-\varepsilon, p]$.

Next we describe how the common consequence conditions derived here were implemented to elicit the curvature of the PWF of the participants in the study.

## VII.3 Experimental Design and Implementation

In what follows we describe the additional data collection instruments for this part of the paper. First, we present the design of the common consequence ladders and the rationale for the interval of probabilities and the magnitude of the common consequence shifts. Next, we illustrate the implementation of the game.[26]

### VII.3.1 Experimental Design

The common consequence ladder (CCL) implemented in the gains domain is depicted in Table III.8. Each pair of prospects or rung is the result of a common consequence shift, $\varepsilon = 0.05$, from the first and least attractive rung in terms of the expected value of the prospect (rung I), all the way up to the most attractive (rung X). Each pair is made up of a safe and risky prospect with three outcomes, represented by a different colour each, whose probability appears in parenthesis in Table III.8.

The comparison of the choices between rungs enables pronouncements on the relative steepness of the participant's PWF for intervals of probabilities, denoted by $[p+q, p+q+\varepsilon]$ and $[p'+q', p'+q'+\varepsilon]$ with $p'+q' > p+q$.

Let us look for example at the comparison between rungs I and II. The sum of probabilities for the intermediate ($y$) and best outcome ($x$) in the safe prospect of rung I (I.S) are equal to 55 percent, $p'+q' = .55$, whereas for the risky prospect (I.R) they are $p+q = .35$. Through a common consequence shift $\varepsilon$ from the neutral ($z$) to the intermediate outcome ($y$), they become $p'+q'+\varepsilon = .6$ and $p+q+\varepsilon = .4$, respectively, in rungs II.S and II.R. A preference reversal from $R$ to $S$, or vice versa, indicates a change in the curvature of the PWF between probability intervals $[.35, .4]$ and $[.55, .6]$. The same logic is followed to ascertain the relative steepness of the PWF by comparing rungs across the rest of the domain. A total of $10 * 9/2 = 45$ comparisons can be drawn across each combination of rungs, including adjacent and non-contiguous rungs.

[26] The experimental script can be read in full in Appendix A of Verschoor and D'Exelle (2018).

Not all the domain of the PWF for gains could be mapped with the common consequence ladder implemented, namely, the tracking was restricted to the interval $[.35, 1]$. The decision to focus on just this part interval has to do with an effort to avoid cognitive overload, and because the risky prospects farmers typically face are associated with a probability of success higher than 35 percent.[27]

As it is explained in the next sub-section, the probabilities for each of the three outcomes were represented by counters of different colours in the visual aids that depicted the choice of prospects. The precise number of counters in each prospect are shown in the last three columns of Table III.8 alongside the corresponding probability for the outcome.[28]

**Table III.8: Common Consequence Ladder (Gains)$^{\Psi}$**

| Rung | Order | Risky or Safe | Neutral/Worst Outcome 8,000 ($z$) | Interm. Outcome 10,000 ($y$) | Best Outcome 13,000 ($x$) |
|---|---|---|---|---|---|
| I | 7a | S | 9 ($r' = 0.45$) | 11 ($q' = 0.55$) | 0 ($p' = 0$) |
| | 7b | R | 13 ($r = 0.65$) | 0 ($q = 0$) | 7 ($p = 0.35$) |
| II | 6a | S | 8 ($r' = 0.4$) | 12 ($q' = 0.6$) | 0 ($p' = 0$) |
| | 6b | R | 12 ($r = 0.6$) | 1 ($q = 0.05$) | 7 ($p = 0.35$) |
| III | 10a | S | 7 (0.35) | 13 (0.65) | 0 (0) |
| | 10b | R | 11 (0.55) | 2 (0.1) | 7 (0.35) |
| IV | 5a | S | 6 (0.3) | 14 (0.7) | 0 (0) |
| | 5b | R | 10 (0.5) | 3 (0.15) | 7 (0.35) |
| V | 2a | S | 5 (0.25) | 15 (0.75) | 0 (0) |
| | 2b | R | 9 (0.45) | 4 (0.2) | 7 (0.35) |
| VI | 3a | S | 4 (0.2) | 16 (0.8) | 0 (0) |
| | 3b | R | 8 (0.4) | 4 (0.25) | 7 (0.35) |
| VII | 4a | S | 3 (0.15) | 17 (0.85) | 0 (0) |
| | 4b | R | 8 (0.35) | 5 (0.3) | 7 (0.35) |
| VIII | 9a | S | 2 (0.1) | 18 (0.9) | 0 (0) |
| | 9b | R | 7 (0.3) | 6 (0.35) | 7 (0.35) |
| IX | 8a | S | 1 (0.05) | 19 (0.95) | 0 (0) |
| | 8b | R | 6 (0.25) | 7 (0.4) | 7 (0.35) |
| X | 1a | S | 0 (0) | 20 (1) | 0 (0) |
| | 1b | R | 5 (0.2) | 8 (0.45) | 7 (0.35) |

$^{\Psi}$ The number of counters of each column determines the probability of the outcomes $x$ (white), $y$ (light blue) and $z$ (lilac); probabilities of the outcomes are in parenthesis.
The first column indicates the rung of the CCL each pair of prospects represents.
The second column shows the order in which they where presented to subjects.

[27] Verschoor *et al.* (2016) provide some evidence of the latter for the agricultural investment decisions studied in this paper.

[28] The best outcome $x$ takes the colour white, the intermediate $y$ is light blue and the worst $z$ is represented by lilac counters.

The next table presents the CCL implemented to trace the PWF in the losses domain. Once again, each rung contains the pair of safe and risky prospects constructed by shifting probability mass from the worse to the intermediate outcome. These rungs are presented in Table III.9 from least to most attractive as defined by their expected value. The comparisons across prospects that reveal the curvature of the PWF for losses are between probability intervals $[p^{'} - \varepsilon, p^{'}]$ and $[p - \varepsilon, p]$, with $p > p^{'}$.

Take for example the comparisons of rungs I and II. The common consequence shift $\varepsilon = 0.05$ transforms the probability of the worse outcome $(x)$ in prospect I.R from $p = .8$ to 75 percent in rung II.R, $p - \varepsilon = .75$. Similarly, the probability of the worse outcome associated with the safe prospect $(p^{'})$ goes from 70 percent in prospect I.S to $p^{'} - \varepsilon = .65$ for prospect II.S. A preference reversal between the prospects in these adjacent rungs would signal a change in the relative steepness of the PWF for losses across the probability intervals $[.65, .7]$ and $[.75, .8]$. The same logic follows for all the remaining comparisons, up to a maximum of 45 once more.

Only part of the PWF was mapped in the domain of losses as in the case of gains. Due to the importance of preventing cognitive overload and tracing the most meaningful parts of the weighting function, the study of the curvature of the PWF was restricted to the interval $[0, .8]$. This section of the probability domain comprises plausible probabilities for sharp negative income shocks commonly faced by farmers in the study area.

Furthermore, the endpoints of the probability domain represent the most consequential transition, that from possibility to certainty. In the gains domain the certainty of a positive outcome is defined by probability 1, and for losses, 0 is the certainty of avoiding the worst loss. Such importance justifies building the probability intervals studied from the relevant extremes, ensuring they form part of the domain.

The validity of the two common consequence ladders implemented in this experimental design hinges on successfully establishing 8,000 Ugandan Shillings as the neutral outcome $z$ in the subjects' minds. This crucial step was carried out by distributing a voucher three weeks prior to the experiments, which entitled the holder to 8,000 Shillings that could be increased or diminished depending on the choices made.

**Table III.9: Common Consequence Ladder (Losses)$^{\Psi}$**

| Rung | Order | Risky or Safe | Worst Outcome 3,000 ($x$) | Interm. Outcome 5,000 ($y$) | Neutral/Best Outcome 8,000 ($z$) |
|---|---|---|---|---|---|
| I | 3a | S | 14 ($p' = 0.7$) | 6 ($q' = 0.3$) | 0 ($r' = 0$) |
| | 3b | R | 16 ($p = 0.8$) | 0 ($q = 0$) | 4 ($r = 0.2$) |
| II | 1a | S | 13 ($p' = 0.65$) | 7 ($q' = 0.35$) | 0 ($r' = 0$) |
| | 1b | R | 15 ($p = 0.75$) | 1 ($q = 0.05$) | 4 ($r = 0.2$) |
| III | 6a | S | 12 (0.6) | 8 (0.4) | 0 (0) |
| | 6b | R | 14 (0.7) | 2 (0.1) | 4 (0.2) |
| IV | 9a | S | 10 (0.5) | 10 (0.5) | 0 (0) |
| | 9b | R | 12 (0.6) | 4 (0.2) | 4 (0.2) |
| V | 4a | S | 8 (0.4) | 12 (0.6) | 0 (0) |
| | 4b | R | 10 (0.5) | 6 (0.3) | 4 (0.2) |
| VI | 10a | S | 6 (0.3) | 14 (0.7) | 0 (0) |
| | 10b | R | 8 (0.4) | 8 (0.4) | 4 (0.2) |
| VII | 5a | S | 4 (0.2) | 16 (0.8) | 0 (0) |
| | 5b | R | 6 (0.3) | 10 (0.5) | 4 (0.2) |
| VIII | 2a | S | 2 (0.1) | 18 (0.9) | 0 (0) |
| | 2b | R | 4 (0.2) | 12 (0.6) | 4 (0.2) |
| IX | 7a | S | 1 (0.05) | 19 (0.95) | 0 (0) |
| | 7b | R | 3 (0.15) | 13 (0.65) | 4 (0.2) |
| X | 8a | S | 0 (0) | 20 (1) | 0 (0) |
| | 8b | R | 2 (0.1) | 14 (0.7) | 4 (0.2) |

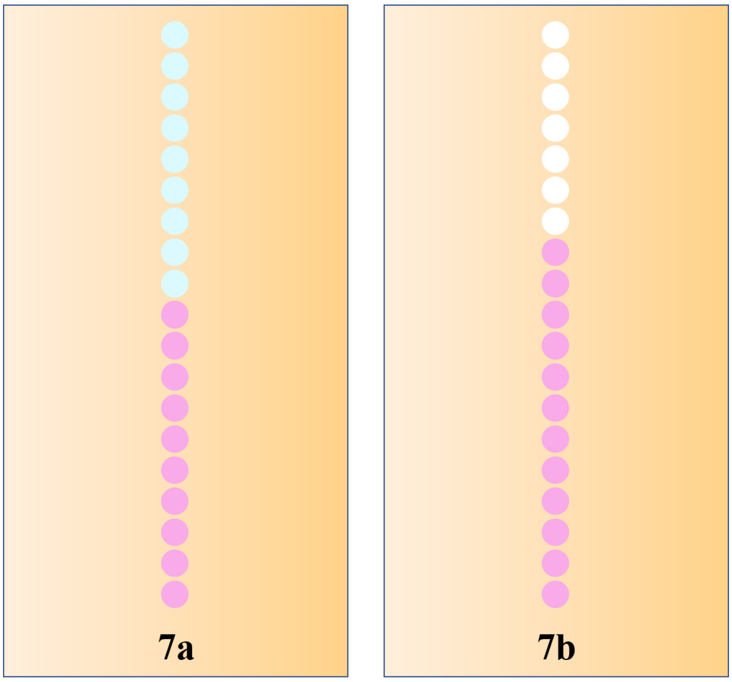
$^{\Psi}$ The number of counters of each column determines the probability of the outcomes $x$ (lilac), $y$ (light blue) and $z$ (white); probabilities of the outcomes are in parenthesis.
The first column indicates the rung of the CCL each pair of prospects represents.
The second column shows the order in which they where presented to subjects.

### VII.3.2 Implementation

In the experiment each prospect was represented by twenty counters of three different colours, one for every possible outcome. For example, prospect 7a in rung I of the CCL for gains is characterised by 45 percent probability of the neutral (and worse) outcome ($z$), a 55 percent chance of the intermediate outcome $y$ and no chance of the best outcome $x$. This distribution of probability was represented by 9 lilac counters for outcome $z$ (9/20=.45) and 11 light blue counters denoting the chances of outcome $y$. The counters were neatly arranged in a single column over a wooden plank, placed vertically on a table so participants could comfortably study it. Right next to the column depicting prospect 7a, a similar arrangement was presented for prospect 7b, in this case with 13 lilac and

7 white counters; the latter denoting the chances of the best outcome $x$. Figure III.7 illustrates the visual representation of the choices just described.

**Figure III.7: Example Representation Common Consequence Ladders**




All others rungs were presented in equal manner, adequately separated, so each decision between risky and safe prospects was taken in isolation.

Before participants made their choices, a demonstration of the outcome of their decisions between the two prospects was played out.[29]

### VII.3.3 Sample Selection

Participants in the experiments to elicit the curvature of the probability weighting function were a sub-sample of the representative sample of 1,803 individuals selected employed in the base analysis above.

Out of the total sample of selected individuals, 370 were randomly assigned to participate in the common consequence ladder experiments, 184 in the gains and 186 in the losses condition.[30]

Refer back to section IV for all the details about the area of study, sample selection and variables used, save for those representing the probability weighting patterns of interest, which we discuss in the next section.

[29] The entire experimental script can be found in Appendix A of Verschoor and D'Exelle (2018)
[30] The candidate supervised the entire fieldwork and was present during the experiments.

## VII.4 Extended Econometric Analysis

In this section we carry on with the analysis of the two investment variables in technology adoption which have been our focus so far: purchasing fertiliser and growing cash crops with the recommended inputs. Yet we extend the empirical model to include probability weighting indicators among the covariates to better characterise risk attitudes.

Before presenting the results, we explain how the variables which embody the probability weighting patterns of interest were created.

### VII.4.1 Study Variables

The variables generated to represent probability weighting in the analysis aim at singling out individuals who exhibit a tendency to downplay small risks of losses and overweight the chances of success for middle to high probabilities in the gains domain. Farmers who weight probability in such manner are expected to invest more in the hazardous environment where they operate, characterised by non-negligible chances of negative income shocks and lack of certainty of success when taking risks.

These patterns are broadly consistent with convexity in the domain of losses for small probabilities, which we circumscribe to a range between 40 percent and a zero chance of losses, and with concavity in the gains domain for probabilities above a fifty percent chance, comprised in the interval [0.45, 1].

The procedure followed was to create a variable for every manifestation of the pattern sought starting from the end of the common consequence ladder (*i.e.* with prospects closest to certainty), and increasing the probability range until it spanned across the whole interval of interest.

In order to identify concavity patterns in the gains domain, we began by creating a variable that singled out all participants who reverse their preference from the safe ($S$) to the risky ($R$) prospect between rungs IX and X. Such switch shows that the PWF for [.75, .8] is steeper than between .95 and 1. We then proceeded to generate a variable for all the concavity patterns falling in an increasingly wider probability interval, characterised by a preference reversal from $S$ to $R$ ever further away from certainty, as shown in Table III.10. Every row in the table represents a variable that denotes a pattern consistent with concavity within the relevant probability range of making gains [0.45, 1]. The last pattern traced, rungs III to X, implies that the PWF in the interval .45 – .5 is steeper than between .65 and 1.[31]

[31] Note that by not defining behaviour prior to the last preference reversal (closest to the rungs with the best prospect), we allow both preference reversals in previous rungs or consistent preference for the safe option up to the reversal (resulting in one $SR$ switch only).

**Table III.10: Probability Weighting Patterns**

| | | | **Rungs** | | | | |
|---|---|---|---|---|---|---|---|
| **III** | **IV** | **V** | **VI** | **VII** | **VIII** | **IX** | **X** |
| | | | | | | S | R |
| | | | | | S | R | R |
| | | | | S | R | R | R |
| | | | S | R | R | R | R |
| | | S | R | R | R | R | R |
| | S | R | R | R | R | R | R |
| S | R | R | R | R | R | R | R |

For simplicity and to save degrees of freedom, we generated the variable *concave* denoting all the individuals who follow one of the patterns in Table III.10, and therefore exhibit behaviour consistent with concavity in the PWF across the gains domain for middle to high probabilities. A sizeable proportion of the sample (32%) weighs probability in such a way and can be thought of overweighting the probability of gains for some part of the domain of medium to high probabilities.

Likewise, we captured all the patterns of interest in the losses condition within a variable (*convex*). In this case we were interested in individuals who underweight small probabilities of making a loss (probabilities between 0 and .4), as they would be more resilient to invest on the face of possible failure. Same as before, we identified all the subjects who reversed their preference from $S$ to $R$, starting at the end of the ladder where the best prospects were presented. The first preference reversal singled out was the switch from $S$ to $R$ between rungs IX and X, akin, as shown in sub-section VII.2.2, to exhibiting a PWF steeper for [.1, .15] than for [0., .05]; that is, a PWF consistent with convexity in the interval [0, .15]. From there, following the same procedure as for gains, we classified all individuals who displayed one of the choice patterns in Table III.10 from rung VI onwards, characterised by a preference reversal from $S$ to $R$ moving down the ladder.[32] The last step consisted in creating the summary variable *convex* employed in the analysis, which included all individuals exhibiting behaviour consistent with convexity over the interval of interest.

[32] The vertical line in Table III.10, dividing rungs V and VI, and the horizontal one, between the fourth and fifth row, separates the patterns singled out consistent with convexity in the losses domain. As explained earlier, all patterns in the table were employed to represent concavity in the gains domain.

### VII.4.2 Extended Analysis

The analysis presented in this section continues to feature results for the two different models corresponding to the pair of decisions analysed: fertiliser purchased (Table III.11) and growing cash crops using the recommended inputs (Table III.12).

Likewise, there are two types of specifications, the first including only the key covariates (specs. [1], [3], [5] and [7]), and the second ([2], [4], [6] and [8]) adding all the controls ($\boldsymbol{X}_{ij}$):

$$y_{ij} = \alpha + \beta risk\ aver_{ij} + \delta concave_{ij} + \theta wealth_{ij} + \varepsilon_{ij} \tag{44}$$

$$y_{ij} = \alpha + \beta risk\ aver_{ij} + \delta concave_{ij} + \theta wealth_{ij} + \boldsymbol{\delta X}_{ij} + \varepsilon_{ij} \tag{45}$$

The difference with respect to the models in the base analysis (expressions [34] and [35]) being the inclusion of the variable representing the curvature of the PWF, named *concave* in the gains sub-sample and *convex* in the losses sample.[33]

The first four specifications ([1]–[4]) in both tables display results for the sub-sample of participants whose PWF was elicited in the gains domain. The relationship investigated in these models is therefore between investment behaviour and the probability weighting patterns consistent with concavity in the gains domain. In contrast, the last four specifications ([5]–[8]) featured the models estimated with the subjects taking part in the losses exercise, implying that the object of study is now the influence on investment of weighting probability consistently with a convex PWF in the domain of losses.

Once again, we implement a heteroskedasticity-robust estimator of the variance-covariance matrix, and the coefficients reported are the estimated marginal effects at the means for each of the explanatory variables.

[33] Due to drop in sample size, location dummies were omitted from the models to maintain degrees of freedom.

**Table III.11: Probit Regressions: Fertiliser Purchase (Probability Weighting)$^{\Psi}$**

| **Specification** | **(1)** | **(2)$^{\psi}$** | **(3)** | **(4)$^{\psi}$** | **(5)** | **(6)$^{\psi}$** | **(7)** | **(8)$^{\psi}$** |
|---|---|---|---|---|---|---|---|---|
| Concave PWF | 0.0204 | 0.0162 | 0.0293 | 0.0234 | | | | |
| | (0.0740) | (0.0692) | (0.0741) | (0.0683) | | | | |
| Convex PWF | | | | | 0.0404 | 0.0575 | 0.0444 | 0.0708 |
| | | | | | (0.0710) | (0.0694) | (0.0712) | (0.0734) |
| Risk aversion (exp.) | | | 0.0026 | -0.0055 | | | 0.0377* | 0.0404** |
| | | | (0.0150) | (0.0124) | | | (0.0206) | (0.0187) |
| Risk aversion (hypo.) | 0.0144 | 0.0212 | | | -0.0496** | -0.0432* | | |
| | (0.0227) | (0.0196) | | | (0.0214) | (0.0224) | | |
| Wealth index | 0.0908*** | 0.0371** | 0.0908*** | 0.0363** | 0.0813*** | 0.0612*** | 0.0805*** | 0.0555** |
| | (0.0224) | (0.0177) | (0.0227) | (0.0179) | (0.0188) | (0.0225) | (0.0199) | (0.0237) |
| Credit constrained | -0.0370 | | -0.0515 | | -0.0789 | | -0.0815 | |
| | | (0.0610) | | (0.0607) | | (0.0657) | | (0.0686) |
| Gender (1=female) | | -0.0252 | | -0.0250 | | -0.0637 | | -0.0821 |
| | | (0.0655) | | (0.0654) | | (0.0681) | | (0.0699) |
| Education (years) | | 0.0184* | | 0.0154 | | -0.00473 | | -0.000276 |
| | | (0.0107) | | (0.0111) | | (0.0118) | | (0.0119) |
| Age | | -0.00580** | | -0.00514** | | -0.00461* | | -0.00486* |
| | | (0.00226) | | (0.00230) | | (0.00252) | | (0.00252) |
| Farm workforce | | -0.00391 | | -0.0138 | | -0.0127 | | -0.00450 |
| | | (0.0252) | | (0.0255) | | (0.0285) | | (0.0307) |
| Off-farm employment | | -0.0748 | | -0.0879 | | -0.0130 | | -0.0349 |
| | | (0.0743) | | (0.0763) | | (0.106) | | (0.106) |
| Contact AES | | 0.0338 | | 0.0298 | | 0.0961 | | 0.0973 |
| | | (0.0660) | | (0.0647) | | (0.0742) | | (0.0738) |
| Information Assets | | 0.347*** | | 0.383*** | | 0.177** | | 0.171** |
| | | (0.0690) | | (0.0648) | | (0.0808) | | (0.0852) |
| Distance to market | | -0.0601 | | -0.0366 | | 0.0700 | | 0.0156 |
| | | (0.0443) | | (0.0495) | | (0.0718) | | (0.105) |
| Transport Assets | | -0.114 | | -0.113 | | -0.0982 | | -0.105 |
| | | (0.0817) | | (0.0825) | | (0.0932) | | (0.0949) |
| **N** | 178 | 176 | 178 | 173 | 177 | 173 | 177 | 168 |
| **Pseudo $R^2$** | 0.08 | 0.29 | 0.08 | 0.3 | 0.12 | 0.22 | 0.10 | 0.21 |

$^{\Psi}$ Marginal probability effects estimated at the means reported. Details of the variables can be found in Table III.2.
$^{\Psi}$ Heteroskedasticity-robust standard errors reported in parentheses, $^{*}$ $p < 0.1$, $^{**}p < 0.05$,$^{***}$ $p < 0.01$
$^{\psi}$ Dummies for recent shocks included but not reported for specifications.

## Table III.12: Probit Regressions: Growing Cash Crops with Recommended Inputs (PW)$^{\Psi}$

| Specification | (1) | (2)$^{\psi}$ | (3) | (4)$^{\psi}$ | (5) | (6)$^{\psi}$ | (7) | (8)$^{\psi}$ |
|---|---|---|---|---|---|---|---|---|
| Concave PWF | -0.0261 | 0.0068 | -0.0317 | 0.0057 | | | | |
| | (0.0698) | (0.0632) | (0.0688) | (0.0635) | | | | |
| Convex PWF | | | | | -0.0446 | -0.0699 | -0.0477 | -0.0744 |
| | | | | | (0.0654) | (0.0646) | (0.066) | (0.0659) |
| Risk aversion (exp.) | | | -0.0099 | -0.0061 | | | -0.0063 | 0.0138 |
| | | | (0.0138) | (0.0115) | | | (0.0156) | (0.0148) |
| Risk aversion (hypo.) | -0.0087 | 0.0085 | | | -0.029 | -0.0161 | | |
| | (0.0213) | (0.0184) | | | (0.0192) | (0.0197) | | |
| Wealth index | 0.0561*** | 0.0333* | 0.0576*** | 0.0317 | 0.0573*** | 0.0536*** | 0.0568*** | 0.0512*** |
| | (0.0158) | (0.0195) | (0.0154) | (0.0196) | (0.0114) | (0.0165) | (0.0115) | (0.0161) |
| Credit constrained | | 0.0615 | | 0.0600 | | -0.0164 | | -0.0175 |
| | | (0.0557) | | (0.0558) | | (0.0639) | | (0.0635) |
| Gender (1=female) | | -0.151*** | | -0.149*** | | -0.177*** | | -0.191*** |
| | | (0.0545) | | (0.0542) | | (0.0565) | | (0.0570) |
| Education (years) | | 0.00469 | | 0.00505 | | 0.00577 | | 0.00620 |
| | | (0.00959) | | (0.00961) | | (0.00898) | | (0.00875) |
| Age | | -0.00782*** | | -0.00754*** | | -0.00241 | | -0.00279 |
| | | (0.00212) | | (0.00219) | | (0.00220) | | (0.00211) |
| Farm workforce | | -0.0609** | | -0.0648** | | -0.0508** | | -0.0489** |
| | | (0.0285) | | (0.0292) | | (0.0253) | | (0.0246) |
| Off-farm employment | | -0.0671 | | -0.0711 | | 0.0397 | | 0.0286 |
| | | (0.0695) | | (0.0688) | | (0.0850) | | (0.0839) |
| Contact AES | | -0.0388 | | -0.0401 | | 0.0105 | | 0.00990 |
| | | (0.058) | | (0.0578) | | (0.0687) | | (0.0695) |
| Information Assets | | 0.257** | | 0.26** | | 0.0916 | | 0.092 |
| | | (0.108) | | (0.105) | | (0.0849) | | (0.0853) |
| Distance to market | | 0.0047 | | 0.0059 | | -0.00232 | | 0.0064 |
| | | (0.0491) | | (0.0499) | | (0.0507) | | (0.0509) |
| Transport Assets | | 0.0377 | | 0.0428 | | -0.113 | | -0.110 |
| | | (0.0667) | | (0.0665) | | (0.0846) | | (0.0835) |
| **N** | 178 | 173 | 178 | 173 | 177 | 164 | 177 | 164 |
| **Pseudo $R^2$** | 0.07 | 0.28 | 0.07 | 0.28 | 0.13 | 0.28 | 0.12 | 0.28 |

$^{\Psi}$ Marginal probability effects estimated at the means reported. Details of the variables can be found in Table III.2.
$^{\Psi}$ Heteroskedasticity-robust standard errors reported in parentheses, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$
$^{\psi}$ Dummies for recent shocks included but not reported for specifications.

None of the variables conveying the probability weighting patterns of interest turn out to be statistically significant, neither in the gains nor in the losses sub-samples. Even though the sign that the variables take is typically as hypothesised, positive for concavity in the gains domain and negative for a convex PWF in the case of losses, the standard errors of the estimates are too high and the intervals comprise both positive and negative values.

The current analysis suffers from a severe drop in the sample size with respect to the base entry, which likely hampers the precise estimation of the relationship between the probability weighting indicators and agricultural investment. In fact, the sample size affects some other key covariates, like risk aversion, which ceases to be significantly different from zero in several specifications and switches sign in some others. On the other hand, wealth maintains its strong association with all forms of investment.

Few other variables continue to correlate strongly with investment decisions. The two exceptions are age, older individuals appear to invest significantly less, and ownership of information assets, which is still strongly related with higher investment levels.

# VIII Discussion & Conclusion

This paper has investigated whether, and to what extent, risk preferences matter for investment in agricultural technology adoption by a representative sample of 1,803 households from a rural region in Eastern Uganda. The exercise was carried out through the study of the main correlates of investing in two meaningful examples of this phenomenon, purchase of fertiliser and growing cash crops with the recommended inputs.

The need for pursuing this line of research stems, first, from the fact that risk aversion is often simply assumed in a many applications without much thought or evidence about how, and to what extent, it affects economic decisions. Second, because a long-standing explanation for the intractability of poverty is that material hardship makes the poor particularly averse to risk. Haushofer and Fehr (2014) epitomise this view, claiming that by increasing the level of stress among those suffering from it, poverty leads to short-sighted and risk-averse decision making. Lastly, as it has been argued throughout the review, the current body of research has not yet explored sufficiently the relationship between risk preferences and investment in technology adoption, let alone its relative importance with respect to other factors. As a result, a well-defined research gap exists that the above analysis has tried to mitigate.

With this purpose in mind, a model was laid down to demonstrate the influence of wealth and risk for agricultural investment, and how risk preferences play a role in determining the extent of this effect. Subsequently, an empirical framework was devised to test the predictions arisen from the theoretical model. In order to conduct a meaningful analysis, detailed and comprehensive information about the area of study and the dataset employed was presented which, in conjunction with the literature review, informed the selection of the variables utilised in the econometric analysis. The findings were robust to the inclusion of controls for other factors which may correlate with wealth, like credit constraints, transaction costs, diversity in the sources of income or education.

The main lesson from the base analysis is that risk aversion, measured both through an incentivised experimental investment game and a hypothetical question, plays a non-trivial role in investment decisions. However, its importance pales in comparison to that of asset wealth, as demonstrated by the predicted probability analysis undertaken in section VI.3. There, it could be appreciated, for example, how the different values of wealth described almost the whole spectrum of probabilities that a farmer grows crops with the recommended inputs, as opposed to barely a ten percent change in probabilities across the range of risk aversion values.

Even though our results in the base analysis do not conform with EUT, which is not compatible with our assumption of narrow bracketing, the representation of risk preferences had been limited to risk aversion. With the aim of widening the spectrum of risk attitudes in the empirical model, the analysis was extended to include probability weighting; a rare example in the literature. Its inclusion was achieved by eliciting the curvature of the probability weighting function utilising common consequence effects in the gains and losses domain. Preference reversals from the safe to the risky prospects, or *vice versa*, indicated shifts in the steepness of the function and the existence of heterogeneous weighting of probabilities. We were particularly interested in subjects who overweighted the chances of gains for medium to high probabilities in the gains domain, and in farmers downplaying the likelihood of losses for small probabilities, as we hypothesised that they would tend to invest more in the hazardous context where they operate. These patterns are consistent with concavity in the gains domain of the PWF and convexity for losses, which we strived to capture in the variables featured in the estimated models. However, the findings of the analysis did not provide empirical support for these conjectures, and none of the curvature patterns proved to be significant for agricultural investment.

The reduced sample size of the extended analysis may have been a factor in the absence of defined results, as it also affected the significance of other covariates, including risk aversion. Yet, despite the loss of degrees of freedom, wealth was still shown to be highly correlated with investment in technology adoption throughout.

As it has been noted, the crucial relevance of having the material means for investment in modern technologies has been documented, in general, for developing countries (Foster and Rosenzweig, 2010), and, for a similar settings in the country where this study takes place (Vargas Hill, 2009). Nevertheless, recent research indicates that the relative importance of wealth comes not just from being a proxy for the capacity of a farming household to afford the financial effort that investing entails, but, more importantly, from being the best representation of the household ability to cope with ever-present risk.

In their pioneering article, Karlan *et al.* (2014) demonstrate that credit constraints are not binding for investment, which is much more affected by uninsured risk —in the form of adverse weather events. This is proven by their finding that relaxing farmers' risk constraints by offering insurance leads to a greater change in investment behaviour than providing access to capital. Dercon and Christiaensen (2011) also illustrate this notion showing how consumption risk due to poor rainfall (conductive to harvest failure) can have a sizeable negative effect on fertiliser uptake, even when *ex-ante* credit constraints (proxied by asset wealth) are controlled for.

Adverse rainfall patterns are only but one of the many risks faced by farmers in developing countries deterring agricultural investment. Rural inhabitants in developing countries, for a myriad of reasons, are especially exposed to the pervasive presence of risk. First off, there is a much higher incidence of diseases and environmental hazards. Secondly, business risk is a major factor for most rural people since the majority run, at least, one business—typically a farm (Fafchamps, 2003). The returns to farming are uncertain and heteregenous (Suri, 2011), and these enterprises are usually small, undercapitalised and underequipped, which makes them very vulnerable to shocks. Moreover, recent evidence indicates that the uncertainty extends to the inputs used in agricultural production too, which are often of sub-standard quality, yet difficult to detect (Bold *et al.*, 2017).

There is, therefore, a sound rationale to see risk as one of the main drivers of mechanisms perpetuating poverty, in which poorer household, unable to protect themselves against downside risk, are forced to avoid some of it by foregoing profitable investment opportunities (Dercon and Christiaensen, 2011). Yet the plausibility of such mechanism driven by risk does not imply that the poor are intrinsically more risk averse, it can be simply that poor individuals often face a higher degree of uninsurable and non-diversifiable background risk. As a result, they may display less risk-taking behaviour with regard to avoidable risks, even though their risk preferences may not differ from those who are less exposed to background risks (Haushofer and Fehr, 2014).

Our results back this interpretation and conform with reports of a risk-income paradox in comparisons of risk attitudes across countries. Rieger *et al.* (2014) and Vieider *et al.* (2015) find risk aversion to be considerably lower in developing countries than in richer ones, when comparing risk attitudes of students from a large number of different countries elicited through the same methods. Vieider *et al.* (2018) provide evidence that this result is not due to a selection effect caused by comparing only the preferences of students, who typically come from more affluent backgrounds, by repeating the exercise with a large rural sample in Ethiopia, and finding the rural population significantly more risk seeking than the average student in the West.

The present study suffers from some limitations that should be noted. Chief among them, it employs a cross-sectional dataset for the study of investment decisions in technology adoption. Such approach has been criticised by Besley and Case (1993) in their review of methodological applications for the study of adoption decisions in developing countries. They argue that cross-sectional studies like the present one, based on recall information about whether the farmer invested in the technology, implicitly make some strong assumptions about the covariates of the model, namely, that influential farm and farmer variables do not change over time. These assumptions are difficult to sustain since, for example, farmer wealth and credit-worthiness are likely to both influence and be influenced by the investment decisions made. If this is the case, as is plausible, the capacity of cross-section models to infer causal relations is severely hindered, given that the estimations of the parameters will likely be biased. This critique can be extended to the entirety of the studies closest in purpose to this paper, which perform their analysis with data for a sample of farmers at a sole point in time. Nevertheless, Besley and Case (1993) still grant that cross-sectional studies may be able to provide insights into farm and farmer characteristics associated with ultimately investing in modern agricultural technologies.

In any event, future research on this topic should strive to gather panel data to overcome these issues.

In addition, the representation of risk preferences fails to account for loss aversion, an important domain of risk preferences in CPT. A commonly reported pattern arising from the empirical work testing CPT is that losses loom larger than gains, which means that the attitude of decision makers towards risky prospects could change when losses are present. The omission of this dimension in the analysis prevents us from being on par with the work at the vanguard of the enquiry on the relationship between investment and risk preferences—the study by Liu (2013), an exception in the literature.

In sum, this paper has presented empirical evidence that wealth is overwhelmingly important for agricultural investment. By contrast, risk aversion, plays a small but significant role, while probability weighting does not matter at all—neither in the losses, nor the gains domain. The former result echoes recent evidence showing that risk aversion does not correlate with income. There are compelling reasons to believe that wealth proxies for the capacity to cope with the risk sustained in farming and that this is the crucial barrier for investment in agriculture.

Overall, these findings go against the old narrative of a risk-aversion-induced poverty trap with ample sway in development circles—despite its lack of empirical grounding—and which should be revisited.

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# Appendix A: First-Order Conditions Model

## A.1 Model Perfect Risk Pooling

The maximisation problem can be expressed as:

$$\begin{aligned}
\text{Max } V = u(c^0) + \theta \sum_{s \in S} \pi_s u(c_s^1) \text{ s.t.} \\
c^0 = Y - x_r - x_h - a \\
c_G^1 = c_B^1 = c^1 = \sum_{s \in S} \pi_s (f_s(\boldsymbol{x}) + Ra)
\end{aligned} \tag{A1}$$

Given that $c_G^1 = c_B^1 = c^1$ the objective function $V$ can be written as:

$$\begin{aligned}
V &= u(c^0) + \theta[\pi_G u(c^1) + \pi_B u(c^1)] \\
&= u(c^0) + \theta[(\pi_G + \pi_B) u(c^1)] \\
&= u(c^0) + \theta u(c^1)
\end{aligned} \tag{A2}$$

We can re-state the objective function by substituting the constraints into it:

$$V = u(Y - x_r - x_h - a) + \theta u\Big[\pi_G\big(A_G f_G(x_r) + R_a\big) + \pi_B\big(A_B f_B(x_h) + R_a\big)\Big] \tag{A3}$$

The first-order condition for the risky input $x_r$ is:

$$\frac{\partial V}{\partial x_r} = -u'(c^0) + \theta A_G \pi_G f'(x_r) u'(c^1) = 0 \tag{A4}$$

from which we obtain that:

$$\theta \pi_G A_G f'(x_r) u'(c^1) = u'(c^0) \tag{A5}$$

Similarly, the FOC for the safe input $x_h$ is:

$$\frac{\partial V}{\partial x_h} = -u'(c^0) + \theta A_B \pi_B f'(x_h) u'(c^1) = 0 \tag{A6}$$

from which we get that:

$$\theta \pi_B A_B f'(x_h) u'(c^1) = u'(c^0) \tag{A7}$$

If we equalise the two FOC we have:

$$\begin{aligned} \theta \pi_G A_G f'(x_r) u'(c^1) &= \theta \pi_B A_B f'(x_h) u'(c^1) \\ \pi_G A_G \frac{\partial f(x_r)}{\partial x_r} &= \pi_B A_B \frac{\partial f(x_h)}{\partial x_h} \end{aligned} \tag{A8}$$

As in equation (15).

## A.2 Model No Risk Pooling

$$\begin{aligned} \text{Max } V = u(c^0) + \theta \sum_{s \in S} \pi_s u(c_s^1) \ \text{ s.t.} \\ c^0 = Y - x_r - x_h - a \\ c_G^1 = f_G(\boldsymbol{x}) + Ra \\ c_B^1 = f_B(\boldsymbol{x}) + Ra \\ a \geq 0 \end{aligned} \tag{A9}$$

We can re-state the objective function by substituting the constraints into it:

$$V = u[Y - x_r - x_h - a] + \theta \Big\{ \pi_G u\big[f_G(\boldsymbol{x}) + Ra\big] + \pi_B u\big[f_B(\boldsymbol{x}) + Ra\big] \Big\} \tag{A10}$$

The first-order condition for the risk-free asset $a$ is:

$$\frac{\partial V}{\partial a} = -u'(c^0) + \theta \big\{ \pi_G R u'(c_G^1) \ + \ \pi_B R u'(c_B^1) \big\} = 0 \tag{A11}$$

Given that $R = 1/\theta$, equation (A11) can be written as follows:

$$u'(c^0) = \pi_G u'(c_G^1) \ + \ \pi_B u'(c_B^1) \tag{A12}$$

which is equation (18) in the model.

The FOC for the risky input $x_r$ is:

$$\frac{\partial V}{\partial x_r} = -u'(c^0) + \theta \pi_G f'_G(\boldsymbol{x}) u'(c^1_G) = 0 \tag{A13}$$

The latter equation can be rewritten as:

$$f'_G(\boldsymbol{x}) = \frac{u'(c^0)}{\theta \pi_G u'(c^1_G)} \tag{A14}$$

Using eq.(A12) to substitute $u'(c^0)$, we have:

$$\begin{aligned} \frac{\partial f_G(\boldsymbol{x})}{\partial x_r} &= \frac{\pi_B u'(c^1_B) + \pi_G u'(c^1_G)}{\theta \pi_G u'(c^1_G)} \\ &= R\left[\frac{\pi_B}{\pi_G}\frac{u'(c^1_B)}{u'(c^1_G)} + 1\right] \end{aligned} \tag{A15}$$

which is the same as equation (16).

Likewise, the FOC for the safe input $x_h$ is:

$$\frac{\partial V}{\partial x_h} = -u'(c^0) + \theta \pi_B f'_B(\boldsymbol{x}) u'(c^1_B) = 0 \tag{A16}$$

which can be rewritten as:

$$f'_B(\boldsymbol{x}) = \frac{u'(c^0)}{\theta \pi_B u'(c^1_B)} \tag{A17}$$

Substituting $u'(c^0)$ we get:

$$\begin{aligned} \frac{\partial f_B(\boldsymbol{x})}{\partial x_h} &= \frac{\pi_G u'(c^1_G) + \pi_B u'(c^1_B)}{\theta \pi_B u'(c^1_B)} \\ &= R\left[\frac{\pi_G}{\pi_B}\frac{u'(c^1_G)}{u'(c^1_B)} + 1\right] \end{aligned} \tag{A18}$$

which is eq.(17) in the model.

# Appendix B: Wealth Index

The appendix provides a detailed description of the creation of the wealth index, a measure of household well-being, which plays a key role in the analysis above. First of all, we describe the methodology employed in building the index. This part is followed by the list of variables included in the index. Lastly, the list is complemented with some descriptive statistics on the variables that constitute it.

## B.1 Methodology

The wealth index is constructed utilising Principal Component Analysis (PCA), which is a multivariate statistical technique used to reduce the number of variables in a dataset into a smaller number of 'dimensions.' In mathematical terms, from an initial set of $N$ correlated variables, PCA creates uncorrelated indices or components, where each component is a linear weighted combination of the initial variables (Vyas and Kumaranayake, 2006). In this way, the technique helps to reduce the number of variables in the analysis by describing a series of uncorrelated linear combinations of the variables that contain most of the variance (StataCorp, 2009).

In what follows, we describe the underlying methodology for constructing the index based on the work of Filmer and Pritchett (2001).

Suppose we have a set of $N$ variables, $a^*_{1j}$ to $a^*_{Nj}$, representing the ownership of $N$ assets by each household $j$. PCA starts by specifying each variable normalised by its mean and standard deviation; for example, $a_{1j} = (a^*_{1j} - a^*_1)/s^*_1$, where $a^*_1$ is the mean of $a^*_{1j}$ across households and $s^*_1$ is its standard deviation.

These selected variables are expressed as linear combinations of the set of $M$ underlying components for each household $j$:

$$\begin{aligned} a_{1j} &= v_{11} \times A_{1j} + v_{12} \times A_{2j} + \ldots + v_{1M} \times A_{Mj} \\ &\ldots \qquad\qquad n = 1, \ldots N; j = 1, \ldots J;\ k = 1, \ldots K \\ a_{Nj} &= v_{N1} \times A_{1j} + v_{N2} \times A_{2j} + \ldots + v_{NM} \times A_{Mj} \end{aligned} \tag{B1}$$

where $A_{mj}$ is the component and $v_{nm}$ are the coefficients on each component $m$ for each variable $i$ (and do not vary across households).[34] Because only the left-hand side of each equation is observed, the problem does not have a determinate solution.

[34] The number of components is equal to the number of assets in the initial dataset ($K = N$), however, for ease of presentation we have assigned them a different subscript.

PCA solves this indeterminacy by finding a linear combination of the variables with maximum variance—the first principal component $A_{1j}$—and then finding the second linear combination of variables, orthogonal to the first, with maximal remaining variable, and so on.

Specifically, the procedure solves the equations $(\boldsymbol{R} - \lambda_m \boldsymbol{I})\boldsymbol{v_m}$ for $\lambda_m$ and $\boldsymbol{v_m}$, where $\boldsymbol{R}$ is the matrix of correlations between the scaled variables ($a_{nj}$ in eq.[B1]) and $\boldsymbol{v_m}$ is the vector of coefficients on the *mth* component for each asset (*e.g.* the set of coefficients that multiply the first $A_1$ in eq.[B1])).

Solving the equation yields the characteristic roots of $\boldsymbol{R}$, $\lambda_m$ (also known as eigenvalues) and the associate eigenvectors, $\boldsymbol{v_m}$. The eigenvalues represent the variance of each principal component. As the sum of the eigenvalues equals the number of assets in the initial dataset, the proportion of the total variation in the original dataset accounted for by each principal component is given by $\lambda_m/N$.

The final set of estimates is obtained by scaling the eigenvectors ($v_{nm}$) so the sum of their squares sums the total variance, a restriction imposed to achieve determinacy in the problem.

Inverting the sysytem implied by eq.(B1) yields a set of estimates for each of the $N$ principal components:

$$A_{1j} = f_{11} \times a_{1j} + f_{12} \times a_{2j} + \ldots + f_{1N} \times a_{Nj}$$

$$\ldots \tag{B2}$$

$$A_{Mj} = f_{M1} \times a_{1j} + f_{M2} \times a_{2j} + \ldots + f_{MN} \times a_{Nj} \tag{B3}$$

From this equation we can recover the "scoring factors" $f_{mn}$, which are the weights for each principal components and every asset.

The first principal component, expressed in terms of the original (unnormalised) variables, is therefore an index for each household (*i.e.* our wealth index) based on the expression:

$$A_{1j} = f_{11} \times (a^*_{1j} - a^*_1)/(s^*_1) + \ldots + f_{1N} \times (a^*_{Nj} - a^*_N)/(s^*_N) \tag{B4}$$

The first principal component has maximal overall variance, thus, it explains the largest fraction of the common variance. The second component is completely uncorrelated with the first, and explains additional but less variation than the first component.

The crucial assumption for the analysis is that the factor of interest—household long-term wealth—explains the maximum variance in the set of variables chosen (*i.e.* variables aimed at capturing household asset worth) and therefore it is represented by the first component. There is no way to test this assumption directly, only whether the results exhibit internal coherence, which we do below.

## B.2 List of Variables

The list of variables included in the wealth index is only a selection of all the assets available in the household survey. The criteria employed was to restrict the analysis to those variables with sufficient weight in explaining the first principal component—household wealth—in previous preliminary analysis with a wider database of household assets. In other words, we selected variables with a high enough scoring factor ($f_{mn}$) in these prior analyses. As a result, only variables with a scoring factor of 10 percent or higher feature in the final PC analysis.

The eigenvalue for the selected group of variables is very high, yet the first component only explains 19% of the variation in the asset indicators data. This is, however, in the middle-to-high range of variance accounted for by the first principal component according to Filmer and Pritchett (2001) and Vyas and Kumaranayake (2006).

The variables are listed in Table III.B1 below.

## Table III.B1: List of Variables Wealth Index

| Category | Variable | Abbreviation | Description |
|---|---|---|---|
| ***Ownership of durable goods*** | | | |
| **Transport** | Bicycles | *bicycles* | Number of bicycles owned by the household |
| | Motorised vehicles | *motor vehicles* | Number of motor vehicles (motorcycles, cars, vans, trucks or tractors) owned |
| **Household assets** | Generators | *generators* | Number of generators owned by the household |
| | Stoves | *stoves* | Number of stoves owned by the household |
| | Sofas | *sofas* | Number of sofas owned by the household |
| | Beds | *beds* | Number of beds owned by the household |
| | Jewellery and Watches | *jewellery* | Number of pieces of jewellery or watches owned |
| | Household Appliances | *HH appliances* | Number of household appliances (electrical iron, kettle ...) owned |
| **Information assets** | Radios | *radios* | Number of radios owned by the household |
| | Phones | *phones* | Number of telephones owned by the household |
| | Televisions | *TVs* | Number of televisions owned by the household |
| **Farm buildings** | Storage | *storage* | Number of storage facilities (e.g. granary, store room etc.) owned |
| | Stalls | *stalls* | Number of livestock stalls owned by the household |
| **Farm equipment** | Water cans | *water cans* | Number of watering cans owned by the household |
| | Insecticide pumps | *insec. pumps* | Number of insecticide pumps owned by the household |
| | Pulping machines | *pulpchines* | Number of pulping machines owned by the household |
| | Wheelbarrows | *wheelbarrows* | Number of wheel barrows owned by the household |
| | Animal ploughs | *animal ploughs* | Number of animal pulled ploughs owned by the household |
| ***Land*** | | | |
| | Land Size | *land* | Total size (in acres) of land owned by the household |
| ***Livestock*** | | | |
| | Indigenous cattle | *cattle ind.* | Number of indigenous cattle heads (heifers, cows, bulls, oxen or calves) owned |
| | Exotic or cross cattle | *cattle exocross* | Number of exotic or cross cattle heads (heifers, cows, bulls, oxen or calves) owned |
| | Goats | *goats* | Number of goats (indigenous, exotic or cross) owned |
| ***Dwelling*** | | | |
| **Rooms** | Rooms | *rooms* | Number of rooms in household's dwelling |
| **Major material dwelling floor** | Floor earth/dung | *floor earth/dung* | Whether floor made of earth and cow dung (dummy) |
| | Floor cement | *floor cement* | Whether floor made of cement (dummy) |
| **Main source lighting dwelling** | Electricity | *electricity* | Whether source of lighting is electricity (dummy) |
| | Lantern | *lantern* | Whether source of lighting is paraffin, kerosene or gas lantern (dummy) |

## B.3 Summary Statistics

In order to prove the validity of the assumption about the first component represeting household wealth, Filmer and Pritchett (2001) suggest evaluating the internal coherence of the index, which can be deemed as such if the distribution of assets is associated with the classification of households according to the wealth levels derived from the index.

To this end, the authors propose to divide the sample in groups according to wealth as measured by the index and study the distribution of the different asset variables with respect to the classification. We denote those in the bottom 40% as "low wealth," the next 40% as "middle wealth," and the top 20% as "high wealth." Table III.B2 presents the resulting descriptive statistics next.[35]

**Table III.B2: Summary Statistics Wealth Index**

| Variable | Scoring Factor | Mean | Stand. Dev. | Min | Max | Wealth | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Low | Medium | High |
| Bicycles | 0.18 | 0.16 | 0.40 | 0 | 3 | 0.03 | 0.16 | 0.44 |
| Motor vehicles | 0.17 | 0.03 | 0.21 | 0 | 4 | 0 | 0.01 | 0.14 |
| Generator | 0.18 | 0.02 | 0.16 | 0 | 3 | 0 | 0 | 0.09 |
| Stoves | 0.22 | 0.45 | 0.62 | 0 | 5 | 0.16 | 0.49 | 0.94 |
| Sofas | 0.25 | 0.12 | 0.34 | 0 | 3 | 0 | 0.06 | 0.46 |
| Beds | 0.29 | 1.18 | 1.02 | 0 | 9 | 0.62 | 1.22 | 2.21 |
| Jewellery | 0.22 | 0.28 | 0.50 | 0 | 3 | 0.06 | 0.30 | 0.68 |
| HH appliances | 0.17 | 0.02 | 0.19 | 0 | 4 | 0 | 0 | 0.08 |
| Radios | 0.19 | 0.65 | 0.55 | 0 | 4 | 0.36 | 0.74 | 1.02 |
| Phones | 0.26 | 0.73 | 0.85 | 0 | 7 | 0.27 | 0.81 | 1.51 |
| TVs | 0.23 | 0.05 | 0.22 | 0 | 2 | 0 | 0.01 | 0.20 |
| Storage | 0.21 | 0.35 | 0.55 | 0 | 9 | 0.06 | 0.42 | 0.76 |
| Stalls | 0.20 | 0.49 | 0.61 | 0 | 9 | 0.16 | 0.62 | 0.88 |
| Water cans | 0.14 | 0.22 | 0.63 | 0 | 11 | 0.09 | 0.19 | 0.56 |
| Insec. pumps | 0.16 | 0.16 | 0.46 | 0 | 10 | 0.03 | 0.15 | 0.43 |
| Pulpchines | 0.16 | 0.08 | 0.27 | 0 | 2 | 0.01 | 0.07 | 0.22 |
| Wheelbarrows | 0.25 | 0.05 | 0.24 | 0 | 3 | 0 | 0.01 | 0.24 |
| Animal ploughs | 0.10 | 0.02 | 0.16 | 0 | 2 | 0 | 0.01 | 0.08 |
| Land | 0.16 | 1.73 | 2.92 | 0 | 75 | 0.90 | 1.70 | 3.47 |
| Cattle ind. | 0.11 | 0.47 | 1.21 | 0 | 12 | 0.14 | 0.54 | 1.02 |
| Cattle Exocross | 0.16 | 0.38 | 0.80 | 0 | 6 | 0.08 | 0.44 | 0.88 |
| Goats | 0.13 | 0.76 | 1.44 | 0 | 24 | 0.36 | 0.80 | 1.46 |
| Rooms | 0.25 | 3.27 | 1.47 | 1 | 19 | 2.42 | 3.52 | 4.48 |
| Floor earth/dung | 0.14 | 0.86 | 0.34 | 0 | 1 | 0.91 | 0.91 | 0.68 |
| Floor Cement | 0.20 | 0.07 | 0.25 | 0 | 1 | 0 | 0.03 | 0.27 |
| Electricity | 0.17 | 0.04 | 0.19 | 0 | 1 | 0 | 0.02 | 0.15 |
| Lantern | -0.15 | 0.95 | 0.22 | 0 | 1 | 0.98 | 0.97 | 0.83 |
| **Observations** | **1803** | **1803** | **1803** | **1803** | **1803** | **722** | **720** | **361** |

[35] For ease of illustration, the descriptives present, in most cases, the proportion of households owning a particular asset rather than its number, although the latter form of the data was actually employed to estimate the index.

Judging from the above results, the wealth index proves to be coherent with the distribution of assets among the classification of households. We highlight next some of the most illustrative examples that support this conclusion.

Only 3% of the 'low' wealth households own a bike, whereas 15% and 38% of the 'middle' and 'high' wealth ones possess this asset, respectively.

Ownership of charcoal stoves is one the variables which best captures asset wealth differences, as it is starkly differently distributed among households, with 18% of the 'low', 43% of the 'middle' and 73% of the 'high' wealth owning this kind of asset.

Sofas, a luxury good, are owned by only 1% and 6% of the 'low' and 'middle' wealth households, respectively, but by 43 % of the 'high' wealth sample.

Beds are an asset widely available for 'middle' and 'high' wealth households, with 90% and 97%, respetively, reporting having at least one. By contrast, only 58% of the 'low' wealth possess a bed.

Ownership of radios is another variable rather differently distributed among groups with the following ownership rates: 35% for the poorest, 73% for the middle range and 88% for the relatively wealthiest households.

Perhaps the variable most markedly distributed among groups by its ownership percentage is phones. Just 26% of those on the bottom of the classification own one, whereas 63% of the households in the middle and 86% at the top have at least one phone at their disposal.

As expected the acreage of land owned is significantly different among wealth groups, with the poorest owning an average of 0.87 acres, the middle group 1.6 and the richest as much as 3.5 acres.

The number of households with at least one head of either cross or exotic cattle, highly valued in the area for its greater milk production, is 47% for the 'high' wealth, 30% for the 'middle' group and merely 6 % for those who are worse-off according to the index.

The average number of rooms for the richest households is close to five, while the typical house for the relatively poor consists of just two.

Other good examples of differential asset distribution across the classification are: ownership of jewellery and watches, storage facilities, animal stalls, insecticide pumps and pulping machines.

The rest of the variables maintain this internal coherence, yet do not capture as neatly the distribution of assets among the categories arising from the index.

# Conclusion

This thesis has strived to investigate how risk affects the livelihood decisions of poor individuals in rural areas of developing countries. It has done so by addressing three relevant questions to understand the effect risk exerts on crucial life choices in a representative context.

In the last chapter we evaluated how much truth there is in the old narrative that risk aversion causes the perpetuation of poverty by inducing poor individuals to take detrimental decisions about their livelihoods. Haushofer and Fehr (2014) epitomise this view, claiming that poverty—by increasing the level of stress among those suffering from it—leads to short-sighted and risk-averse decision making. With this purpose in mind, we set out to investigate whether, and to what extent, risk preferences matter for investment in agricultural technology adoption by a representative sample of 1,803 households from a rural region in Eastern Uganda. This exercise was carried out through the study of the main correlates of investing in two meaningful examples of this phenomenon, purchase of fertiliser and growing cash crops with the recommended inputs.

A model was laid down to demonstrate the influence of wealth and risk for agricultural investment, and to show how risk preferences play a role in determining the extent of this effect. Subsequently, we devised the empirical framework to test the predictions arisen from the theoretical model. In order to conduct a meaningful analysis, detailed and comprehensive information about the area of study and the dataset employed was presented. These insights, in conjunction with the literature review, informed the selection of the variables utilised in the econometric analysis. The main lesson from the analysis is that risk aversion, measured both through an incentivised experimental investment game and a hypothetical question, plays a non-trivial role in investment decisions. However, its importance pales in comparison to that of asset wealth, whose values describe almost the whole spectrum of the likelihood to invest, as opposed to the small portion explained by the values of risk aversion.[36] Our findings were robust to controlling for other factors which may correlate with wealth, like credit constraints, transaction costs, diversity in the sources of income or education.

[36] This was especially true for the decision to grow cash crops with the recommended inputs. In the case of purchasing fertiliser, wealth described a probability range of 'just' 60%.

We then extended the analysis to include further dimensions of risk preferences, namely, probability weighting—a rare example in the literature. Its inclusion was achieved by eliciting the curvature of the probability weighting function utilising common consequence effects in the gains and losses domain. We were particularly interested in subjects who overweighted the chances of gains for medium to high probabilities in this domain, and in farmers downplaying the likelihood of losses for small probabilities, as we hypothesised that they would tend to invest more in the hazardous context where they operate. However, the findings of the analysis did not provide empirical support for these conjectures, and none of the patterns tested proved to be significant for agricultural investment.

Recent research indicates that the relative importance of wealth comes not just from being a proxy for the capacity of a farming household to afford the financial effort that investing entails, but, more importantly, from representing best the household's ability to cope with ever-present risk (Dercon and Christiaensen, 2011; Suri, 2011; Karlan *et al.*, 2014; Bold *et al.*, 2017). This situation hints at a mechanism perpetuating poverty, in which poorer households, unable to protect themselves against downside risk, are forced to avoid some of it by foregoing profitable investment opportunities. Yet the plausibility of such mechanism driven by risk does not imply that the poor are intrinsically more risk averse, it can simply be that poor individuals often face a higher degree of uninsurable and non-diversifiable background risk. As a result, they may display less risk-taking behaviour with regard to avoidable risks, even though their risk preferences may not differ from those who are less exposed to background risks (Haushofer and Fehr, 2014).

Our results back this interpretation and conform with reports of a risk-income paradox in comparisons of risk attitudes across countries, according to which risk aversion is considerably lower in developing countries than in richer ones (Rieger *et al.*, 2014; Vieider *et al.*, 2015, 2018). All this piling evidence goes against the old narrative of a risk-aversion-induced poverty trap, and points towards a vicious circle caused by the insurmountable level of risk present in rural areas of developing countries. This circle can worsen once the risk materialises in the form of a shock, continuously weakening the capacity of a household to absorb subsequent negative events (Banerjee and Duflo, 2011). Consequently, diminishing these environmental risk constraints should be a key priority for development, a conclusion backed by a long-standing and still burgeoning literature relating these two aspects.

Rural peoples in least-developed countries are indeed more exposed to risk than almost anyone else in the world. Among the most salient reasons are the much higher incidence of environmental hazards and the major role that business risk plays in the lives of the inhabitants of these areas, who usually own at least one business—most commonly, a farm. The strategies they have developed to combat risk are effective to some extent, but often come at a hefty cost (Fafchamps, 2003). Risk avoidance, for example, involves engaging in low risk traditional activities at the expense of foregoing opportunities with higher expected returns, obtainable through more innovative, albeit riskier, methods (Carter *et al.*, 2014). As noted earlier, recent research has held this behaviour responsible for driving a poverty trap fuelled by risk. In addition, liquidating accumulated assets—especially productive ones—as a consequence of a shock can lead to similarly harmful effects on productivity, as does the reduction in consumption (Fafchamps, 2003). The option of sharing risk with members of the family or community can go a long way to protect households against idiosyncratic shocks (Townsend, 1994). However, covariate shocks affecting the whole sharing community cannot be effectively shielded and remain a major source of risk (Banerjee and Duflo, 2011).

In such context, formal insurance would seem to be the ideal instrument to manage these threatening level of risk, as it mitigates negative shocks by offering a compensation when they occur. Yet, despite its strong rationale, insurance has so far failed to fulfil its potential, plagued by serious informational and enforcement problems (Dercon *et al.*, 2009). In recent years, index insurance has emerged as a promising instrument to deliver formal coverage in the developing world, overcoming the mentioned issues through its particular design (Barnett and Mahul, 2007). Alas, index insurance is not without problems, its key limitation is the imperfect correlation between index and losses (*i.e.* basis risk), a problem that partially explains the low demand it has been met with (Dercon *et al.*, 2014; Mobarak and Rosenzweig, 2013).

Many observers have proposed the combination of traditional and modern forms of insurance as the way forward. They argue that informal risk sharing can complement the coverage of index insurance, by partially absorbing basis risk (Dercon *et al.*, 2014; Mobarak and Rosenzweig, 2013). However, the possibility that pre-existing risk-sharing arrangements hamper formal insurance uptake cannot be dismissed (Arnott and Stiglitz, 1991; De Janvry *et al.*, 2014). The first chapter of this thesis attempted to shed light on this relationship and the future of index insurance, by investigating how the provision of formal insurance interacts with pre-existing risk-sharing arrangements, employing experimental evidence from a rural area in eastern Uganda. Our experiment aimed primarily at studying the effect of anticipated risk sharing on insurance purchase decisions. For this purpose, the exogenous source of variation was restricted to, firstly, the possibility of receiving informal transfers or the lack of thereof, and, secondly, the type of insurance available, which could be of the indexed or indemnity kind. To the best of our knowledge, we are the first who vary exogenously actual risk sharing—to study its effect on insurance demand—and insurance characteristics—to test whether this effect varies depending on the type of insurance.

The results showed that anticipated informal risk sharing crowds out demand for index insurance, but it does not affect purchases of indemnity coverage. These findings are at odds with the prevailing narrative in the literature, which supports the complementarity between being index insured and receiving informal help, while maintaining that the latter is incompatible with traditional forms of insurance. The arguments put forward in support of this narrative are sustained by tentative evidence (Mobarak and Rosenzweig, 2013; Dercon *et al.*, 2014) nonetheless, and further empirical tests are required to unravel this important issue.

To some extent our findings are grounded in a theoretical framework based on two seminal contributions by Arnott and Stiglitz (1991) and Clarke (2016, 2011), combined in the model of Mobarak and Rosenzweig (2012) and adapted here. The model demonstrates how informal risk sharing is bound to affect demand for index insurance, although the direction of the effect is uncertain, yet it is innocuous for the uptake of indemnity securities. The latter result is explained by the rational goal of the agent to fully hedge against covariate shocks by purchasing fairly-priced insurance, regardless of transfers received to mitigate idiosyncratic losses. In contrast, achieving full protection is unattainable through index insurance due to basis risk. Risk sharing can mitigate its effects by providing assistance, making the indexed cover more attractive. However, informal support also renders index insurance redundant, as it provides further compensation against losses when insurance payouts have already been made, reducing the utility of the formal cover.

Our data seems to indicate that negative considerations about the loss of utility of insurance with risk sharing weigh more heavily in the decision to purchase index insurance than the positive ones. Coupled with these perceptions, participants appear to correctly anticipate a sizeable level of risk sharing from their partners, significantly higher than for indemnity insurance, which appears to exacerbate the fall in demand for the indexed cover. Nevertheless, these negative aspects appear to go beyond those featured in the theoretical framework, given that the impact of basis risk sharing is markedly negative too, when theory says otherwise.

It is hard to explain the reasons for this result, but it is safe to assume that other considerations, different to basis risk mitigation, are at play. A plausible explanation comes from behaviour already observed in the area by D'Exelle and Verschoor (2015), which the authors refer to as indebtedness aversion. This behavioural pattern refers to the reluctance of burdening members of the community with the consequences of the risks one takes. Such preference stems from a combination of altruism and a wish to avoid potential expectations of reciprocity, which induces in individuals an aversion to become indebted to others.

The first chapter also investigated how risk sharing decisions are affected by the availability of formal insurance. Of special importance, when formal insurance is introduced where previously only informal arrangements existed, is the change in control over risk exposure; a factor shown to hold sway over the propensity to share (Cettolin and Tausch, 2015; Lenel and Steiner, 2017). Insurance allows individuals to reduce their exposure to risk and may alter perceptions about who is deserving of help. However, the sensitivity of informal risk sharing to formal insurance will also depend on the actual ability of the product to control the exposure to risk.

Based on the lessons from Cettolin and Tausch (2015) and Lenel and Steiner (2017), we hypothesised that the lower the control over the risk sustained, the greater the help received from the partner would be. Our findings only conform with this general rule to a limited extent. Contrary to expectation, those without access to insurance (and completely reliant on informal help to deal with losses) did not receive a higher degree of support on average; neither compared to those index insured nor to individuals protected by an indemnity cover. However, when comparing support towards those who are insured, we observed a significantly higher level of transfers in favour of those insured under an indexed cover rather than an indemnity one, even when controlling for other factors correlated with sharing. As noted earlier, these results, in particular the higher level of informal assistance received by those index insured, help explain the patterns in demand, driving indexed coverage markedly down.

Notwithstanding the discrepancies between our findings and some of the empirical literature (Mobarak and Rosenzweig, 2013; Dercon *et al.*, 2014), they demonstrate that risk sharing plays an important role in the demand for index insurance, and that, therefore, pre-existing informal arrangements need to be taken into account in the marketing of the product.

Both proponents of the complemetarity argument (Mobarak and Rosenzweig, 2013; Dercon *et al.*, 2014) and those warning about issues of incompatibility between informal and formal protection (Boucher and Delpierre, 2014; De Janvry *et al.*, 2014) agree that the best vehicle for achieving synergies between risk sharing and index insurance is insuring sharing groups, rather than individuals not belonging to these arrangements. Nevertheless, the issues raised in our investigation and the related literature (De Janvry *et al.*, 2014), leading to the crowding out of the formal cover by informal support, would persist unless the insured unit is the group as a whole rather than individuals within the group, as proposed by the critics of complementarity (Boucher and Delpierre, 2014; De Janvry *et al.*, 2014). Despite its advantages, marketing index insurance in this way would curtail the ability of farmers to decide in accordance with their own insurance needs and possibly increase spatial basis risk, since weather conditions may vary between the location set for the group and that of the farmers forming it.

An intermediate solution, benefiting from the advantages of both options, would be selling insurance to members of informal groups with an in-built mechanism to deal with basis risk as well as other idiosyncratic shocks; in other words, groups in which risk sharing is to some extent enforced (*e.g.* village savings and loans associations [VSLAs]). Suggestive evidence in support of this approach is presented by Berg *et al.* (2017), who report that a guaranteed transfer from the partner to the person facing losses leads to a substantial surge in index insurance demand.

Interest in insurance as a developmental tool stems, first and foremost, from its potential to improve the capacity to absorb and overcome negative shocks of those in need, as noted above. Nevertheless, intertwined with this aspect, formal coverage is also expected to play a fostering role in improving agricultural productivity, by increasing the adoption of modern agricultural technologies. Underpinning this expectation lays the notion, based on the seminal work of Sandmo (1971), that the removal of risk constraints would lead to a rise in the scale and efficiency of farming operations. A prospect yet to be fulfilled, given the insufficient evidence for the benefits of insurance in the context of agricultural investment (Dercon *et al.*, 2009; Cole *et al.*, 2012; Carter *et al.*, 2014; Cole and Xiong, 2017).

At the same time, the only form of self-insurance most rural dwellers have at their disposal—risk sharing—is often deemed as a deterrent for investment. Despite its recognised importance in smoothing consumption in response to individuals shocks (Townsend, 1994), some observers fault the strong redistributive norms underpinning their functioning for diluting the incentives to invest, with perverse consequences for the economic performance (Platteau, 2009; Baland *et al.*, 2011; Di Falco and Bulte, 2011).

The middle entry in this thesis investigated precisely the impact that formal insurance and risk sharing exert on investment in a controlled environment. We started by devising an original theoretical framework that borne our key predictions. The model featured an agent maximising utility by choosing the amount to invest in a risky input, which can result in higher wealth if the investment is successful, but also in the loss of the monetary resources invested in case it fails. Risk sharing was then incorporated to this basic setting, and it was shown to foster risk taking due to its capacity to mitigate the losses in the event of a failed investment. Next, the basic framework was modified to accommodate formal insurance. The protection of a cover that provides a payout when the investment is lost unequivocally encourages risk taking, yet the obligation of paying the premium results in an ambiguous overall effect. Nevertheless, it was shown that investment will be higher—in no uncertain terms—under a compliant insurance, provided the cover is fairly priced and the chances of investment failure are the same (or higher) as for success. This conclusion may not hold for the case of index insurance as, first, the benefits of insurance are diminished by the non-compliance of the cover and, second, its drawbacks become more acute, with the premium being payable despite making losses and receiving no compensation in one of the states of the world. However, it was demonstrated that informal transfers—which always have a positive effect on investment—can especially improve the appeal of index insurance, as they enable assistance in the worst state, when the cover fails to perform.

The predictions of the model are in line with the conclusion from the third chapter (Pérez-Viana, 2019), which pointed at risk constraints as the main factor holding investment down. Interestingly, the results about the positive influence of risk sharing and performing insurance on investment remain valid regardless of whether the agent is averse to risk or neutral to it, accommodating a further insight from Pérez-Viana (2019) about the relative unimportance of the degree of risk aversion.[37]

With our main hypotheses in place, we developed an empirical test to evaluate them, under the controlled conditions created by the experimental setting implemented. Our design enabled us to restrict the source of variation to our representation of the elements of interest in order to observe their impact on investment behaviour. The elements purposefully varied randomly were, first, the insurance status of the investor—who could be index, indemnity or not insured—and, second, her chance of receiving informal support, which was binary: either permissible or not.

We find that insurance—in any of its forms—is innocuous for investment; a surprising result given our theoretical predictions, but one that, regrettably, is in tune with a sizeable part of the literature. The presence of risk sharing revealed some interesting, albeit faint, patterns in our results. As predicted in the theoretical framework, risk sharing wields a positive influence on investment, in particular, when the investor is uninsured or protected by an indexed cover. The latter finding was significant at conventional levels, and occurred despite the crowding out of informal transfers when the investor is insured. The result cannot be understated, since the presence of basis risk dilutes the benefits of insurance and exacerbates its drawbacks. In line with the theory, risk sharing was shown to seemingly improve the appeal of the cover and lead to a significant increase in risk taking. It did so by mitigating the inflated losses in the worst state, offsetting, to a certain degree, the disadvantages brought about by the indexed nature of the cover. This benefit was apparent to investors in the experiment, who increased the resources committed by an economically large amount; a rise with respect to the transfer-less scenario which appears to have been prompted by the anticipated receipt of informal transfers.

Despite observing the positive influence of risk sharing on investment, it was insurance which was expected to shatter the risk constraints and foster risk taking. Yet to achieve this outcome, the tool employed to diminish uncertainty (*i.e.* the insurance product) must be capable of reducing risk, and in a meaningful way too; only then a farmer would have an objective reason to change her investment portfolio. In addition, the farmer must trust that the cover will perform and that a payout will be disbursed when it is due. Our experimental design probably failed to capture at least one of these aspects, as the insurance on offer did not make a meaningful difference across states of the world, nor with respect to the treatments where it was absent. As such, our empirical test

[37] The only difference under the assumption of risk neutrality is that investment might be equal or higher with than without insurance or risk sharing, rather than strictly higher.

became a failed attempt to evaluate the conjecture drawn from the conclusions of the third chapter attributing to the risk environment the main responsibility for underinvestment in agriculture.

The present chapter also investigated the response of informal risk sharing to the decisions of investors under different insurance arrangements. As noted earlier, this is an especially important aspect when formal insurance is introduced where only informal arrangements existed, as it changes the risk exposure of beneficiaries, and their standing as recipients of informal assistance. Same as before, we hypothesised that individuals exposed to arbitrary risk can be seen as more deserving of help than those in control of their own exposure. In our context, that would entail that insured individuals would receive less informal support than unprotected ones, the more so the more effective the cover is in reducing risk. Nevertheless, deciding about the degree of exposure to risk is inherent to the act of investing. Consequently, even though benefactors might be more sympathetic towards individuals facing a prospect with a higher variance, committing substantial resources to a volatile investment can be penalised with the withdrawal of assistance. However, in a society characterised by risky investment and accustomed to sharing risk, this perception might be diluted, and only arise in levels of risk taking above the social norm.

Our results appear to back this conjecture, as we find that informal transfers are the highest towards uninsured investors, facing the most volatile prospect, and that the level of assistance falls when the partner is insured. Furthermore, the extent of the crowding out almost doubles if the partner is protected by a cover that performs well (*i.e.* of the indemnity type). In sum, the more volatile the investment prospect is, the higher the level risk sharing. However, even though sharing increases with losses and the amount invested, the proportion of losses shared decreases sharply at higher levels of investment.

Three main lessons emerge from the thesis. First of all, aversion to risk does not appear to be a major barrier for investment in technology adoption, which seems to be much more affected by the overall level of risk sustained by farmers, proxied by wealth, dismantling the old narrative of a risk-aversion driven poverty trap.

Secondly, the pervasive and substantial level of risk in rural areas of developing countries can in theory be curtailed by tackling the failure of absent insurance markets in these places, introducing formal coverage. However, the demand for feasible types of insurance (*i.e.* indexed) can be hindered by pre-existing informal arrangements, possibly due to the aversion to become indebted to others when the cover does not perform adequately.

Lastly, even if the demand for the product manages to expand, formal insurance would only lead to a behavioural change in investment if the cover is capable of actually diminishing risk and alter the investment prospect meaningfully. A lot of this has to do with reducing basis risk, which can be mitigated by risk sharing, shown to moderately encourage investment, particularly, when the investor is protected by an indexed cover.

As with other financial initiatives (*e.g.* microcredit) the goal of insurance, alongside other innovations, is to overcome the market failures that hinder prudent risk-taking, thereby, increasing productivity, market orientation and the scale of operations. The ultimate hope is that the rise in agricultural productivity frees up resources and labour, by producing the same or more food with fewer workers, setting in motion what Lewis (1954) called a structural transformation of the economy. This transition consists primarily in the movement of workers from the low to the high productivity activities and sectors, dissolving the duality within the economy and increasing the standard of living.

Such goals, however, cannot be achieved solely by reducing the risk of lowness of income, since like poverty itself, risk is multidimensional and manifests in many domains (*e.g.* health, political and property rights, freedom of choice, *etc.*). All of them are relevant to economic progress and, more importantly, to improving the standard of living—the ultimate measure of development—understood as the capacity of an individual to live the life she has reason to value (Sen, 2001).

The latter interpretation of living standards underpins the capability approach proposed by Sen (1980), based on the idea that development should be measured by the extent of an individuals freedom of choice. He identifies five main types of freedoms: political freedoms, economic facilities, social opportunities, transparency guarantees and protective security; among which the first is pre-eminent. Political freedom, Sen (2001) argues, is instrumental in providing incentives and information in the solution of acute economic needs.

Contrary to the way many development initiatives are structured, where political rights take a back seat and purely economic goals are pursued, giving a political voice to the poor is more urgent the more acute the plight of those in need. Sen (2001) forcefully illustrates this argument pointing out that the most dreadful hazard for the poor—the risk of starvation—has never occurred in an independent country with a functioning democracy and a relatively free press. First, because democracy provides the political incentives to prevent any threatening famine, and, second, thanks to the function performed by a free press in distributing the relevant information for famine prevention (Tungodden, 2001).

Yet the importance of political freedom extends far beyond the most basic needs, and can only be fully appreciated with a wider temporal lens. From the opposition to the construction of railways and bans against factories in the Austro-Hungarian and Russian Empires—for the benefit of stability and preservation of absolute authority—to the suppression of productive investment in the African Kingdom of Kongo—due to the rapacious nature of its monarchy—, history is littered with examples where the lack of political freedom prevented economic development and the betterment of living conditions (Acemoglu and Robinson, 2012).[38]

[38] When a plan to build a railway was put before the Austro-Hungarian emperor Francis I, he answered, “No, no, I will have nothing to do with it, lest a revolution might come into the country” (Acemoglu and Robinson, 2012).

The recent history of the country where the present study was conducted is testament to the importance of political rights. Uganda was a colony of the British Empire until its independence in 1952. As in most territories in Africa, the colonial rulers set up extractive institutions to collect resources and exploit the labour force (Byrnes, 1990; Acemoglu and Robinson, 2012). The colonisers implemented a system of indirect rule, by which ample authority was given to local authorities in exchange of advancing the colonial economic agenda (Platteau, 2009). This set of extractive institutions and the divisions along ethnic and local interests were inherited by the newly created Republic of Uganda. The problems arising from this inheritance and the disastrous rule of president Milton Obote during the first period post-independence, eventually led to the tyrannical regime—after a successful coup—of General Amin, under whom the country descended into ruin. The military dictatorship claimed the lives of half a million Ugandans. Furthermore, by the time a semblance of stability returned in 1986, the year Yoweri Musenveni ascended to the presidency, seven percent of the population had been displaced, per capita income had plummeted 40 percent and most of the population had retreated into subsistence activities (Byrnes, 1990; Reinikka and Collier, 2001).

In sum, the absence of political freedom has dominated the short history of Uganda and coincided with the periods of most severe decline in the living conditions of the people inhabiting these lands. Despite their apparent importance, political liberties appear secondary to economic considerations in some international fora[39] and even to the poor themselves.[40]

The prevalence of economic needs over other concerns in the minds of the poor is unsurprising, and it is grounded on sound logic. As acknowledged by Sen (2001), inadequate income is a strong predisposing condition of an impoverished life. Furthermore, he argues, the perspective of capability-poverty does not contradict the sensible view that low income is one of the main causes of poverty, since its absence can severely deprive a person of her capabilities. Consequently, initiatives to mitigate the risk of lowness of income, as this thesis has investigated, are still worth undertaking, in as much as the ends are not mistaken by the means. Achieving a sufficient level of income is not a goal in itself, but it is often instrumental in unleashing the capacity of a person to lead the life she values, the ultimate aim of development. The latter, therefore, should be the underlying yardstick of success for any development initiative.

The motivation behind devising feasible insurance products for small farmers is to tackle

[39] The foreign minister of Singapur warned in a conference held in Vienna in 1993 that the "universal recognition of human rights can be harmful if universalism is used to deny or mask the reality of diversity." In the same forum the spokesperson for the Chinese foreign ministry added that "individuals must put the state rights before their own" (Cooper [1994] cited in Sen [2001]).

[40] In a survey to deepen the understanding of poverty conducted by the Ugandan Ministry of Finance (RoU, 2002), the most pressing concerns cited were economic in nature (*e.g.* market availability and access to micro-credit and farm inputs).

the absence of insurance markets in rural areas of developing countries—a glaring market failure. The necessity of bringing absent markets to the poor is advocated even by the most sceptical critics of aid, who deem free markets as the foundation of prosperity (Easterly, 2007). In the particular case of insurance, the success of the endeavour would provide farmers with an effective tool to prevent risk, enabling them to invest in modern inputs and increase productivity. That is, if successful, such initiative would expand the choices available to farmers in their efforts to mitigate the, often overwhelming, risk they sustain in their livelihoods and smooth the volatility of their income.

The outcome of this chain of events would likely go beyond the mere increase of a household's steady income, and lead to improvements, for example, in their capacity to consume better food more regularly, access health care, obtain further education or expand their businesses. Nevertheless, to a large extent, these prospects would depend on the availability of certain services and markets in the vicinity. Something that a household cannot directly decide upon, and which may depend on the ability to advocate for their rights through political action. Such capability can be enhanced by a more secure income flow, which as argued by Sachs (2005), can enable a more active participation in civil society, helping to keep governments more accountable. Moreover, a higher income conductive to reduced deprivation can empower poor individuals to take part in the life of the community, diminishing their social exclusion and transforming them into active political agents (Sen, 2001). Lastly, this process could, in turn, bring about change to the local institutions governing communities, which in time may affect the rules of engagement at a wider level (Banerjee and Duflo, 2011).[41] A case in point, illustrating the importance of civil society in Uganda, is the inspiring story of the research conducted by Reinikka and Svensson in 1996 (Banerjee and Duflo, 2011). Their investigation of the allocation of funds to schools in Uganda unearthed vast misappropriations of resources, to the extent that only 24 percent of the funds ever reached the schools (Reinikka and Svensson, 2004). When their findings were made public, they caused such popular uproar that the government was forced to correct its ways. By 2001, when the authors repeated their school surveys, they found the schools were getting, on average, over 80 percent of the money that they were entitled to (Reinikka and Svensson, 2011).

In spite of the need of an integrated approach to development as proposed by Sen (2001), we should also be aware of the problems attached to this approach as a framework for research. By trying to capture everything, we might find it hard to establish anything precisely (Tungodden, 2001). For this reason, it is often important to narrow the scope of the research, as this thesis has done by focusing on how risk affects smallholder livelihoods with a specific set of concerns related to absent insurance markets, risk taking and

[41] Banerjee and Duflo (2011) refer to the set of rules followed in local communities as institutions, as opposed to the higher order INSTITUTIONS, such as, democracy, decentralization, property rights or the caste system, of much wider application.

preferences over risk. By tackling a piece of the overall problem at a time, we are able to draw firmer and more reliable conclusions. Nevertheless, in doing so, we cannot forget the need of interpreting our results in a broader integrated context. In our case, this broader view should help us remember that poverty extends far beyond lowness of income, as do the solutions to overcome it, since as Sen (2001:296) eloquently wrote "human beings are not merely the means of production, but also the end of the exercise." This exercise is the increase in the standard of living, understood as an extension of the capabilities of a person to pursue the life of her choice, making development a momentous engagement with the possibilities that these newly found freedoms have to offer.

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