Analyzing the drivers of agricultural technology adoption among smallholder farmers in Uganda

Courtney Blair

St. Antony's College
University of Oxford

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This thesis contributes to the rich literature on agricultural technology adoption in developing countries, which seeks to understand the barriers to greater use of technologies such as fertilizer and improved seed. I focus on two types of risk that are under-researched in this area: the risk of purchasing counterfeit products, and the risk of experiencing an idiosyncratic shock. My case country is Uganda, which is appropriate given the relatively low use of agricultural technologies. I use a combination of qualitative and quantitative methods, applied to both existing data and novel information collected during fieldwork. My first paper interrogates whether the knowledge that there are counterfeit products on the market acts as a deterrent for input purchases; I find a positive relationship between knowledge of counterfeits and purchase of agricultural chemicals, which suggests that farmers have strategies for identifying or avoiding fake products. My second paper analyzes whether the incidence of idiosyncratic shocks such as illness and death impact a households' ability to invest in inputs; I find no impact of the shocks on input purchase at the extensive margin, and a limited, negative impact at the intensive margin. Finally, my third paper is a qualitative deep-dive into the impact of shocks on investment in agricultural inputs; I find further evidence that shocks do not impact the decision to invest but do reduce the amount that is ultimately purchased. Overall, I find high levels of resilience among the households profiled in the data, and risk-management strategies that serve to limit households' exposure to the risk of counterfeits and idiosyncratic shocks. The results from my second and third papers also hint at full insurance, though this is notoriously difficult to prove.

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Contents

Chapter 1

Introduction

1.1 Context

Growth in agricultural productivity is essential for economic development and poverty reduction in sub-Saharan Africa (Peter Timmer (1988), Gollin et al. (2002), Minten and Barrett (2008), McArthur and McCord (2017), de Janvry and Sadoulet (2020), Jayne et al. (2021)). The international community has prioritized agricultural productivity as one of the targets under the UN Sustainable Development Goals (Target 2.3): "By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment" (UN, 2022).

Africa has fallen behind the rest of the world in terms of agricultural productivity. Though agricultural yield is not always accurately measured, especially in national statistics, the data that is available shows that maize yields in Africa have remained largely stagnant since data was first collected in 1961, and have fallen behind the yields achieved in other regions (as seen in Figure 1.1). Similarly, rice yields in Africa largely stagnated or collapsed between the 1960s and early 2000s (Ray et al., 2012), and calories per capita per day have remained stagnant since 2010 (FAO, 2022).

It is widely recognized that agricultural production in Africa is below the technological frontier (Bridle et al., 2019), and a proximate cause for the low yields is that use of agricultural inputs is low. Across much of sub-Saharan Africa, data suggest that relatively few farmers make use of technology that demonstrably enhances agricultural productivity, such as improved seed,

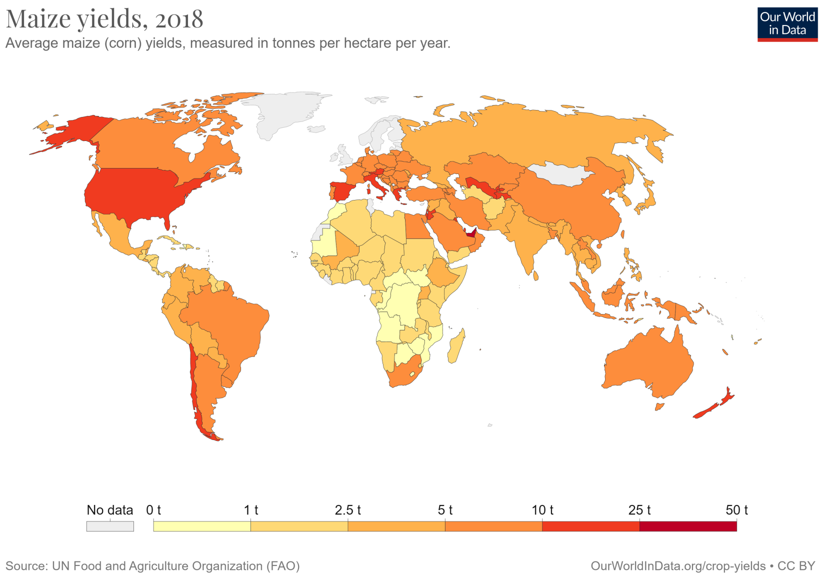

Figure 1.1: Average maize yields, 2018 (Source: Our World in Data)

agricultural chemicals, irrigation, machinery, etc. (de Janvry and Sadoulet (2002), Sanchez et al. (2009), McArthur and McCord (2017), Bonilla-Cedrez et al. (2021)). Thanks in part to high-yielding varieties and chemical fertilizers, for example, food production tripled in Asia and Latin America between 1960 and 2000 (Sánchez, 2010). Currently, the usage of agricultural technologies in Africa is low: for example, African countries rank at the bottom globally in usage of fertilizer and pesticides, as can be seen in Figures 1.2 and 1.3.

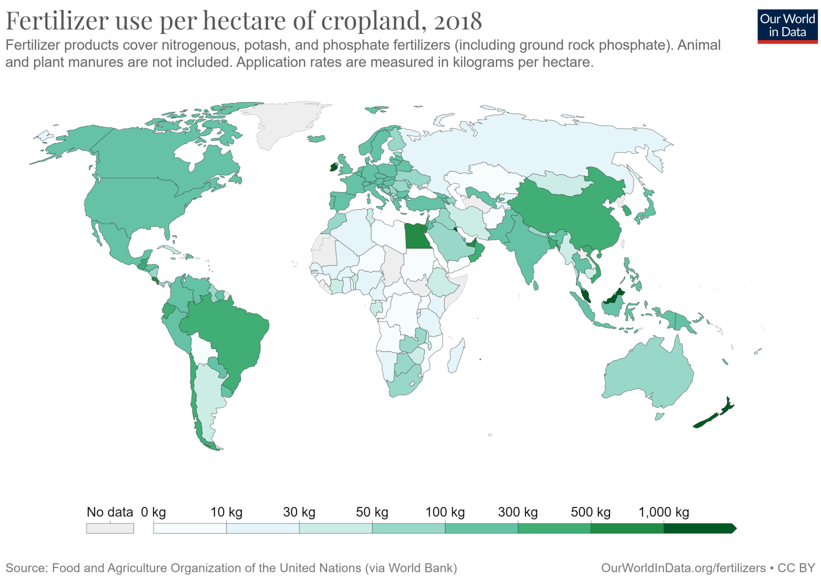

Figure 1.2: Fertilizer use per hectare of cropland, 2018 (Source: Our World in Data)

Increasing the use of agricultural technologies has become a priority for the development community, and researchers have turned to smallholder farmers to understand why their adop-

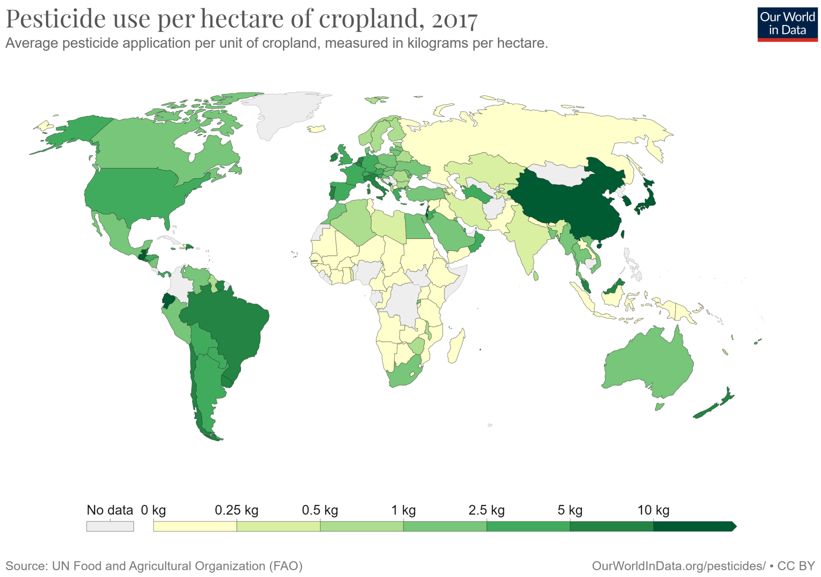

Figure 1.3: Pesticide use per hectare of cropland, 2017 (Source: Our World in Data)

tion of modern technologies is so low. For smallholder farmers, technologies like seed and fertilizer can represent a substantial outlay of funds. Farmers must make a fundamental risk calculation, taking into consideration the possibility of a bad harvest or other shock to the household, when determining whether to invest in agricultural inputs. This calculation is especially important when the inputs are purchased on credit. The probability of adoption, of course, also depends on whether the farmer has access to the technologies and understands how to use them.

There is an extensive literature on the adoption of technology in developing countries. The agricultural technology adoption literature can be divided into two broad strands: one that considers farmers' tolerance for taking on the risk of agricultural input purchases, and one that focuses on an array of other factors and constraints that impact a farmer's ability to invest. This thesis contributes to this literature by examining the drivers of technology adoption in one particular country (Uganda), focusing specifically on the risks faced by farm households and how these risks influence their technology adoption decisions.

1.2 Conceptual Framework

For the purposes of this thesis, I have developed a conceptual framework that offers one representation of the drivers and enablers of agricultural technology adoption, based on my own experience and a thorough exploration of the existing literature. As discussed in Section 1.3 below, the most recent reviews of the technology adoption literature have taken varying approaches to organizing the extant scholarship, largely by organizing the research into thematic categories. These reviews do not necessarily attempt to provide formal conceptual frameworks, but they nevertheless provide insight into the key constraints that have surfaced in the literature. For example, Jack (2013) points to inefficiencies in externalities, input and output markets, land markets, labor markets, credit markets, risk markets, and information. Suri and Udry (2022) highlight six different constraints: credit, liquidity, and savings; insurance; information; high transaction costs and infrastructure; imperfect labor markets; and imperfect land markets.

Building on these approaches, I offer a conceptual framework that embodies the theoretical approach underpinning the chapters that follow, and forms the basis for my empirical analysis. Figure 1.4 provides a visual representation of this conceptual framework, which characterizes the technology adoption decision for a smallholder farmer or farm household through the lens of the individual adopter. I choose a farmer-centered approach as ultimately the farmer is the locus of agency, making what can be a quite sophisticated set of calculations to determine whether to adopt a particular technology. The framework incorporates a range of factors that shape a farmer's decision, each of which is addressed in the literature.

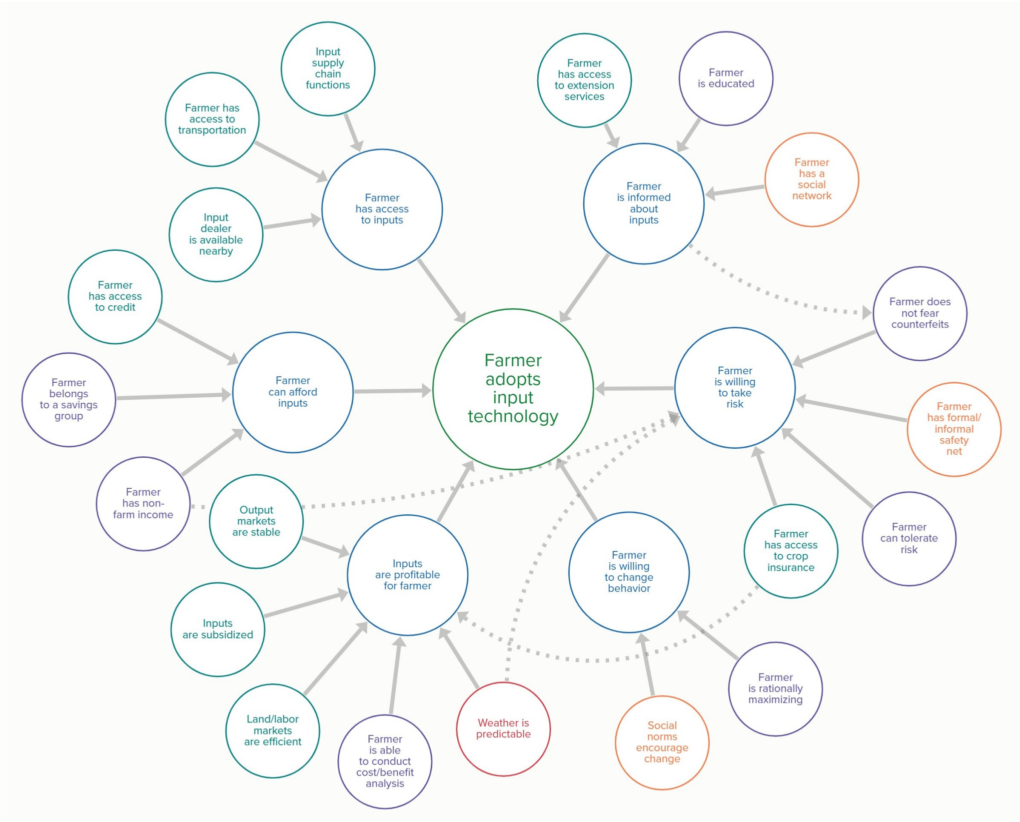

Figure 1.4: Conceptual Framework

As can be seen in Figure 1.4, the key outcome at the center of the framework (in green) is “Farmer adopts input technology.” For this framework, and indeed for the remainder of the thesis, “input technology” refers to improved or modern inputs, such as hybrid seed, fertilizer, or pesticide.[1] The literature usually considers technology adoption as a binary choice, focused on a farmer’s first usage of a particular technology. In the data, many farmers vary their usage of technologies from season to season, on both the extensive and intensive margins. A farmer’s choice often reflects what she or he can afford in a particular year. In that sense, the technology adoption decision could be considered to take place for every new season. However, my framework focuses on the barriers to, and enablers of, the initial adoption decision.

The next ring in the diagram (blue) depicts six necessary (and arguably jointly sufficient) conditions for input adoption from the perspective of an individual farmer. In theory, these must all be satisfied for input adoption to take place. In practice, this is not always the case, particularly when it comes to the farmer having adequate information about the inputs and being able to accurately assess whether they are profitable. The outer ring of the diagram shows key enablers that support the necessary conditions. They represent various characteristics of the household (purple), community (orange), market (teal), and environment (red) that influence the adoption decision. This set of characteristics is not intended to be exhaustive, as there is a universe of other factors shaping the political, economic, and even normative context in which farmers make decisions. I focus on a relatively small set of factors that I consider the key characteristics mediating the immediate technology adoption decision, most frequently studied in academic and policy spaces. In reality, these enablers often exist as their converse, as the barriers that farmers face – a lack of access to credit, for example. For the purposes of the framework, however, they are represented in their positive, ideal form.

[1]In the case of seed, the question of where to draw the line between “traditional” and “modern” technologies is a bit blurred. Indigenous varieties, for example, can theoretically be cultivated using “open-source” seed stocks that have been maintained for generations. For other crops, the picture is less clear: scientists and plant breeders have been developing improved varieties of various crops for centuries, from landraces through to hybrid and GMO varieties, and so it is likely that even the “local” varieties many farmers purchase contain embedded technological improvements. Nevertheless, a distinction is typically made between these local seed varieties and “improved” seeds, which are usually hybrid varieties that perform better (yield, drought resistance, etc.) and cost substantially more. Yet recent research has shown that farmers can be poorly informed about whether or not they are using hybrid seeds, with some unknowingly cultivating hybrids they believe are local varieties and vice versa (Bohr et al., 2024). Additionally, farmers often recycle hybrid seeds for several seasons, despite the fact that this often leads to the degradation of whatever beneficial characteristics had been bred into the variety, such that they may report that they did not purchase seed for a particular season yet are technically still using improved seed (if it can even still be considered improved once it has been recycled). All of this points to a fundamental unreliability of farmer-reported data when it comes to measuring the use of “improved” seed. As a result, I consider only agrochemicals as “technologies” in Chapter 2, I conduct sensitivity analysis for the different types of inputs in Chapter 3, and include both local and improved seed in my analysis for Chapter 4.

To begin, and perhaps most importantly, the farmer must have access to information about inputs. This information requirement is multi-dimensional. At the most basic level, the farmer must be aware that improved inputs exist. The farmer must also know where to purchase them, how much they cost, which types are appropriate for his or her farm, and in what quantities. The farmer needs at least a basic understanding of the benefits of the inputs (e.g. expected improvement in yield), as well as how to correctly apply or use them. Ideally, all of these conditions are met, to enable the farmer to make an informed decision. There are a few important enablers: extension workers, for example, can be a vital source of information about agricultural inputs. Farmers with robust social networks also have more opportunities to learn about input usage from trusted sources. And there is some evidence that better-educated farmers are more likely to have access to this information and better equipped to apply it.

Next, perhaps most obviously, the farmer must have physical access to inputs. This is often not the case – as seen in Chapter 2, only 43% of sample households in Uganda reported having a local input shop. This condition is enabled, of course, by the presence of a nearby input shop. "Nearby" is a flexible concept, and in the survey used in Chapter 2, the definition is left up to the respondent. This depends in part on another enabler, access to transportation – the definition of "nearby" changes if the farmer has a bicycle, for example, or is near a major road with transportation links to a large market center. Of course, if the farmer has to incur transportation costs, these must be fed into the cost-benefit calculation. The input shop must also have the requisite inputs in stock, which in turn depends on the efficient functioning of the input supply chain, represented by a single element here but containing multiple potential points of failure. The farmer must also be able to afford the inputs, which essentially means that he or she has sufficient resources at the moment of purchase. This is enabled by access to credit, either from the input dealer, as is frequently the case, or from a formal or informal financial institution. Many farmers also belong to savings groups, such as SACCOs, which could be a source of loans to finance inputs. Many also have non-farm sources of income which can be essential sources of liquidity.

Next, the inputs must be profitable for the farmer. This is essential, and as discussed in Section 1.3.4 below, not always accounted for. The farmer must be sufficiently numerate to conduct a basic cost-benefit analysis, and must have the information he or she requires to do so – the expected costs and benefits of the inputs, as discussed above, but also a rough measure of previous years' production volumes or yields to serve as a baseline. He or she also needs to estimate expected yield, which is easier when weather patterns are predictable. When they are not, the availability of crop insurance can influence the cost-benefit calculation. Such a calculation also would ideally consider opportunity costs, which requires efficient local land and labor markets. It also requires an expected price for the crop, if the harvest is to be sold, which is enabled by stable output markets. Finally, in many countries, inputs are subsidized, which improves the cost-benefit calculation from the farmer's perspective.

Adopting a new technology is fundamentally a behavior change, and requires that the farmer is willing to change his or her behavior. This is much easier when other farmers are doing so, and when the local social norms encourage change and innovation. As some behavioral economics research has shown, adoption is also more likely when the farmer is rationally maximizing – though of course *homo economicus* is rarely encountered in reality.

A corollary to the farmer's willingness to adopt a new behavior is the farmer's willingness to take on risk. Even the highest quality inputs, correctly applied, do not always deliver the expected results in a stochastic production environment. And in reality, farmers have limited knowledge about the quality of their soil (and thus the appropriate combination of inputs), weather patterns are increasingly unpredictable, and pests and diseases are common. Assuming farmers are fully informed, especially about the potential risks, they must actively decide to take on the risk that the inputs they purchase will not produce the expected financial gains. This is enabled, of course, by a tolerance for risk, which has been shown to vary. It is also enabled by predictable weather; in its absence, access to crop insurance removes some of the risk of unfavorable weather outcomes. The presence of a formal or informal safety net, along with non-farm income, also enables the farmer to take more risk, which is explored in Chapter 4. Finally, it helps if the farmer has confidence in the quality of the products, given the presence of counterfeit products in many markets, which is further enabled by access to information about these products; this is explored further in Chapter 2.

This thesis focuses primarily on one necessary condition: the farmer's willingness to take on risk. In particular, it explores farmers' experience with counterfeit products (Chapter 2), the impact of household shocks on the adoption decision (Chapter 3), and the various coping strategies that enable farmers to take on risk (Chapter 4). Nevertheless, all six of the necessary conditions influence an individual farmer's adoption decision, and are accounted for in various ways as control variables and mediating influences.

1.3 Literature

The literature on agricultural technology adoption goes back at least as far as Griliches (1957), who studied the rates of adoption of hybrid maize in the United States, and whose work documented the sensitivity of adoption decisions to location-specific geographic and economic factors. Research on technology adoption proliferated during the Green Revolution in Asia and Latin America, amid efforts to understand the unnevenness of take-up of the new technologies. Over subsequent years, this literature expanded in an effort to understand the "failure" of the Green Revolution in Africa. Over the decades, a series of explanatory factors emerged.

Given how extensive the literature is, there have been several attempts to organize it, each of which provides insight into the prominent topics. Feder et al. (1985), reviewing the empirical literature nearly forty years ago, categorized the extant papers into eight categories: farm size, risk and uncertainty, human capital, labor, credit constraints, land tenure, supply constraints, and aggregate adoption studies. Foster and Rosenzweig (2010) reviewed the literature since 1985 and framed their discussion around learning, education, risk and insurance, credit constraints, and behavioral economics. In a thorough review on behalf of the Agricultural Technology Adoption Initiative, Jack (2013) frames the barriers to technology adoption as inefficiencies in seven market aspects: externalities, input and output markets, land markets, labor markets, credit markets, risk markets, and information.

In another review of the existing literature, Magruder (2018) focuses on access to credit, access to insurance, and information as constraints to technology adoption. He finds that all three constraints are binding for at least some population of farmers. In another recent review, Bridle et al. (2019) look at the four constraints with the most experimental studies: credit and savings, risk, information, and input and output markets.

Many studies look at multiple constraints. For example, Shiferaw et al. (2015) use a double hurdle model to analyze constraints to adoption of improved groundnut varieties in Uganda, focusing specifically on information, seed supply, and credit constraints; they find that all three are binding constraints. Many studies also find that there are multiple drivers of technology adoption. For example, Alene et al. (2008) examine the impact of transaction costs on maize marketing and fertilizer usage in the context of Kenya. They find that maize price, age of household head, distance to fertilizer market, and access to extension services have a significant effect on fertilizer adoption rates.

The most recent review, Suri and Udry (2022), finds that there is no single binding constraint on adoption. Rather, farmers face combinations of constraints that prevent them from investing in technologies. They touch on six different constraints that are common in the literature: credit, liquidity, and savings; insurance; information; high transaction costs and infrastructure; imperfect labor markets; and imperfect land markets. They further highlight heterogeneity in agriculture and market conditions as a key reason that Africa has fallen behind the technological frontier.[2]

For the purposes of this thesis, I have organized the literature in line with the conceptual framework discussed above. First, access to information: the farmer must know about the technology and how to use it. Second, physical access: the farmer must have access to the technology. Third, affordability: the farmer may need credit or a subsidy to be able to afford the technology. Fourth, profitability: the farmer must decide that the technology is profitable to use. Fifth, risk: the farmer must decide that the risk calculation is in favor of adoption. Finally, other factors: the farmer is influenced by cultural and behavioral factors that may impact the investment decision.

1.3.1 Information

In order to encourage greater use of agricultural inputs, it is essential to ensure that farmers have access to information about inputs: where to purchase them, what to buy, and how to use them. One set of studies looks at the importance of learning, knowledge and access to information (Foster and Rosenzweig (1995), Kabunga et al. (2012), Freeman and Qin (2020), Van Campenhout et al. (2017)). A substantial number of articles focus on social capital and learning through social networks: Conley and Udry (2001), Bandiera and Rasul (2006), Katungi et al. (2008), Conley and Udry (2010), Liverpool-Tasie and Winter-Nelson (2012), Cai et al. (2015), Beaman et al. (2018), Mekonnen et al. (2018), Shikuku (2019), Freeman and Qin (2020). For example, Conley and Udry (2010) find evidence of social learning among pineapple farmers in Ghana, particularly for those who are new to the crop. Other studies have looked at learning through experience (Mishra et al., 2020) or more traditional channels such as radio (Wekesa et al., 2003). Van Campenhout et al. (2017) find that showing extension videos to rice farmers outlining both the technology and its returns does not increase fertilizer use. Other research

[2] For an updated, dynamic review by these authors, see `https://voxdev.org/voxdevlit/agricultural-technology-africa`.

has looked at the role of education, such as Appleton and Balihuta (1996) and Huffman (2020), and the role of technology (Freeman and Qin, 2020). Sseguya et al. (2021) found that access to demonstration plots increased the probability of purchasing inputs in Tanzania, while Emerick et al. (2017) looked at the benefits of farmer field days in India.

Agrodealers are another potential source of information about agricultural technologies, though not as consistently as might be ideal. Farmers in Kenya cited agrodealers as a source of information, yet tended not to ask agrodealers for advice when it came time to purchase (Rutsaert and Donovan, 2020). Staudacher et al. (2021) found in an experiment that only 26.6% of mystery shoppers received advice from agrodealers when buying pesticides.

1.3.2 Access

Access itself is important, as discussed by Dibba et al. (2015) and Dontsop Nguezet et al. (2013), though not as extensively studied. Ali (2010) and Jacoby (2000) look at roads and infrastructure, while Fafchamps and Shilpi (2003) find that the distance to the urban center impacts technology adoption. Stifel and Minten (2008) find that more isolated farmers in Madagascar are less likely to use fertilizer. Distance imposes costs: Minten et al. (2013) found that transportation and transaction costs increased fertilizer prices by 50% for the most rural farmers in their sample. Suri (2011) considers distance to the nearest input dealer, and finds that long distances to seed and fertilizer distributors can explain why some farmers with potentially high returns do not invest. Accessibility is usually studied alongside several other constraints, such as Alene et al. (2008), which finds that distance to the fertilizer market has a significant effect on fertilizer adoption rates.

1.3.3 Affordability

It is also essential that the technology is affordable to farmers – that the inputs themselves are available at a price the farmers can afford to pay. A significant strand of the literature looks at access to credit as an enabler of affordability (Boucher et al. (2008), Guirkinger and Boucher (2008), Giné and Yang (2009), Matsumoto and Yamano (2011), Verteramo Chiu et al. (2014)). In Ethiopia, Croppenstedt et al. (2003) found that credit is a major constraint to fertilizer adoption, while Awotide et al. (2015) find that access to credit increases cassava productivity in Nigeria. Karlan et al. (2011) offered indemnified loans in Ghana, but found little impact on investment in inputs. In a study of a microcredit and grant intervention in

Mali, Beaman et al. (2014) find heterogeneity in marginal returns to input usage and binding liquidity constraints. They observe that farmers who borrow have higher marginal returns, and respond to the relaxation of credit constraints by increasing input usage. However, Bridle et al. (2019) found in a review of nine randomized evaluations that a majority of farmers did not take out loans when offered credit. Veljanoska (2022) finds that remittances increase fertilizer use by acting to remove credit and insurance constraints.

Magruder (2018) reviews evidence that 15-30% of farmers would take up credit if it were available and would increase their input usage – though the increase in input expenditure is only a fraction of the overall loan or grant amount. He also finds that the provision of cash, credit, or insurance on its own is not enough to impact adoption decisions for the majority of farmers. He finds strong evidence that information acts as a constraint to technology adoption, and posits that supply chain failures are another constraint to input adoption.

Several studies have used vouchers or subsidies to eliminate credit or access constraints (Carter et al. (2014), Adong et al. (2020), Carter et al. (2021)), including several in Uganda (Matsumoto et al. (2013), Fishman et al. (2017), Omotilewa et al. (2019)), though subsidies and vouchers are not always enough: in a randomized trial in Mozambique, Carter et al. (2013) found that uptake of voucher coupons was below 50%, suggesting additional constraints to input adoption.

1.3.4 Profitability

Most of the literature takes as given that the technology is profitable for the farmer. However, this is not always a guarantee – the technology may not be profitable on the amount of land that the farmer is cultivating, or may not be profitable at the actual output prices faced by farmers. There is a difference between yield-increasing input use and profit-maximizing input use that is not always taken into account. It can also be difficult to assess farmers' profitability, given the prices that farmers face (such as the value of their own labor) do not always reflect the market prices that are more easily measured.[3]

The literature assessing the profitability calculations for farmers is thin, but compelling.

[3]Many studies fail to account for the fact that the "shadow" prices faced by farmers, for both inputs and outputs, may deviate substantially from market prices. Farmgate prices of output may be lower than market prices, and farmgate prices of inputs may be higher. In particular, the "shadow wage" (i.e., the opportunity cost of time) is typically not observed except in contexts where labor markets are well developed – and even then, there may be important variation through the season or across different tasks. Assessments of the profitability of new technologies are often based on relatively crude calculations that overlook these subtleties.

In a widely-cited and influential study, Suri (2011) finds that the pattern of hybrid maize seed adoption seen in Kenya can be explained by allowing for heterogeneous costs and benefits among farmers. By allowing for household-specific heterogeneity and comparative advantage, she finds that farmers with high net returns will adopt, and farmers with low returns switch in and out of usage. It is assumed that farmers have knowledge of the technology (hybrid seed) as it has been around for many years. Several of the earliest studies in the field also allowed for variable productivity, such as Griliches (1957), who finds that it explains part of the pattern of adoption of hybrid corn in the United States. Other authors who have considered variable returns include Zeitlin et al. (2010) in Ghana, Wossen et al. (2019) in Ethiopia, and Michler et al. (2019) in Ethiopia. Several papers have explored the possibility that the technologies are simply not profitable for some farmers, such as Burke et al. (2017) in Zambia, Liverpool-Tasie et al. (2017) in Nigeria, Magnan et al. (2015) in India, and Duflo et al. (2008) in Kenya.

1.3.5 Risk

The farmer must decide whether to invest in the technology, which is impacted by his or her calculation of the risk of crop failure and other shocks, and influenced by his or her level of risk aversion. One section of the literature on risk focuses on the types of risk preferences displayed by farmers, and how they deviate from standard expected utility theory. Streletskaya et al. (2020), for example, considers prospect theory and rank dependent utility theory, while Liu (2013) analyzes the role of prospect theory in China. Chavas and Nauges (2020) study downside risk aversion, while Carter (2016) examines deviations from expected utility theory. Babcock (2015) looks at prospect theory in the context of crop insurance.

There have been a number of experimental studies that have attempted to understand farmers' risk preferences. Ward and Singh (2014) examine risk aversion and ambiguity in India, while Ross et al. (2012) consider ambiguity aversion in Lao PDR. Knight et al. (2003) studies the relationship between education and risk aversion, and Asravor (2019) looks at risk aversion in Ghana. Many studies attempt to elicit risk preferences directly, such as de Brauw and Eozenou (2014) in Mozambique, Bocquého et al. (2014) in France, and Liu (2013) in China.

A growing number of articles also focus on access to insurance to mitigate production risk, particularly rainfall-indexed insurance (Giné and Yang (2009), Mobarak and Rosenzweig (2013), Carter et al. (2016), Cole et al. (2017)). Karlan et al. (2014) conducted a study in Ghana that finds the main constraint to investment is uninsured risk, with strong demand for rainfall index insurance. I will say more about this in Paper 2.

1.3.6 Other Factors

Finally, a few other factors have been implicated as barriers to input adoption. For example, some studies have looked towards behavioral economics for insights on adoption behavior (Duflo et al. (2011), Brune et al. (2011), Abay et al. (2017), Streletskaya et al. (2020)). Social norms can also play a role (Moser and Barrett, 2006). Zeweld et al. (2019) look at psycho-social factors influencing adoption, while Taffesse and Tadesse (2017) examine a farmer's locus of control, and Jordan and Guerzoni (2021) interrogate the role of culture.

1.4 Case: Uganda

The focus of my research is Uganda. Uganda is a landlocked country in East Africa, with bi-modal rainy seasons and predominantly rain-fed agriculture. More than two-thirds of the population is engaged in agriculture, which contributed nearly a quarter of GDP in 2021 (UBOS, 2021). Its major food crops by volume are plantain bananas, maize, and cassava (UBOS, 2021). Uganda is widely considered as a potential breadbasket for East Africa, given its climatic profile, expanses of arable land, and dual annual growing seasons. However, national agricultural output has only grown at 2% in recent years, less than the population growth rate, and less than the rates in other East African countries (World Bank, 2018).

Maize is widely grown as both a commercial and staple crop in Uganda, and serves as a key benchmark for agricultural productivity. In 2018, the national average maize yield was 1.4 MT/ha, below the estimated potential yield of 5 MT/ha (UBOS, 2020). Recent growth in maize production has been attributed to an increase in acres under cultivation, rather than an intensification of production (Ajambo et al., 2017).

One reason for the low maize yields is Uganda's low use of modern agricultural inputs, which makes Uganda an interesting case for analyzing technology adoption. As can be seen in Figure 1.2, Uganda falls far behind the rest of the world in terms of fertilizer usage, ranking 155 out of 164 countries in 2018 (World Bank, 2022). In 2018, Ugandans used 3.3 kg of fertilizer per hectare of arable land, compared to 15.7 kg/ha in neighboring Kenya and 15.9 kg/ha in Tanzania. By comparison, South Africa registered 72.8 kg/ha, and the United States used 128.8 kg/ha (World Bank, 2022). In pesticide use, Uganda also ranked low (131 out of 166), with 88 tons used in 2019, compared to 1 ton in Tanzania and 1578 tons used in Kenya (FAO, 2022). Furthermore, it was estimated that large-scale plantations in Uganda account for 95% of fertilizer usage, a figure that likely still holds today (IFPRI, 2008).[4]

Ugandan smallholder farmers could benefit from increased agricultural input usage. First, soil fertility is low: a 2005 study by the World Bank found that Uganda had one of the highest rates of soil fertility depletion in sub-Saharan Africa, and that replenishing depleted nutrients in the soil would be costly, representing a cost to farmers of about 20 percent of their annual income obtained from agricultural production (World Bank, 2005). Second, the current yields for rain-fed maize, millet, rice, and sorghum are estimated to be only 20-33% of their potential yield (World Bank, 2018). In past trials, maize yields have responded positively to fertilizer application, and maize yields at research stations have been shown to be 8 to 14 times higher than average farmer yields (Bayite-Kasule (2009), Kaizzi et al. (2012)). One study reported that a "medium" amount of fertilizer application could increase maize yield by 270% (Namaazi, 2008). It is worth noting, however, that the yield gains experienced by farmers do not always match those achieved in agronomic trials (Laajaj et al., 2020). As mentioned in the literature review, it is usually assumed that the technologies are profitable for the farmer, but that may not always be the case.

Growth in modern input usage has been slow. Pender et al. (2001) estimated that fewer than 10% of farm households used fertilizer in 2001. Using data from 2003, Yamano et al. (2004) estimate that 7% of households used fertilizer and 61% used improved seeds. Sheahan and Barrett (2017) estimates that 3.2% of Ugandan farmers used fertilizer in 2010-11, and 10.7% used agricultural chemicals of some type. According to the most recent official statistics from 2019, 25.3% of agricultural households used improved seed in the first agricultural season, and 18.3% used it in the second season. Similarly, for the first season, 9.1% of agricultural households used fertilizer and 22.6% used pesticides, while for the second growing season, 10.1% used fertilizer and 22.7% reported using pesticides (UBOS, 2022). There was considerable regional variation.

Why is input usage in Uganda so low? When farm households were asked why they do not use inorganic fertilizer, the most common responses were that it was too expensive (78.6%

[4] Interestingly, the lack of input usage has not impacted overall yields: Uganda ranks 117 out of 180 on cereal yield (kg per hectare), ahead of Kenya (126) and Tanzania (135) (World Bank, 2022), and ranks 100 out of 166 on maize yield, again ahead of Kenya and Tanzania (FAO, 2022). This may speak to the productivity of a few very large plantations, rather than the experience of the average smallholder farmer – though these plantations only account for a small portion of overall output. It could also be because Uganda has a far smaller proportion of maize being grown on very marginal land, a function of the dual rainy season and the generally favorable production conditions.

in season 1, 77.5% in season 2), it was not available locally (33.3%/31.4%), the soil is fertile enough (28.5%/33.1%), and limited knowledge of its benefits and use (24.9%/25.4%) (UBOS, 2022). It is possible that some of these responses (such as "too expensive" and "soil was fertile enough") could be interpreted as the farmer saying the investment would not be profitable for them. The white papers on Uganda mention the same factors as the literature: price, access to information or extension services, access to credit, production risk, and lack of insurance (Benson et al. (2012), Bayite-Kasule (2009), Namaazi (2008)). Benson et al. (2012) suggest that it is cheaper to bring new land under cultivation than to invest in fertilizer, particularly in the North Central region. Bonilla-Cedrez et al. (2021) finds that Uganda has a very unfavorable ratio of maize-to-nitrogen prices compared to the rest of Africa, with a relative price of 23 kg of maize per kilo of fertilizer compared to 6.6 kg of maize per kilo of fertilizer in Kenya. They further find that there is low profitability for fertilizer use in Uganda.[5]

There is further evidence specific to Uganda which reflects many of the same patterns found in the broader literature. Bizimungu and Kabunga (2018) found education, access to extension services, and membership in social groups were predictors of technology adoption, along with age, gender, farm size, and ownership of a radio/mobile phone. Kasirye (2013) identified education, land size, and peer effects as important. Kassie et al. (2011) studied adoption of improved groundnut varieties, and found that farm size, education, occupation, membership in a farmer organization, number of plots, and participation in the land rental market were all significant predictors of technology adoption. Kiiza and Pederson (2012) document the importance of ICT-based market information, providing farmers information on output prices. Gender has an impact as well, with men found more likely to adopt technology (Larson et al. (2015), Mishra et al. (2020)). Off-farm income has a mixed effect on technology adoption: Diiro and Sam (2015) find a significant effect, while Amare and Shiferaw (2017) find no impact of off-farm income on use of inorganic fertilizers.

Mulvaney and Kelsey (2020) interviewed 30 Ugandan farmers and found a lack of cash/credit and fertilizer affordability as major issues. Using data from 2008-9, Adong (2014) found that Ugandan households that were members of farmer groups were 66% more likely to use improved seed than non-members. Van Campenhout et al. (2016) found that access to credit, assets, and

[5]Why is fertilizer in Africa so expensive? Morris et al. (2007) point to the high variability of yields and the wedge between fertilizer prices and crop prices. Bumb and Gregory (2006) cite high transportation costs, high interest rates, and low volumes precluding economies of scale, among other reasons. The maize-to-nitrogen price ratios are likely even higher than reported, given the difficulty of accounting for last-mile transport costs that cut into the farmgate price of maize and increase the price of fertilizer.

livestock were significant predictors of fertilizer usage among rice and potato farmers.

A survey of farmers in Northern Uganda asked why they chose not to purchase certified seed; the most common responses were a lack of money, lack of information, not knowing where to purchase, and the distance to the shop. The study found that information was not a key constraint: there was no impact of new knowledge about certified seed on farmers' willingness to pay, which averaged about half of the prevailing market price (Mastenbroek et al., 2021)

Matsumoto et al. (2010) conducted a field experiment where farmers were given a maize start-up kit and a training session, and later offered inputs at different price levels and with a credit option. They found that treated households (who received the training and start-up kit) purchased more inputs, and that the provision of credit led to increased purchases by all types of households.

Shiferaw et al. (2015) use a double hurdle model to analyze constraints to adoption of improved groundnut varieties in Uganda, focusing specifically on information, seed supply, and credit constraints. Ownership of transportation assets and membership in a farmer group were statistically significant enablers of all three: access to information, seed, and credit. Farm size per capita had the largest impact on access to credit and demand for new varieties, and impacted access to information (though there is potential for reverse causality). They find that access to information, seed, and capital are all binding constraints.

Adong et al. (2020) conducted an RCT in Mityana district that found that a risk-free trial of fertilizer increased uptake by more than 40%. The study was designed to address multiple constraints (liquidity, risk aversion, product availability, knowledge, and counterfeits). Diiro et al. (2015) found that male-headed households were more likely to use fertilizer than female, and found that the number of extension visits, age of household head, and non-farm income were significant predictors for male-headed households; education and distance to the market were not.

Okoboi and Barungi (2012) analyzed data from 2008-9 and found a number of significant adoption drivers, including household characteristics, access to credit, access to extension services, and distance to market. They found that in 2008-9 the most frequently cited reason for not using fertilizer was the cost (50%), followed by lack of knowledge (25%), lack of access (14.1%) and lack of interest (9.5%).

There is also evidence going back several decades that credit constraints reduce the use of fertilizer (Deinigner and Okidi, 2001). In a study of four countries, Adjognon et al. (2017) find that both formal and informal credit use is very low, and that most input purchases are financed by off-farm income and crop sales. In Uganda, only 6% of households purchasing agrochemicals did so using credit.

The evidence suggests that a multitude of factors can explain the low levels of input usage in Uganda. My thesis focuses on two in particular: the presence of counterfeits in the market, and the impact of household shocks on the household's ability to purchase inputs.

1.5 Thesis Overview

The objective of this research is to explore the factors that inhibit Ugandan farmers from investing in agricultural inputs by analyzing some under-researched aspects of farmers' decision to invest. My thesis consists of three papers, each of which relates to this overall theme. I use a mix of quantitative and qualitative methods, analyzing both existing data and novel information that I gathered during fieldwork.

My first paper focuses on counterfeit inputs, one of the risks that farmers face when purchasing agricultural inputs. Counterfeit inputs are on the rise in Uganda, though the precise scope of the problem is not currently known. The fake products can be difficult even for experienced agrodealers to identify, and some agrodealers themselves are likely responsible for some counterfeit products. As such, there is a real risk that farmers will encounter these products. The paper analyzes whether or not farmers' knowledge of the counterfeit problem influences their decision to purchase; I find there is – somewhat surprisingly – a positive relationship between knowledge of the counterfeit problem and purchase of agricultural inputs. This suggests that the presence of counterfeits may not be the key factor suppressing take-up of agrochemicals in particular.

My second paper seeks to better elucidate the personal, idiosyncratic risks that farmers face and how these risks impact the farmers' decision to invest in agricultural inputs. These risks include health shocks such as illness or pregnancy, deaths, social expenditures such as weddings and funerals, theft, loss of external income, etc. I sought to gain a better understanding of how the experience of these shocks (and the anticipation that such shocks may occur) influences farmers' decisions to invest in their farms. This was achieved through econometric analysis of nationally representative household survey data. I find little relationship between the experience of shocks and the decision to purchase seed and fertilizer, and a minor effect of shocks on the amount spent on agricultural inputs. This is suggestive of full insurance in the villages, a hypothesis I explore further in Paper 3.

My third paper takes a qualitative approach to understanding the impact of idiosyncratic shocks on technology adoption. I conducted interviews with around 30 smallholder farmers in Uganda about their production decisions and experiences with various types of risk. The information that I gathered through these interviews provides greater context to a strand of literature that is primarily based on large national household surveys, where the richer context surrounding agricultural production is sometimes lost. Similar to the results of Paper 2, I find limited impact of shocks on the input purchase decision, although there is a negative impact on the amount spent on inputs. I further explore the various coping strategies employed by the households.

This thesis employs both quantitative and qualitative methodologies, and makes use of field-based research, primary data collection, and existing secondary data. It links to a large and growing literature on technology adoption in Africa, and in Uganda in particular; each paper makes a contribution to a subset of this literature. The work presented here draws both on my own personal experience in Uganda and extensive reading, and is designed to have policy applicability, particularly when it comes to promoting greater usage of agricultural inputs among Ugandan smallholder farmers.

Chapter 2

Do Counterfeit Products Inhibit the Use of Agricultural Inputs? Evidence from Uganda

Courtney Blair
University of Oxford, courtney.blair@sant.ox.ac.uk
Jarrod Goentzel
Massachusetts Institute of Technology, goentzel@mit.edu
Tim Russell
Massachusetts Institute of Technology, trussell@mit.edu
Micaela Wiseman
micaelawiseman@gmail.com

Agricultural productivity in many African countries remains low, whether measured in output per unit of land or output per unit of labor. One key reason is that farmers purchase few agricultural inputs – such as improved seeds or fertilizer – even though these are important for raising productivity. A hypothesis that has gained much attention in recent years is that farmers are reluctant to purchase these inputs because of the ubiquity of counterfeits, such as diluted fertilizers or impure seeds. The widespread prevalence of counterfeits has been documented by researchers, specifically in Uganda. In this paper, we use a novel dataset to address the question of whether farmer awareness of counterfeit seed and fertilizer is a significant constraint to the take-up and use of these inputs. We find that those farmers

most familiar with the problem of counterfeits are also those most likely to purchase inputs. By contrast, those farmers unaware of the problem tend not to purchase inputs. We posit that farmers continue to purchase inputs despite the risk of counterfeits because they trust their agrodealers. Although there are many possible causal interpretations, these results tend to cast doubt on the idea that awareness of counterfeits serves as a primary barrier to agricultural input adoption.

2.1 Introduction

Growth in agricultural productivity has long been seen as a priority for economic development and poverty reduction in sub-Saharan Africa, and remains so today (Peter Timmer (1988), Gollin et al. (2002), Minten and Barrett (2008), McArthur and McCord (2017), Jayne et al. (2021)). It is widely recognized that one solution to the challenge of slow agricultural growth in sub-Saharan Africa lies in greater usage of productivity-enhancing technologies, such as improved seed, agricultural chemicals, irrigation, machinery, etc. (de Janvry and Sadoulet (2002), Sanchez et al. (2009), McArthur and McCord (2017), Bonilla-Cedrez et al. (2021)). Thanks in part to high-yielding varieties and the increased use of complementary inputs, for example, food production tripled in Asia and Latin America between 1960 and 2000 (Sánchez, 2010). Unfortunately, sub-Saharan Africa has fallen behind the rest of the world in terms of agricultural productivity. One proximate cause is low usage of agricultural technology. For example, most African countries rank at the bottom globally in usage of fertilizer and pesticides (FAO, 2022). Uganda, the focus of this paper, has very low rates of agricultural technology adoption even for sub-Saharan Africa: it ranks 155 out of 164 countries in fertilizer usage per hectare of crop agriculture, and 131 out of 166 countries in pesticide usage (World Bank (2022), FAO (2022)). Given the low rates of technology usage in sub-Saharan Africa, both the academic literature and the donor community have been exploring ways to increase technology adoption and generate greater agricultural productivity.

One narrative that has emerged in recent literature about Uganda is that farmers may refrain from purchasing inputs because of the ubiquity of counterfeit agricultural inputs. Examples include diluted (or inert) chemical fertilizer, or low-quality seeds that are passed off as high-yielding varieties. Studies have found evidence suggesting that such counterfeits may be widespread in Ugandan markets, and this raises concerns that awareness of counterfeits is impacting farmers' adoption decisions and driving down the use of genuine agricultural inputs. A feature of these input markets is that the buyer cannot easily discern the quality of the inputs from visual observation – the risk of purchasing "lemon" goods is high. Counterfeit inputs frequently look identical to the "true" inputs, and many farmers operate at such a small scale that they buy quantities that are sold out of their original packaging, making it difficult for the producers of the "true" goods to use brand labels or packaging as a way to signal the quality of their products.[1] Several recent studies (Bold et al. (2017), Ashour et al. (2019), Barriga and Fiala (2020), and Staudacher et al. (2021)) have analyzed this hurdle to adoption and have modeled both the problem itself and the impact it has on adoption decisions.

This paper explores whether the presence of counterfeit inputs has a negative relationship with modern input adoption, based on farmers' awareness of the counterfeits issue and their willingness to pay for genuine products. To shed light on this issue, we use a novel dataset drawn from a specially designed farmer household survey that was collected in five districts of Uganda in 2018. The issue of counterfeit inputs is analyzed alongside the traditional obstacles to input adoption (accessibility, affordability, information, and risk). We also ask whether concerns over counterfeit inputs are related to farm size, by dividing the sample population of smallholders into those farming fewer than five acres and those with larger farms.

Our analysis finds a positive and significant relationship between awareness of counterfeit inputs and the use of agrochemicals in our sample. In other words, those farmers who are aware of the prevalence of counterfeits are those who use purchased inputs most intensively. The significance is maintained when the sample is further split by farm size. This result suggests that the presence of counterfeit inputs in Ugandan markets is not acting as a barrier to the use of technology. Our qualitative evidence suggests that many farmers have developed strategies for avoiding counterfeit inputs, chief among them purchasing from a trusted source. We posit that the farmers who use inputs are better informed about counterfeits due to repeated interactions with input dealers and their own personal experience, and that the agrodealers who are able to establish a positive reputation help to mitigate the information asymmetries inherent in what is essentially a credence good, allowing farmers to trust in their purchases.

This paper also contributes evidence as to the other drivers of input usage in Uganda. Specifically, we find that affordability is the main obstacle to input adoption. Farmers are

[1] Note, however, that some recent studies find little evidence of counterfeiting or adulteration of inputs and suggest instead that flawed testing methods may have led to previous overestimates of the ubiquity of this problem (Michelson et al., 2021, 2023).

better able to afford input purchases when they have off-farm income, sell a portion of their harvest, or have livestock available to sell. We further find that a household's food security status is closely correlated with the usage of agricultural inputs, particularly for smallholder farmers.

This paper contributes to the broader literature on input adoption in Sub-Saharan Africa, and to the nascent literature on counterfeit inputs. To our knowledge this is the first study to focus directly on Ugandan farmers' awareness of and attitudes toward counterfeit inputs. Our results have policy relevance both to the debate over how to increase uptake of modern agricultural inputs and to the formulation of anti-counterfeit measures in Uganda and other countries. There are limitations to our conclusions, however, as the data are not nationally representative. Our results suggest that additional research into the topic is needed, such as a more granular understanding of how farmers' awareness of counterfeits shapes their risk calculations when it comes to purchasing agricultural inputs.

The paper is organized as follows: Section 2.2 discusses the relevant literature on input adoption and counterfeit products, while Section 2.3 provides background on the case country, Uganda. Section 2.4 presents the data and some descriptive statistics, and Section 2.5 describes the methodology used. The main analytical results are presented in Section 2.6, and discussed in Section 2.7. Section 2.8 concludes.

2.2 Literature

There is an extensive literature on the adoption of technology in developing countries, with a subset focused on the adoption of agricultural technologies. The literature is typically framed in terms of constraints to adoption. In a thorough review on behalf of the Agricultural Technology Adoption Initiative, Jack (2013) frames the barriers to technology adoption as inefficiencies in seven market aspects: externalities, input and output markets, land markets, labor markets, credit markets, risk markets, and information. In another review of the existing literature, Magruder (2018) focuses on access to credit, access to insurance, and information as constraints to technology adoption. He finds that all three constraints are binding for at least some population of farmers. Bridle et al. (2019) look at four constraints that have together generated the largest number of most experimental studies: credit and savings, risk, information, and input and output markets. In the most recent review, Suri and Udry (2022) consider six different constraints that are common in the literature: credit, liquidity, and savings; insurance; information; high transaction costs and infrastructure; imperfect labor markets; and imperfect land markets. Together, these literature reviews can be viewed as pointing to three key constraints that determine a farmer's ability to adopt a technology: accessibility, affordability, and information. In this paper, we will consider those three constraints, and we will further consider the farmer's risk calculation, part of which involves assessing the risk of counterfeit products.

2.2.1 Accessibility

Ensuring accessibility requires that the product is available to farmers, and depends on both the quality of local infrastructure and the structure and functioning of input markets. Access is usually taken for granted, and is one of the least studied major constraints. Fafchamps and Shilpi (2003) find that the distance to the nearest urban center impacts technology adoption, while Ali (2010) analyzes the role of roads and infrastructure on the use of high-yielding varieties. Suri (2011) considers distance to the nearest input dealer, and finds that long distances to seed and fertilizer distributors can explain why some farmers with potentially high returns do not invest. Accessibility is usually studied alongside several other constraints, such as Alene et al. (2008), which finds that distance to the fertilizer market has a significant effect on fertilizer adoption rates.

2.2.2 Affordability

Affordability simply means that an individual farmer is able to purchase or finance a technology. In proximate terms, this depends on the cost of acquiring the inputs, which is a function of input prices and transportation costs, weighed against the expected returns from using the inputs (and the probability distribution of said returns). Some farmers are able to finance input purchases from the sale of crops, income that is a function of output prices, farm size, and yield. Other farmers use non-farm income to pay for technologies (Diiro and Sam (2015), Amare and Shiferaw (2017)), while some rely on assets and savings (IFPRI, 2008). However, many farmers lack the cash in hand to purchase inputs, and they require access to credit. There is an extensive literature on access to credit as a binding constraint to technology adoption: Boucher et al. (2008), Guirkinger and Boucher (2008), Giné and Yang (2009), Matsumoto and Yamano (2011), Verteramo Chiu et al. (2014). In Ethiopia, Croppenstedt et al. (2003) found that credit is a major constraint to fertilizer adoption, while Awotide et al. (2015) argue that access to credit increases cassava productivity in Nigeria. In a study of a microcredit and grant intervention in Mali, Beaman et al. (2014) find binding liquidity constraints. They observe that farmers who borrow have higher marginal returns, and respond to the relaxation of credit constraints by increasing input usage. However, the evidence on credit is mixed: Bridle et al. (2019) found in a review of nine randomized evaluations that a majority of farmers did not take out loans when offered credit.

2.2.3 Information

Access to information is a fourfold constraint: first, the farmer must have knowledge that the technology exists; then knowledge about its proper application and/or use; then knowledge about the costs and benefits of a technology, in order to assess whether its use is appropriate for a particular plot; and finally knowledge about output market prices, which impacts the expected cost-benefit analysis. A large set of studies looks at the importance of learning, knowledge and access to information (Foster and Rosenzweig (1995), Kabunga et al. (2012), Freeman and Qin (2020), Van Campenhout et al. (2017)). In particular, a substantial number of articles focus on social capital and learning through social networks: Conley and Udry (2001), Bandiera and Rasul (2006), Katungi et al. (2008), Conley and Udry (2010), Liverpool-Tasie and Winter-Nelson (2012), Cai et al. (2015), Beaman et al. (2018), Mekonnen et al. (2018), Shikuku (2019). For example, Conley and Udry (2010) find evidence of social learning among pineapple farmers in Ghana, particularly for those who are new to the crop. Other studies have looked at learning through experiencing the technology via the use of vouchers or subsidies (Carter et al. (2014), Adong et al. (2020)), including several in Uganda (Matsumoto et al. (2013), Fishman et al. (2017), Omotilewa et al. (2019)).

2.2.4 Risk

Once these constraints have been lifted, the farmer first must assess whether the decision to adopt the technology is profitable. This is usually taken for granted in the literature, but is not always straightforward: Beaman et al. (2014) find heterogeneity in marginal returns to input usage, while Suri (2011) finds that the pattern of adoption seen in Kenya can be explained by allowing for heterogeneous costs and benefits. If the technology is found to be profitable, the farmer then makes a decision whether to adopt that is based on a fundamental risk calculation.[2] This involves weighing the risk of both covariate and idiosyncratic shocks (crop failure, output price fluctuations, illness, etc.) against the household's ability to bear risk. As Dercon and Christiaensen (2011) point out, farmers must consider the welfare consequences for the household if these inherently risky production technologies result in a poor harvest, which can sometimes discourage farmers from investing. If the farmer is accessing credit, this impacts the risk calculation, particularly in the absence of functional insurance markets.[3] If the farmer has imperfect information (i.e. the information constraint has not been fully lifted), this also contributes more risk.

Risk aversion has a documented negative impact on input adoption (Knight et al. (2003), Lamb (2003), Abedullah and Pandey (2004), Simtowe (2006), Brick and Visser (2015)). Tanaka and Munro (2014) find evidence of risk and loss aversion among Ugandan farmers, while Mukasa (2018) finds that Ugandan smallholder farmers are risk averse and consider the possibility of crop failure when making input adoption decisions. Production risk is present whether or not farmers purchase inputs, but the economic risks are exacerbated when farmers have actually paid for inputs. In that case, they stand to lose their up-front investments as well as having a lower-than-expected harvest.

In the case of Uganda (as in many other countries), there is another dimension of risk that farmers must consider: the risk of purchasing counterfeit or substandard products. There is an acknowledged problem with "fake" seed and fertilizer across the continent, as documented by Ariga et al. (2019). Counterfeit products (or products that are merely poor quality) introduce risk via another information constraint: if the farmer cannot confidently identify a genuine product, there is risk of purchasing a substandard one, which will presumably have a reduced impact on output relative to what would be expected from a genuine product. The magnitude of this effect is difficult to predict. Indeed, farmers may not be aware of the true expected gains from using a particular input, and may not be able to identify a product as counterfeit if it still produces partial gains. This information asymmetry (and therefore increased uncertainty) has been posited as one of the reasons for low uptake of agricultural technologies in Uganda, particularly seeds and agrochemicals.

[2]The farmer is often assumed to be rationally maximizing, with a structured set of risk preferences, but of course this is not always the case in reality; other literature has looked at behavioral constraints to adoption such as time-inconsistent preferences (see for example Duflo et al. (2011), Abay et al. (2017)).

[3]Another constraint that is explored in the literature is access to insurance to mitigate production risk, particularly rainfall-indexed insurance (Giné and Yang (2009), Mobarak and Rosenzweig (2013)). Karlan et al. (2014) conducted a study in Ghana that finds the main constraint to investment is uninsured risk, with strong demand for rainfall index insurance.

There is a nascent but important and growing literature focused on counterfeit inputs in sub-Saharan Africa, and in particular how input quality, and farmers' beliefs about input quality, impact adoption rates. In a seminal paper, Bold et al. (2017) provide evidence that there are poor quality products on the market in Uganda, in what they call the first "large-scale empirical assessment of the prevalence of poor-quality technologies... in local markets in Africa". Using a mystery shopper approach, they purchased samples of fertilizer and hybrid seed in two regions of Uganda, finding that 30% of the nutrient content was missing in fertilizer and hybrid seed contained less than 50% authentic seeds. This would confirm that there is a problem with counterfeits/sub-standard products in Uganda, and they further confirm through field trials that these products lead to lower than average returns.[4]

Using a Bayesian learning model, Bold et al. (2017) find that farmers' ability to learn about quality is limited, particularly given noisy yield signals, which they suggest might help to explain the equilibrium level of input usage in Uganda. They found that 95% of fertilizer samples had low to moderate dilution levels (10-50%) which makes the dilution difficult to detect – the farmer may not know what level of yield to expect in the first place, and as such may not realize that they have a substandard product, as their yield outcomes may still improve even with moderate levels of dilution. The seed and fertilizer on the market yielded low but positive returns; they estimated that two-thirds of the fertilizer samples would lead to positive returns. They suggest that farmers do have some ability to learn about quality, given the market has not collapsed entirely. The smallholder farmers they surveyed had a relatively accurate expectation of the quality of inputs available in their nearest shop, though there was substantial variation in the responses, suggesting that some farmers were better informed or better able to infer quality than others. Finally, they find that the heterogeneity in fertilizer quality is uncorrelated with prices, which were relatively homogeneous.

Ashour et al. (2019) build on the Bold et al. (2017) study to test whether farmers' beliefs about the quality of herbicide in their local market correspond to the actual quality that is available. They collected samples from 120 markets in 25 districts and tested the concentration of active glyphosate herbicide, then conducted lab-in-the-field games with more than 1,300 farmers served by the 120 markets in their sample. They find that low quality herbicide is

[4]Some recent evidence suggests that the testing used by Bold et al. (2017) may not have been entirely accurate, however, due to issues with the chemical analysis such as poor calibration at the testing facilities. See `https://blogs.worldbank.org/impactevaluations/devil-details-measuring-agricultural-input-quality` or Michelson et al. (2021, 2023) for more.

common, with 15% of the active ingredient missing from their samples on average; 31% of the samples contain less than 75% of the advertised concentration. This corresponds to the findings from the Bold et al. (2017) study, as for the majority of products sampled, the concentration is diluted, but not so much so as to completely erode the effectiveness of the product. From their farmer survey they find that the farmers believe that using genuine herbicide can be profitable, but are also aware that some of the herbicide in their local market is low quality. The lab-in-the-field game revealed that farmers believed that 40.7% of the herbicide in their local market was either counterfeited or adulterated, and they find that these beliefs are statistically significantly correlated with the actual measures of herbicide quality. The farmers surveyed were aware of the issues with quality, with 80% of those who use herbicide believing that quality is sometimes intentionally altered. Similar to Bold et al. (2017), they also find that prices do not completely adjust to reflect quality, with differences in price accounting for only a fraction of the difference in quality between markets. They also conclude that the equilibrium of low adoption that we see in Uganda can be explained by farmers' uncertainty about the quality of products they are purchasing.

Barriga and Fiala (2020) had different results, finding little evidence of counterfeiting of maize seed. They collected and tested samples of OPV and hybrid maize seed along the supply chain from Kampala to Northern Uganda, and found little evidence of counterfeiting but highly variable quality of seed. They concluded that their results were consistent with mishandling and poor storage rather than deliberate adulteration. Staudacher et al. (2021) visited agro input shops in 35 districts in western and central Uganda and found that 25% of shops were selling repackaged products and 10.5% of shops sold unmarked or unlabeled products. Almost all input dealers believed counterfeits were a big problem (93.3%) though most believed they could identify counterfeit products.

Beyond Uganda, there is limited research on the prevalence and causes of counterfeits. There is preliminary evidence of adulterated fertilizer in Tanzania (Fairbairn et al., 2017), as well as research on farmers' beliefs about fertilizer in that country (Michelson et al., 2021), and published research on glyphosate in Mali (Haggblade et al., 2021) and pesticides in Saudi Arabia (Kassem and Alotaibi, 2020). A recent experiment in Kenya found that training buyers to identify quality-verified seeds caused some seed sellers to exit the market (Hsu and Wambugu, 2023). Much of the research on counterfeits is limited to white papers funded by donor agencies, such as Tjernström et al. (2015), Monitor Deloitte (2014), and Joughin (2014). Previous research by our team has touched on the issue, though not in-depth (Reinker and Gralla, 2018).

This paper contributes to this growing literature on counterfeit products in sub-Saharan Africa, adding specific evidence as to the impact of these products on input adoption in Uganda. Ours is the first study, to our knowledge, to include farmer-level data on awareness of counterfeit inputs to analyze the relationship between awareness and adoption. We also contribute to the literature that seeks to explain the current low level of input usage in Uganda.

2.3 Context

Uganda is a landlocked country in East Africa, with bi-modal rainy seasons and predominantly rain-fed agriculture. More than two-thirds of the population is engaged in agriculture, which contributed nearly a quarter of GDP in 2021 (UBOS, 2021). Its major food crops by volume are plantain bananas, maize, and cassava (UBOS, 2021). Uganda is widely considered as a potential breadbasket for East Africa, given its climatic profile, expanses of arable land, and dual annual growing seasons. However, national agricultural output has only grown at 2% in recent years, less than the population growth rate, and less than the rates in other East African countries (World Bank, 2018).

Maize is widely grown both for home consumption and for the market in Uganda and serves as a key benchmark for agricultural productivity. In 2018, the national maize yield was 1.4 MT/ha, below the estimated potential yield of 5 MT/ha (UBOS, 2020). Recent growth in maize production has been attributed to an increase in area under cultivation, rather than an intensification of production (Ajambo et al., 2017).

As noted above, one reason for the low maize yields is Uganda's low use of modern agricultural inputs. In 2018, Ugandans used 3.3 kg of fertilizer per hectare of arable land, compared to 15.7 kg/ha in neighboring Kenya and 15.9 kg/ha in Tanzania. By comparison, South Africa registered 72.8 kg/ha, and the United States used 128.8 kg/ha (World Bank, 2022). Furthermore, it has been estimated that large-scale plantations account for 95% of fertilizer usage in Uganda (IFPRI, 2008).[5] According to the most recent official statistics from 2019, 25.3% of agricultural households used improved seed in the first agricultural season, and 18.3% used it in the second season. Similarly, for the first season, 9.1% of agricultural households used fertilizer and 22.6% used pesticides, while for the second growing season, 10.1% used fertilizer and 22.7%

[5]Although this IFPRI study is 15 years old, there is little reason to think that there has been much change in the pattern of input use across the past two decades.

reported using pesticides (UBOS, 2022).

When farm households were asked why they do not use inorganic fertilizer, the most common responses were that it was too expensive (78.6% in season 1, 77.5% in season 2), it was not available locally (33.3%/31.4%), the soil is fertile enough (28.5%/33.1%), and limited knowledge of its benefits and use (24.9%/25.4%) (UBOS, 2022). This reflects the three constraints discussed above. Interestingly, only 0.3% of households responded that they do not use inorganic fertilizer because the available fertilizer is of poor quality or counterfeit, with several possible explanations: a lack of awareness about the prevalence of counterfeits, an overstatement at the national level of the true prevalence of counterfeit products, or simply that the possible presence of counterfeits is not the proximate reason why most households do not purchase fertilizer. These figures also suggest that there is an information gap when it comes to soil fertility, as a 2005 study by the World Bank found that Uganda had one of the highest rates of soil fertility depletion in sub-Saharan Africa (World Bank, 2005).

There is some Uganda-specific evidence in the literature, which broadly confirms the importance of accessibility, affordability, information, and risk, along with household-specific characteristics that are predictors of access to inputs, credit, and information. Bizimungu and Kabunga (2018) found education, access to extension services, and membership in social groups were predictors of technology adoption, while Kasirye (2013) identified education, land size, and peer effects as important. Kassie et al. (2011) studied adoption of improved groundnut varieties and found that farm size, education, occupation, membership in a farmer organization, number of plots, and participation in the land rental market were all significant predictors of technology adoption. Other studies looked at ICT-based market information (Kiiza and Pederson, 2012), mobile phones (Martin and Abbott, 2011), and gender (Larson et al., 2015). Off-farm income was found to have a significant effect on technology adoption (Diiro and Sam, 2015). Mulvaney and Kelsey (2020) interviewed 30 Ugandan farmers and found a lack of cash/credit and fertilizer affordability as major issues. Using data from 2008-9, Adong (2014) found that Ugandan households that were members of farmer groups were 66% more likely to use improved seed than non-members. Van Campenhout et al. (2016) found that access to credit, assets, and livestock were significant predictors of fertilizer usage among rice and potato farmers.

There is a widely acknowledged problem with counterfeit agricultural inputs in Uganda, though no reliable statistics are available on the scope or prevalence of the issue. Various figures have been proposed, often projecting that around 30% of products on the market are counterfeit, with estimates for some areas as high as 50% (New Vision, 2022). The government reports that 30-40% of the seed on the market is counterfeit, though it is not clear how this estimate was produced (MAAIF, 2018). Several recent studies have begun to build the evidence base, as discussed above. As of yet there is insufficient evidence as to where in the supply chain counterfeiting or adulteration occurs, nor is it clear which products are most heavily counterfeited. The belief that there are counterfeit products on the market appears widespread: as Ashour et al. (2015) report, 39.6% of their respondents believed that the quality of most or all of the hybrid maize on the market had been lowered by adulteration or counterfeiting, while 26.4% felt this way about herbicide and 47.0% about fertilizer. There have been efforts by donor agencies to address the issue, such as the introduction of e-verification labelling (discussed further in Section 2.7.1.3), with limited success (see Ashour et al. (2015) and Gilligan et al. (2019)). It is possible, as some researchers have suggested, that sensational media coverage has overblown the scope of the problem and generated a false sense of panic. But anecdotal evidence and the authors' own experiences in Uganda suggest that the problem is widespread, and should be a priority area for researchers.

2.4 Data

The data was collected in 2018 under the auspices of the USAID/Uganda Feed the Future Market System Monitoring Activity. The household survey was designed to collect information about farmers' engagement with the market system, and included modules on demographics, agronomic practices, input usage, production and harvest, access to finance, and access to information; the questionnaire is included in the Appendix. The final sample included 498 households from five districts: Gulu, Ibanda, Iganga, Mubende, and Pader. These districts were selected purposively from the districts in the Feed the Future Uganda Zone of Influence (ZOI), with one district representing each of four regions of Uganda (Central, North, East, West) plus one particularly rural district (Pader).[6] The survey received ethical approval from both the Massachusetts Institute of Technology and the Uganda National Council for Science and Technology.

[6] The Zone of Influence districts were selected by USAID according to three criteria (number of smallholder farms, number of people living in poverty, and number of underweight children) as well as the potential for commercialization of one of three priority crops: coffee, beans, and maize. Given this second requirement, it is possible that the ZOI districts have more developed market systems than some of the other areas of Uganda; the districts were also the recipients of Feed the Future programming on market systems development. This would mean the estimates in this paper represent an upper bound on both input adoption and awareness of counterfeits.

A two-stage sampling procedure was used, with heavy use of GIS methods. As the focus was on farming households, we excluded the sub-counties in each district that contained population centers. The remaining sub-counties were divided into 2km x 2km squares, which served as the first stage sampling unit. Thirty squares were sampled for each of the five districts, using a probability proportional to size method, to ensure each farm household had an equal probability of being selected. The squares were then inspected using satellite imagery on Google Maps, and squares that contained more than 50% water or forest cover were excluded, as well as squares with fewer than ten visible buildings. We then used satellite imagery on Google Maps to identify and number the man-made structures in each square, excluding those that had already been labeled as commercial or religious buildings. These formed the pool for the secondary sampling unit: a list of 30 buildings was randomly selected for each square. Enumerators visited ten squares per district, with a target of ten households per square.[7] Each household was given a modest honorarium in exchange for their time and participation.

Overall, 39.2% of respondents had purchased agrochemicals in the previous year, almost all of which were purchased from an input shop. Pesticides were the most common agrochemical at 32.5%, followed by herbicides (16.7%) and fertilizer (14.1%). The respondents who did not purchase agricultural chemicals were asked why, and could choose more than one response. The overwhelming majority reported that they could not afford to purchase (76.2%). A further 29.4% reported that the inputs were either not available or too far away, which are also both markers of affordability (the inputs are available somewhere, such as the nearest large town, but the farmer has deemed it too costly to travel to obtain them). Fully 17.5% of respondents said they did not need the chemicals or did not see the value in using them, the latter of which can again be linked to affordability.

The data bears out the importance of the accessibility constraints discussed in the literature: only 42.8% of sample households reported having an input shop nearby, suggesting that availability is a major constraint to input adoption.[8] On average, respondents were located 3KM from the nearest road, and 22.7KM from the nearest town. When it comes to owning or having access to a means of transportation to reach input shops, 49.0% of respondents reported owning

[7]The enumerators pre-screened to ensure that the chosen building represented a household that participated in agriculture, or selected a replacement if not. The target was ten households for each square, or 100 households per district; the actual figures were between 7-12 households per square and between 96 and 102 households per district.

[8]We assume that accessibility equals availability; however, having an input shop nearby does not always guarantee that the shop has the required products in stock.

or having access to a bicycle, and 21.5% reported owning or having access to a motorcycle, while 38.6% reported no access to means of transportation at all.

Surprisingly, many households in the sample reported that they did have access to credit. The main source of financing among respondents was from village savings and loan associations (VSLAs) or other savings groups, of which 54.5% of the sample were members. Almost 40% of respondents had borrowed in the previous year. The main reasons cited for borrowing were to pay school fees (40.1%), to purchase inputs (39.0%), and to invest in non-agricultural businesses (14.3%). Given the number of farmers who cited affordability as a barrier to input usage, we might have expected higher rates of borrowing for inputs. In fact, this rate of borrowing seems relatively high, compared to what is expected in the literature. For example, Adjognon et al. (2017), studied four countries, including Uganda, and found that input credit usage tends to be very low, with inputs usually self-financed from off-farm income or crop sales. This also tracks with Christiaensen and Demery (2017) description of African farmers, tending to use credit to finance non-farm businesses or consumption, and with Diiro and Sam (2015), who find a negative relationship between receipt of credit and improved seed usage. We will see later that credit access is not significantly related to input adoption in this sample.

As for the information constraint, only 62.9% of respondents reported owning a mobile phone. When asked about access to information, the two most commonly available types of information were market prices (73.9% of respondents) and weather data (45.6%). The most common sources of market price information and weather data were word of mouth and the radio.

Overall, the main crops grown were maize, beans, and sorghum. About one third (33.7%) of farmers reported non-farm income, and about one third of these farmers said it represented more than 50% of their overall income. Farmers who used chemicals were more likely to plant maize, own a mobile phone, have off-farm income, and plant more than 5 acres.[9]

As for the counterfeits issue, only 39.6% of the farmers in our sample responded that they were aware of the problem with counterfeit inputs. The majority of these (59.2%) had heard about the issue from friends or neighbors, while 28.3% were told by an input dealer, 21.5% learned through personal experience, and 20.9% heard about it on the radio. The respondents were also asked what they do to avoid counterfeit inputs, an open-ended question, which is

[9] Interestingly, there were 13 farmers who neither sold crops nor reported off-farm income, whom we would expect to rely on credit for input purchases and yet who seemingly have no source of income to repay it. These farmers are a mystery to us.

discussed in Section 2.6.4 below. Despite only about 40% of respondents expressing awareness of the counterfeits issue, even more were willing to pay a premium to guarantee a genuine product. When asked what premium they would be willing to pay on a bottle of pesticide that cost 20,000 Ugandan shillings (UGX) to guarantee that it was genuine, nearly a third (28.1%) were willing to pay UGX 5,000 extra, or a 25% premium. Respondents were also offered the option of UGX 1000 (17.9%), UGX 2,000 (22.1%), and UGX 10,000 (14.9%). Around 8% of respondents wrote in other values; of these, 9 respondents (1.8% of the total) responded that they were unwilling to pay any premium (UGX 0). The large number of respondents willing to pay a premium for a genuine product suggests a latent awareness of issues in the supply chain (both quality issues and the presence of counterfeits). Of the farmers who were aware of counterfeits, 46.6% went on to purchase agrochemicals anyway – a higher percentage than in the overall sample (39.2%). Similarly, during the fieldwork described in Paper 3, respondents were asked both whether they purchased inputs and whether they were aware of counterfeit products; 87.5% of respondents were aware of counterfeits (possibly because they were from an area where sensitization campaigns had taken place), and all of these respondents reported having purchased some kind of inputs for at least one of the two previous seasons. This suggests, as we will see below, that awareness of counterfeits is not always a barrier to agricultural input adoption.

The variables included in the analysis are described in Table 2.1.

The first set of descriptive statistics is provided in Table 2.2, with households divided into adopters (of agricultural chemicals) and non-adopters. As can be seen in the last column, there were a number of variables for which there was a statistically significant difference between the mean value for adopters and the mean value for non-adopters, as calculated using a simple t-test. For example, non-adopters were less likely to have an input shop nearby, and less likely to own or have access to a means of transportation. This speaks to the importance of accessibility in enabling input adoption. There were differences when it comes to affordability as well: adopters were more likely to have non-farm income, to have sold a portion of their harvest, and to own livestock. They were also more likely to have received credit from a business, often a key source of financing for input purchases. There were significant differences in mobile phone ownership and cooperative membership as well. Adopters planted more total acres of crops, suggesting a

Table 2.1: Variable Descriptions

Variable	Type	Description
Anti-Counterfeit Variables		
Awareness of Counterfeits	Binary	Respondents were asked "Are you aware of the problem with counterfeit inputs?"
Pesticides Willingness to Pay (UGX)	Continuous	Respondents were asked the following question: "Let's say 1L of pesticides costs 20,000/=. How much more would you pay for 1L of pesticides that were certified as genuine and effective?" The answer choices were UGX 1,000, UGX 2,000, UGX 5,000, and UGX 10,000. Respondents could also specify an "other" value; these were coded and included.
Accessibility Constraint		
Nearby Input Shop	Binary	Respondents were asked whether there was an input shop nearby where they could purchase inputs. The definition of "nearby" was left up to the respondent.
Distance to Nearest Road (km)	Continuous	We used GIS data to calculate the minimum straight-line distance from each household to the nearest major road.
Distance to Nearest Town (km)	Continuous	We used GIS data to calculate the minimum distance each household would have to travel along roads to reach the nearest town or city.
Transport Means	Binary	Respondents were asked whether they owned or had access to a means of transportation, such as a bicycle or a motorcycle.
Affordability Constraint		
Non-farm Income	Binary	Households were asked whether any portion of their income was earned outside of their farm in the previous year.
Sold Portion of Harvest	Binary	Respondents were asked whether they had sold any of their harvest from the previous two growing seasons.
Livestock Owned (TLUs)	Continuous	Each respondent was asked whether the household owned livestock, what kind, and how many of each. These figures were then converted into Tropical Livestock Units using conversion factors from the Food and Agriculture Organization, and the total number of TLUs was calculated for each household.
Number of Adults	Continuous	Respondents were asked how many adults live in the household.

Variable	Type	Description
Borrowed Money	Binary	Each household was asked whether anyone in the household had borrowed money in the previous year.
Received Credit	Binary	Respondents were asked whether anyone in the household received credit from a business in the previous year.
Belong to Savings Group	Binary	This variable represents whether anyone in the household belonged to a savings group, such as a village savings and loan association.
Access to Information Constraint		
Age	Continuous	This represents the age of the respondent, who was not necessarily the household head.
Education (Years)	Continuous	The respondent was asked the highest level of education that he or she had attained. This was then converted into the number of years of education. Again, the respondent was not necessarily the head of the household.
Mobile Phone Ownership	Binary	The respondent was asked whether he or she owned a mobile phone.
Member of Cooperative	Binary	The respondent was asked whether he or she was a member of a producer organization or cooperative.
Access to Market Price Info	Binary	The respondent indicated whether he or she had access to information about market prices.
Access to Weather Info	Binary	The respondent was asked whether he or she had access to weather data.
Ability to Bear Risk		
Acres Planted (total Seasons A & B)	Continuous	This variable represents the total number of acres of crops each household planted across the two seasons that were covered by the survey.
Acres Planted Per Adult	Continuous	As a measure of labor intensity, we calculated the total number of acres planted divided by the number of adults in the household.

Variable	Type	Description
Food Security Status	Continuous	Respondents were asked how often anyone in the household had to skip meals because there was not enough food. Answer choices included "once or twice a week," "once or twice a month," "a few times per year," and "never." Based on our research, we decided to convert this ordinal variable into a continuous variable by assigning numbers to these frequencies – for example, "a few times per year" was coded as 6, "once or twice a month" as 12, etc. These values were then scaled by dividing by the number of days in a year. As such, a very low value indicates that few meals were skipped, while a higher value suggests greater food insecurity. The mean of the sample is 0.01, for example, which roughly corresponds to "a few times per year."
Household Shock	Binary	The respondents were asked whether the household had experienced any major problems, such as illness or a death in the family, that year or the previous year. The question was open-ended, and the interpretation of "major" was left up to the respondent. The responses were coded, and this variable represents whether the household indicated experiencing a problem.
Experienced Crop Disease	Binary	Respondents were asked whether they had problems with crop diseases in either of the previous two seasons.
Experienced Drought	Binary	Respondents were asked whether they had experienced a drought in either of the previous two seasons.
Experienced Fall Armyworm	Binary	Respondents were asked specifically about whether they had experienced a Fall Armyworm infestation in either of the previous two seasons. This pest had been prevalent in Uganda, feeding on cereals, primarily maize and sorghum.

linkage between farm size and input usage, though this could be a wealth effect as well. Finally, adopters were more likely to be aware of the problem with counterfeits, which we will discuss in due course, and were willing to pay a higher premium for genuine products.

A second set of descriptive statistics is provided in Table 2.3, this time with the sample split into those households that were aware of the counterfeits problem and those that were not aware. Once again, the difference in means was calculated and a simple t-test performed. This time there were fewer significant differences between the two groups, but still a few worth noting. Those aware of counterfeits were more likely to have an input shop nearby; as we will see later, input dealers can be an important source of information about counterfeits. They were also more likely to own or have access to a means of transportation, often essential for accessing an input shop, and to have sold a portion of their harvest, an indicator of engagement with the broader market. The respondents that reported awareness of counterfeits had a higher mean level of education, and were more likely to be a member of a cooperative, both signaling better access to information about counterfeit products. They planted more acres, again a possible wealth effect. Those that were not aware of counterfeits were more likely to have experienced a Fall Armyworm infestation; there is not an immediate explanation for this. Overall these results point to the importance of access to information, which makes intuitive sense.

2.5 Methodology

Our hypothesis is that there is a relationship between knowledge of the issue with counterfeit inputs and the household's decision to purchase agricultural inputs. The relationship could be reflected in either of two directions. One possibility is that households that are aware of the problem are less likely to purchase inputs, in order to avoid the possibility of purchasing a counterfeit. The alternative is that households with awareness of the problem are *more* likely to purchase inputs, simply as a mechanical result of the fact that those who purchase inputs are more likely to have encountered information about counterfeits, owing to their interactions with input dealers and possibly through exchanges of information through their social networks.

Table 2.2: Descriptive statistics: Adopters vs. Non-adopters

Variable	(1) Full Sample n=498	(2) Adopters n=195	(3) Non-adopters n=303	Difference (3)-(2)
Anti-Counterfeit Variables				
Awareness of Counterfeits	0.40	0.47	0.35	-0.12***
Pesticides Willingness to Pay (UGX)	4234.87	4682.64	3930.89	-751.74**
Accessibility Constraint				
Nearby Input Shop	0.43	0.53	0.36	-0.17***
Distance to Nearest Road (km)	2.98	2.84	3.06	0.22
Distance to Nearest Town (km)	22.73	22.15	23.11	0.96
Transport Means	0.61	0.69	0.56	-0.13***
Affordability Constraint				
Non-farm Income	0.34	0.41	0.29	-0.11***
Sold Portion of Harvest	0.82	0.90	0.76	-0.14***
Livestock Owned (TLUs)	1.47	2.21	1.00	-1.20***
Number of Adults	2.85	2.85	2.84	-0.01
Borrowed Money	0.37	0.38	0.35	-0.03
Received Credit	0.09	0.17	0.04	-0.13***
Belong to Savings Group	0.62	0.58	0.64	0.06
Access to Information Constraint				
Age[a]	41.50	40.41	42.21	1.80
Education[a] (Years)	4.85	5.47	4.45	-1.02***
Mobile Phone Ownership	0.63	0.82	0.50	-0.32***
Member of Cooperative	0.09	0.10	0.08	-0.02
Access to Market Price Info	0.74	0.82	0.69	-0.13***
Access to Weather Info	0.46	0.51	0.42	-0.09*
Ability to Bear Risk				
Acres Planted (total Seasons A & B)	5.97	6.79	5.45	-1.34***
Acres Planted Per Adult	2.53	2.81	2.35	-0.47**
Food Security Status	0.01	0.01	0.01	0.00
Household Shock	0.72	0.69	0.74	0.05
Experienced Crop Disease	0.55	0.55	0.55	0.01
Experienced Drought	0.80	0.79	0.81	0.02
Experienced Fall Armyworm	0.56	0.59	0.53	-0.06

***, **, and * represent significance at the 1%, 5%, and 10% level.
TLU stands for tropical livestock units; UGX stands for Ugandan Shillings.
[a] Note: The respondent was not necessarily the household head.
Source: Authors' calculations using data collected by the USAID/Uganda Market System Monitoring Activity.

Table 2.3: Descriptive statistics: Aware of Counterfeits vs. Not Aware

Variable	(1) Full Sample n=498	(2) Aware n=191	(3) Not Aware n=291	Difference (3)-(2)
Anti-Counterfeit Variables				
Awareness of Counterfeits	N/A	N/A	N/A	N/A
Pesticides Willingness to Pay (UGX)	4234.87	4333.33	4095.44	-237.90
Accessibility Constraint				
Nearby Input Shop	0.43	0.51	0.39	-0.12***
Distance to Nearest Road (km)	2.98	3.19	2.85	-0.34
Distance to Nearest Town (km)	22.73	23.63	22.21	-1.43
Transport Means	0.61	0.76	0.53	-0.23***
Affordability Constraint				
Non-farm Income	0.34	0.38	0.31	-0.06
Sold Portion of Harvest	0.82	0.86	0.80	-0.06*
Livestock Owned (TLUs)	1.47	1.70	1.38	-0.32
Number of Adults	2.85	2.90	2.78	-0.12
Borrowed Money	0.37	0.40	0.34	-0.06
Received Credit	0.09	0.12	0.08	-0.04
Belong to Savings Group	0.62	0.66	0.59	-0.07
Access to Information Constraint				
Age[a]	41.50	41.86	41.43	-0.43
Education[a] (Years)	4.85	5.51	4.46	-1.05***
Mobile Phone Ownership	0.63	0.63	0.63	-0.01
Member of Cooperative	0.09	0.13	0.06	-0.07**
Access to Market Price Info	0.74	0.77	0.72	-0.05
Access to Weather Info	0.46	0.50	0.43	-0.08
Ability to Bear Risk				
Acres Planted (total Seasons A & B)	5.97	6.50	5.72	-0.78*
Acres Planted Per Adult	2.53	2.72	2.46	-0.26
Food Security Status	0.01	0.01	0.01	0.00
Household Shock	0.72	0.72	0.71	0.00
Experienced Crop Disease	0.55	0.58	0.53	-0.06
Experienced Drought	0.80	0.78	0.82	0.04
Experienced Fall Armyworm	0.56	0.44	0.62	0.18***

Note that 16 respondents selected “Don’t know” in response to this question.
***, **, and * represent significance at the 1%, 5%, and 10% level.
TLU stands for tropical livestock units; UGX stands for Ugandan Shillings.
[a] Note: The respondent was not necessarily the household head.
Source: Authors’ calculations using data collected by the USAID/Uganda Market System Monitoring Activity.

Using our data, we seek to infer whether either of these relationships exists between knowledge of counterfeits and input purchases.

2.5.1 Model Specification

The basic underlying model that we use in our analysis is shown below. Our dependent variable (*Inputs*) is a binary indicator of agrochemical usage that represents whether the farmer used pesticides, herbicides, or fertilizer at any point in the previous year (two growing seasons).

$$Inputs_i = \beta_1 * Awareness_i + \beta_2 * Willingness_i + \beta_3 * Availability_i + \beta_4 * Affordability_i$$
$$+ \beta_5 * Information_i + \beta_6 * X_i + \beta_7 * District + \epsilon_i \qquad i = 1, ..., N \tag{2.1}$$

We include two variables related to counterfeit inputs, derived from two questions in our survey. The first (*Awareness*) asked whether the farmer was aware of the problem with counterfeit inputs, and is included as a dummy variable.[10] The second question elicited farmers' willingness to pay for pesticides that were certified as genuine and effective, and the variable (*Willingness*) is an ordinal one with the values they could choose from: UGX 1,000, UGX 2,000, UGX 5,000, or UGX 10,000.[11] We also included vectors of controls for each of the key constraints discussed above (*Availability*, *Affordability*, and *Information*) as well as a vector of controls measuring a household's ability to bear risk.

We included four variables in the vector *Availability* to represent the accessibility constraint: whether the farmer has a nearby input shop, the distance to the nearest road in KM, the distance to the nearest town in KM, and whether the farmer has access to means of transportation such as a bicycle or motorbike. The definition of "nearby" was not specified, and left to the farmer to determine.

Affordability encompasses the household's ability to purchase inputs with or without credit. Non-farm income is included as it can be an important source of input financing, as can the income from selling a portion of the harvest. Livestock is included, as it represents an asset

[10] The exact question asked was: "Are you aware of the problem with counterfeit inputs?"

[11] We asked farmers to consider a 1L container of pesticides that cost UGX 20,000, and asked how much more they would pay for for 1L of pesticides that were certified as genuine and effective. ("Let's say 1L of pesticides costs UGX 20,000. How much more would you pay for 1L of pesticides that were certified as genuine and effective?") Some farmers wrote in answers that were higher than UGX 10,000; these are not included in the analysis.

base that can either be sold to purchase inputs or used as collateral. We include the number of adults as a proxy for the household's ability to provide the extra labor required to apply the inputs.[12] Finally, access to credit is represented by membership in a savings group, the most common source of credit, as well as whether the household had borrowed money in the previous year or had received credit from a business.

To control for access to information, we started with two variables that are common in the literature: age and education. Older farmers are presumed to have accumulated more farming knowledge and have broader networks (though the literature also suggests that older farmers tend to be more risk averse). Education is a proxy for the farmer's ability to digest and act upon new information. We include mobile phone ownership as a proxy for access to information, as well as membership in a cooperative as another potential source of information about the benefits and proper usage of agricultural inputs.

As mentioned above, we included a vector of controls X at the household level. Following Dercon and Christiaensen (2011), we explicitly consider the farmer's ability to absorb risk, both production shocks and other adverse events, as a determinant of the farmers' willingness to invest in agricultural inputs. We include the number of acres planted as a proxy for overall income and food security, as well as a measure of acres planted per adult, to capture the amount of consumption pressure on the land under cultivation.[13] Our survey explicitly asked farmers questions about their food security, and so we include a measure of how often members of the household skip meals. Finally, we include dummy variables representing several shocks to the household: whether they experienced any adverse events in the past year (many reported illnesses and deaths), exposure to crop disease, drought in the area, and whether they suffered from Fall Armyworm infestation, a particular problem during the two seasons included in the survey.

Finally, we include a vector of dummy variables for four of the districts in our sample (*District*), using Pader as the omitted category, since it is the most rural district. In this case, the five districts also correspond with five different agro-ecological zones. As such it will not be possible to tease out the different effects of regional or cultural differences from the influence of different farming systems on farmers' production decisions.

[12]A separate specification using the number of man-days of labor hired by the household did not yield substantially different results, and was open to possible endogeneity issues.

[13]We use 'acres planted' and 'number of adults' as separate independent variables, which might suggest that 'acres per adult' suffers from perfect collinearity, but we do not observe this issue in our regression results.

2.5.2 Analytical Approach

We estimate Equation (1) above using the probit model as our primary approach and the linear probability model as a robustness check. Our standard errors are clustered at the level of the first stage sampling unit, which is the grid square in which the household was located.

Given the limitations of the data that is available to us, we do not view these as causal analyses. There is no treatment effect to be measured, no discontinuity that can be exploited, and no obvious instrumental variable. As the data is cross-sectional, it is not possible to eliminate potential confounding factors through differencing or fixed effects. There is certainly a potential for omitted variable bias, from unobserved characteristics that are correlated with both awareness of counterfeit inputs and the decision to purchase, such as the potential spillover effect of one's neighbors or social network spreading information about both input usage and counterfeits. We do include dummy variables at the district level to try to address some of the inherent variation in agroecology and access to inputs across districts. Propensity score matching is not an option either, as with this dataset its not possible to match on the characteristics that likely determine knowledge of counterfeits, such as social networks or exposure to a public information campaign. As such, the analysis that follows is limited to descriptive findings on the correlative associations between variables, and we acknowledge the possibility of bias in our results.

There are two other features of the data that limit our ability to draw firm conclusions. First, when it comes to awareness of counterfeits, we are not certain about the timing of knowledge acquisition. The survey asks whether the respondent was aware of the problem at the current period, and then asks about input purchases in a one-year lookback. The survey did not ask when the respondent learned about the counterfeits issue. It is possible that the respondent acquired this knowledge *after* the input purchasing decisions were made. As such, the imputed association between counterfeit awareness and input purchasing may not be as strong as we estimate, or indeed may actually be in the opposite direction.

Secondly, it is worth noting that the households in these districts may have had access to information via a USAID program that spread information about counterfeit inputs, which could influence the pattern of knowledge that we see in the data. Despite our best efforts, we were not able to obtain records of where this program operated or what messaging it used. Absent more information about which districts the program operated in and the specific interventions that were deployed in those districts, it is impossible to quantify the potential confounding effect of this program. As such, it is possible (even likely) that the results obtained for the districts in our sample are not generalizeable outside the Feed the Future districts, or indeed outside the group of districts that were potential beneficiaries of this program.

Finally, it is worth briefly discussing our treatment of the open-ended questions in our survey. We made use of two of these questions in our analysis below: one which asked those households that were aware of counterfeit products how they avoid them, and one which asked those who specified that their nearby input shop had a good reputation to explain what this meant to them. We followed the same procedure for both questions, in which the responses were parsed, broad themes were identified, and a category was created if it contained five or more responses. The respondents often provided more than one reason or explanation in their response, and each of these was counted separately, as is noted below. We were strict in our definitions of the categories, so as to limit the room for interpretation and therefore error. Additionally, some of the qualitative evidence in Section 2.6.4 comes from the fieldwork described in Paper 3, which has a more thorough treatment of the methodology used.

2.6 Analysis

2.6.1 Full Sample Results

The correlates of agricultural chemical adoption, as estimated using probit regressions, are reported in Table 2.4. Regression (1) reports the results of a probit regression with clustered standard errors; regression (2) adds the dummy variables for the sampled districts. Marginal effects are reported.

Table 2.4 gives us our main result: awareness of counterfeits is strongly associated with agrochemical usage in both models, with a positive marginal effect and similar coefficients (0.150 and 0.179). In other words, awareness of counterfeits is associated with a 15-18% increase in the probability of input adoption. This seems *prima facie* to be counterintuitive, as one could expect that awareness of counterfeits in the market would discourage farmers from purchasing. At the same time, it is more likely for farmers who use inputs to be aware of counterfeits in the first place; as discussed above, input dealers and personal experience were among the main sources of information about counterfeit products. It is not possible to draw causal conclusions from this analysis, but it is certainly suggestive of the fact that farmers are not deterred by the presence of counterfeits in the market – this is not a binding constraint on adoption, nor does it seem to be discouraging input usage.

The other counterfeit-related control, willingness to pay for genuine pesticides, was not statistically significant in either model. If we view this as a rough proxy for some combination of risk aversion and ability to pay, this result suggests that even farmers who are more risk averse (willing to pay a higher premium for a genuine product) are still using agrochemicals at the same rate as less risk averse farmers. This again suggests that counterfeits are not having as much of a dampening effect on demand as one might expect.

The analysis also adds to the evidence base about the drivers of input adoption in Uganda. Several variables are significant across both specifications. Access to a means of transportation is significant (coefficients of 0.093 and 0.145), representing the importance of physical access to agricultural inputs. Whether or not a portion of the harvest was sold is also significant, with coefficients of 0.168 and 0.191. Sales of output form an important source of financing for input purchases. The amount of livestock owned, measured in tropical livestock units (TLUs), is also significant, with coefficients close to 0.20. This serves as a proxy for the wealth of the household, and livestock can also be used as collateral for loans. Several of the studies about Uganda have found livestock ownership to be a significant enabling factor associated with input usage (Okoboi and Barungi (2012), Kasirye (2013), Amare and Shiferaw (2017)).[14]

As would be expected, whether or not the farmer received credit from a business is strongly significant, with large coefficients of 0.379 and 0.365; more than half of farmers who received credit from a business said it came from an input dealer. Mobile phone ownership is also significant, which acts as a proxy for access to information both about how to access inputs and their correct usage. Food security is very strongly associated with a decrease in input usage (coefficients of -1.962 and -3.117), which makes intuitive sense – the more food insecure a household is, the less likely they are to have the extra capital available to invest in inputs. Food security status also has far and away the largest coefficients, and therefore the largest influence on whether or not agrochemicals are used (although there is obviously potential here for reverse causation and/or simultaneity).

Several variables were significant in only one of the models. The presence of a nearby input shop was weakly significant in Model (1), while the distance to the nearest road was weakly significant in Model (2). Non-farm income is significant at the 5% level in the second

[14] It is worth noting, however, that all of these factors are potentially associated with income level or wealth. Better-off farmers are more likely to have access to a means of transportation, more likely to hold more livestock, and more likely to have surplus crops to sell. As such, it is difficult to tease out the individual effects of these variables, and also challenging to think about causation in this context.

regression, as is whether the farmer experienced a drought (at 10%). The number of acres planted is significant at at 1% in Model (2); it makes sense that this would be significant once the district-specific differences in average land size are accounted for; Gulu and Pader have the highest average number of acres farmed.

Three of the district-specific dummy variables included in Model (2) were significant at the 1% level, with relatively large coefficients, suggesting there are distinct regional characteristics or characteristics of the agro-ecological zones that are impacting farmers' decision to use agrochemicals. This was a common result in previous studies of Uganda, which found significant dummy variables for regions or farming systems (including Kassie et al. (2011), Okoboi and Barungi (2012), Adong (2014), Diiro and Sam (2015), Diiro et al. (2015), Shiferaw et al. (2015)). The Bold et al. (2017) study also found large variation in input usage across Uganda's four regions.

There are a few variables that are notably not significant in these models. Distance to the nearest road is not significant, and distance to the nearest town is only weakly significant when the district dummy variables are included. It is possible that the district dummies are capturing the effects of population density, road networks, or other related characteristics. It is also possible that the effect of distance is already captured by other variables, such as access to a means of transportation. To the extent that these are collinear, it may account for the low significance on these variables. However several studies on Uganda found distance to markets to be a significant predictor of adoption, even in the presence of regional dummies in some cases (Kassie et al. (2011), Okoboi and Barungi (2012), Adong (2014), Diiro and Sam (2015), Diiro et al. (2015)).

We would have expected non-farm income to be more strongly correlated, and significant in both models, given it serves as a common source of funding for agricultural inputs and is found significant in other studies (Diiro and Sam (2015), for example). Age is frequently found to be significant (such as by Diiro et al. (2015) and Amare and Shiferaw (2017)) but in our case the respondent was not necessarily the household head, which may have impacted the results. The same goes for education and gender, which many other studies found to be significant, but which we could not reliably measure with our dataset as we did not require that the respondent was the household head.

Finally, we would have expected acres planted per capita to be significant, as a representation of the amount of consumption pressure on the land. Other have found this variable to be significant, including Larson et al. (2015) and Shiferaw et al. (2015). It is possible that this rough proxy for household food security is less informative than the food security measure that is included. Additionally, more than 80% of households sold a portion of their harvest, who likely had surplus beyond the consumption needs of the household, meaning the level of stress on the land is not overwhelming for most households in the sample.

2.6.2 Focusing on Small Farms

We then limited our sample to the smallest farms, or smallholder farmers who planted five or fewer acres, to see if the impact of awareness of counterfeits differs by farm size. The results of these regressions are displayed in Table 2.5. As above, Model (3) reports results using clustered standard errors while Model (4) adds in district dummy variables.

Again we find that awareness of counterfeits is a significant, positive predictor of agrochemical usage, with similar coefficients (0.121 and 0.123), while willingness to pay for genuine pesticides is not significant. Several of the same variables are significant here as in Models (1) and (2): whether or not the farmer sold a portion of the harvest, credit received from a business, mobile phone ownership (albeit only for Model (3)), and livestock ownership (though only for Model (4)). Food security status remains strongly significant. As for the district dummies, only two are significant, Iganga and Mubende.

A few variables were newly significant when the sample was limited to smallholder farmers. Distance to the nearest town is weakly significant in Model (3), while level of education is significant in Model (4). Membership in a cooperative is newly and strongly significant in Model (4), while whether the farmer was impacted by Fall Armyworm is weakly significant.

In general, adoption of agrochemicals by smallholders is less well predicted than adoption by the full sample. The number of smallholders and non-smallholders using agrochemicals is not that different; 91 smallholders, or 33% of smallholders, compared to 104 non-smallholders, or 46%. The results suggest that the variables used, apart from food security status, are not as important as predictors of behavior when it comes to smallholder farmers.

Finally, we ran probit regressions for the portion of the sample that reported farming more than 5 acres. The results are reported in Table 2.6. As before, Model (5) reports the result of a

Table 2.4: Impact of Counterfeit Awareness on Agrochemical Adoption (Full Sample)

Variable	(1) With Clustered SE	(2) With Clustered SE & Dummy Variables
Anti-Counterfeit Variables		
Awareness of Counterfeits	0.150***	0.179***
	(0.044)	(0.056)
Pesticides Willingness to Pay	0.019	0.045
	(0.045)	(0.051)
Accessibility Constraint		
Nearby Input Shop	0.095*	0.071
	(0.055)	(0.057)
Distance to Nearest Road (km)	-0.005	-0.015*
	(0.009)	(0.008)
Distance to Nearest Town (km)	-0.003	0.004
	(0.003)	(0.003)
Transport Means	0.093**	0.145***
	(0.048)	(0.052)
Affordability Constraint		
Non-farm Income	0.012	-0.115**
	(0.056)	(0.055)
Sold Portion of Harvest	0.168**	0.191**
	(0.071)	(0.085)
Livestock Owned (TLUs)	0.020***	0.019**
	(0.006)	(0.009)
Number of Adults	-0.005	-0.012
	(0.017)	(0.017)
Borrowed Money	-0.044	-0.034
	(0.062)	(0.062)
Received Credit	0.379***	0.365***
	(0.101)	(0.104)
Belong to Savings Group	-0.028	0.126
	(0.064)	(0.081)
Access to Information Constraint		
Age[a]	-0.002	-0.003
	(0.002)	(0.002)
Education[a] (Years)	-0.001	0.002
	(0.008)	(0.009)
Mobile Phone Ownership	0.324***	0.138**
	(0.056)	(0.063)
Member of Cooperative	-0.113	0.019
	(0.082)	(0.072)

Probit regressions. Figures reported are marginal effects at the mean.
***, **, and * represent significance at the 1%, 5%, and 10% level.
TLU stands for tropical livestock units; UGX stands for Ugandan Shillings.
[a] Note: The respondent was not necessarily the household head.
[b] Note: The full sample includes 498 records; some were excluded due to missing values.
Source: Authors' calculations using data collected by the USAID/Uganda Market System Monitoring Activity.

Variable	(1) With Clustered SE	(2) With Clustered SE & Dummy Variables
Ability to Bear Risk		
Acres Planted (total Seasons A & B)	0.011	0.028***
	(0.008)	(0.011)
Acres Planted Per Capita	-0.008	-0.015
	(0.018)	(0.021)
Food Security Status	-1.962*	-3.117***
	(1.179)	(1.135)
Household Shock	-0.069	-0.027
	(0.060)	(0.065)
Experienced Crop Disease	-0.008	0.076
	(0.018)	(0.068)
Experienced Drought	-0.054	-0.133*
	(0.075)	(0.075)
Experienced Fall Armyworm	0.046	0.040
	(0.051)	(0.056)
District Dummy Variables		
Gulu		0.150
		(0.140)
Ibanda		0.368***
		(0.128)
Iganga		0.897***
		(0.122)
Mubende		0.763***
		(0.131)
Summary Statistics		
Log-likelihood Ratio	-228.81701	-181.11256
Pseudo-R^2	0.2060	0.3716
Wald Chi^2(24/28)	287.03	329.58
N[b]	431	431

Probit regressions. Figures reported are marginal effects at the mean.
***, **, and * represent significance at the 1%, 5%, and 10% level.
TLU stands for tropical livestock units; UGX stands for Ugandan Shillings.
[a] Note: The respondent was not necessarily the household head.
[b] Note: The full sample includes 498 records; some were excluded due to missing values.
Source: Authors' calculations using data collected by the USAID/Uganda Market System Monitoring Activity.

Table 2.5: Impact of Counterfeit Awareness on Agrochemical Adoption (Smallholder Farmers)

Variable	(3) With Clustered SE	(4) With Clustered SE & Dummy Variables
Anti-Counterfeit Variables		
Awareness of Counterfeits	0.121**	0.123*
	(0.059)	(0.070)
Pesticides Willingness to Pay	0.047	0.069
	(0.061)	(0.065)
Accessibility Constraint		
Nearby Input Shop	0.054	-0.008
	(0.058)	(0.061)
Distance to Nearest Road (km)	0.015	0.002
	(0.010)	(0.009)
Distance to Nearest Town (km)	-0.006*	0.001
	(0.003)	(0.004)
Transport Means	0.010	0.014
	(0.054)	(0.058)
Affordability Constraint		
Non-farm Income	-0.025	-0.129
	(0.080)	(0.089)
Sold Portion of Harvest	0.119*	0.197**
	(0.068)	(0.078)
Livestock Owned (TLUs)	0.023	0.036**
	(0.019)	(0.018)
Number of Adults	-0.024	-0.025
	(0.023)	(0.023)
Borrowed Money	-0.080	-0.071
	(0.082)	(0.080)
Received Credit	0.200*	0.206*
	(0.120)	(0.116)
Belong to Savings Group	-0.109	-0.022
	(0.075)	(0.086)
Access to Information Constraint		
Age[a]	-0.002	-0.001
	(0.002)	(0.002)
Education[a] (Years)	0.017	0.027**
	(0.012)	(0.011)
Mobile Phone Ownership	0.192***	0.072
	(0.069)	(0.075)
Member of Cooperative	0.150	0.284***
	(0.110)	(0.093)

Probit regressions. Figures reported are marginal effects at the mean.
***, **, and * represent significance at the 1%, 5%, and 10% level.
TLU stands for tropical livestock units; UGX stands for Ugandan Shillings.
[a] Note: The respondent was not necessarily the household head.
[b] Note: The sample includes 273 smallholder farmers; some were excluded due to missing values.
Source: Authors' calculations using data collected by the USAID/Uganda Market System Monitoring Activity.

Variable	(3) With Clustered SE	(4) With Clustered SE & Dummy Variables
Ability to Bear Risk		
Acres Planted (total Seasons A & B)	0.312	0.042
	(0.036)	(0.040)
Acres Planted Per Capita	-0.012	-0.015
	(0.061)	(0.058)
Food Security Status	-2.506**	-3.057***
	(1.066)	(0.943)
Household Shock	-0.003	-0.013
	(0.083)	(0.076)
Experienced Crop Disease	-0.026	0.027
	(0.060)	(0.072)
Experienced Drought	-0.054	-0.095
	(0.073)	(0.065)
Experienced Fall Armyworm	-0.015	-0.111*
	(0.063)	(0.062)
District Dummy Variables		
Gulu		0.078
		(0.182)
Ibanda		0.131
		(0.193)
Iganga		0.655***
		(0.200)
Mubende		0.589***
		(0.195)
Summary Statistics		
Log-likelihood Ratio	-122.013	-98.195681
Pseudo-R^2	0.1616	0.3253
Wald $Chi^2(24/28)$	90.73	438.86
N[b]	229	229

Probit regressions. Figures reported are marginal effects at the mean.
***, **, and * represent significance at the 1%, 5%, and 10% level.
TLU stands for tropical livestock units; UGX stands for Ugandan Shillings.
[a] Note: The respondent was not necessarily the household head.
[b] Note: The sample includes 273 smallholder farmers; some were excluded due to missing values.
Source: Authors' calculations using data collected by the USAID/Uganda Market System Monitoring Activity.

regression with clustered standard errors, while Model (6) introduces dummy variables for the districts.

Once again, awareness of counterfeit inputs is strongly significant, this time with even larger coefficients: 0.239 and 0.306; once again willingness to pay for genuine pesticides is not significant. It is important to note the consistency of this result across the six different specifications – there is clearly a relationship between awareness of counterfeits and usage of agricultural chemicals.

Beyond the two counterfeit variables, the results for Models (5) and (6) are somewhat different. Distance to the nearest road is significant in both models; distance to the nearest town is significant in Model (6), although the sign of the coefficient is opposite what we would expect. Access to transport means is significant in Model (6), as is non-farm income, while selling a portion of the harvest and livestock ownership are significant in Model (5). Whether or not the farmer received credit from a business remained significant in both models, and has been significant throughout.

Membership in a savings group is newly significant in Model (6), as is the age of the respondent. Education is also newly significant for both models. Mobile phone ownership is only significant for Model (5), while membership in a cooperative is significant for both. Cooperative membership is low in the sample overall, but more likely for farmers with more acres.

Notably, and perhaps the most interesting result from these models, food security status is no longer significant in Model (5), and weakly so in Model (6), albeit with a much higher coefficient. It would make sense that food security concerns are less binding for farmers who are farming more acres, and therefore that this characteristic has less predictive power when it comes to agrochemical usage. Interestingly, whether not a household experienced a shock (such as illness or death) was significant for the first time in Model (5). We would have expected this variable to be significant in the earlier models as well.

Whether not the farmer experienced a crop disease is newly significant in Model (6), while experiencing a Fall Armyworm infestation is significant for both. It may be that farmers with more acres are wealthier and therefore better able to afford agrochemical treatments when confronted with pests and disease. Finally, three of the district dummy variables are once again significant, this time with much larger coefficients – the district-specific characteristics apparently matter more for households above a particular farm size.

Table 2.6: Impact of Counterfeit Awareness on Agrochemical Adoption (Large Farms)

Variable	(5) With Clustered SE	(6) With Clustered SE & Dummy Variables
Anti-Counterfeit Variables		
Awareness of Counterfeits	0.239***	0.306***
	(0.078)	(0.104)
Pesticides Willingness to Pay	-0.028	-0.071
	(0.098)	(0.010)
Accessibility Constraint		
Nearby Input Shop	0.095	0.041
	(0.010)	(0.116)
Distance to Nearest Road (km)	-0.023**	-0.050***
	(0.012)	(0.015)
Distance to Nearest Town (km)	-0.003	0.015**
	(0.005)	(0.007)
Transport Means	0.089	0.274**
	(0.090)	(0.110)
Affordability Constraint		
Non-farm Income	0.067	-0.258**
	(0.083)	(0.118)
Sold Portion of Harvest	0.407**	0.112
	(0.161)	(0.170)
Livestock Owned (TLUs)	0.022***	0.026
	(0.008)	(0.021)
Number of Adults	0.057	0.071
	(0.055)	(0.058)
Borrowed Money	-0.015	0.113
	(0.123)	(0.137)
Received Credit	0.684***	0.993***
	(0.251)	(0.349)
Belong to Savings Group	0.075	0.352***
	(0.099)	(0.138)
Access to Information Constraint		
Age[a]	-0.002	-0.019***
	(0.003)	(0.004)
Education[a] (Years)	-0.031**	-0.054**
	(0.013)	(0.021)
Mobile Phone Ownership	0.528***	0.065
	(0.101)	(0.122)
Member of Cooperative	-0.389***	-0.301*
	(0.137)	(0.169)

Probit regressions. Figures reported are marginal effects at the mean.
***, **, and * represent significance at the 1%, 5%, and 10% level.
TLU stands for tropical livestock units; UGX stands for Ugandan Shillings.
[a] Note: The respondent was not necessarily the household head.
[b] Note: The sample includes 225 large farms; some were excluded due to missing values.
Source: Authors' calculations using data collected by the USAID/Uganda Market System Monitoring Activity.

Variable	(5) With Clustered SE	(6) With Clustered SE & Dummy Variables
Ability to Bear Risk		
Acres Planted (total Seasons A & B)	0.001	0.016
	(0.012)	(0.017)
Acres Planted Per Capita	0.010	-0.011
	(0.012)	(0.044)
Food Security Status	-0.554	-6.141*
	(2.390)	(3.326)
Household Shock	-0.204**	0.042
	(0.101)	(0.143)
Experienced Crop Disease	-0.025	0.265**
	(0.087)	(0.116)
Experienced Drought	0.007	-0.351
	(0.167)	(0.221)
Experienced Fall Armyworm	0.140*	0.435***
	(0.084)	(0.119)
District Dummy Variables		
Gulu		0.160
		(0.188)
Ibanda		1.193***
		(0.270)
Iganga		2.141***
		(0.317)
Mubende		1.601***
		(0.201)
Summary Statistics		
Log-likelihood Ratio	-87.895725	-52.396631
Pseudo-R^2	0.3686	0.6236
Wald Chi^2(24/28)	99.81	526.68
N[b]	202	202

Probit regressions. Figures reported are marginal effects at the mean.
***, **, and * represent significance at the 1%, 5%, and 10% level.
TLU stands for tropical livestock units; UGX stands for Ugandan Shillings.
[a] Note: The respondent was not necessarily the household head.
[b] Note: The sample includes 225 large farms; some were excluded due to missing values.
Source: Authors' calculations using data collected by the USAID/Uganda Market System Monitoring Activity.

2.6.3 Robustness check: Linear Probability Models

Tables 2.9, 2.10, and 2.11 in the Appendix present the results of the application of OLS through a linear probability model (LPM), using the same controls as the probit regressions. LPM regressions (7) and (8) mirror probit regressions (1) and (2) above, with clustered standard errors and added district dummy variables. Similarly, the regressions in Tables 2.10 and 2.11 mirror the regressions in Tables 2.5 and 2.6.

As can be seen in Table 2.9, the pattern of significant variables is almost identical to that seen with the full sample probit models. The only differences are that distance to the nearest road and experience with a drought are not significant with the LPM. Transport means, selling a portion of the harvest, off-farm income, livestock, credit received, mobile phone ownership, and acres planted are all similarly significant. Food security status remains significant. The dummy variables for Ibanda, Iganga, and Mubende districts also remain significant, and the R^2 for the model improves from 0.24 to 0.40 with the addition of the district dummy variables.

More importantly, the coefficients for awareness of counterfeits are also strongly significant under the LPM. The coefficients are similar to each other and consistently fall between 0.10 and 0.20. This confirms the finding of the previous section that the awareness of counterfeit inputs has a small but positive and significant relationship with the farmer's decision to purchase and use agricultural chemicals.

We repeated our analysis focused on smallholder farmers using a LPM as well, reported in Table 2.10. Food security status is still significant with large coefficients. Mobile phone ownership remains significant in Model (9), as do education and membership in a cooperative in Model (10). The dummy variables for Iganga and Mubende remain significant, and once again the R^2 nearly doubles with the addition of these dummies. Awareness of counterfeits remains significant, albeit at the 10% level. There are some differences: credit received and selling a portion of the harvest are only significant in Model (10), while livestock ownership, distance to town, and experiencing drought or Fall Armyworm are not significant in the LPM models.

Finally, we repeated our analysis for the larger farmers in the sample using the LPM, as seen in Models (11) and (12) in Table 2.11. The results are very similar to those for regressions (5) and (6), which also limited our analysis to the larger farm sizes in our sample. Once again, awareness of counterfeits is significant and positive for both models. Many of the controls follow the same pattern of significance as in Models (5) and (6): distance to the nearest road, access to transport means, sold portion of harvest, livestock, credit received, membership in savings group, age, education, mobile phone ownership, household shock, experienced crop disease, and experienced Fall Armyworm. The same district dummy variables are also significant: Ibanda, Iganga, and Mubende. There are only a few differences from the probit models: distance to nearest town and food security status are not significant, and membership in a cooperative is only significant in one of the models. A simple Chow test was applied to the linear probability models, finding that there are differences in the model coefficients across the smaller and larger farmers.

2.6.4 Qualitative Evidence

2.6.4.1 Avoiding Counterfeits

What could explain the somewhat counterintuitive result that awareness of counterfeits renders households more likely to purchase agrochemicals? We posit one possible explanation: the farmers felt confident in their ability to identify or otherwise avoid purchasing counterfeit products. As mentioned above, the 191 respondents that reported awareness of the issue were asked what they do to avoid counterfeits. This was an open-ended question. We analyzed the responses and coded them into commonly-occurring categories. Some respondents mentioned more than one strategy, so there are more total responses than there are respondents.

The basic results are presented in Table 2.7. As can be seen in the table, the most commonly reported strategy was to purchase from a trusted source, most often an input dealer. In fact, eighteen of the respondents specifically used the word "trust" in their response. It is logical for these farmers to seek out a source of inputs that they believe they can trust, as agricultural inputs are experience goods whose quality cannot be fully assessed until they are used (as discussed further below). As such, they are reliant on the input dealer to provide high quality, genuine products. This of course means that the farmers have confidence in the input dealers' ability to identify counterfeits and/or in their ability to find a reliable wholesale source. Similarly, a further eighteen households reported that they ask their input dealer for advice, again suggesting that input dealers play an important mediating role for farmers in this market.

The second most common response was "Don't Know," which speaks to the reality that awareness isn't enough – farmers must also be educated on ways to avoid counterfeit products. Of course for some farmers, this is reason not to use inputs at all, the fourth most common response. Along the same lines, a few farmers also stated that counterfeits could not be avoided

– they had not identified a strategy they could use.

Many of the farmers also reported relying on their own expertise. The third most common response was that the farmer examines the product quality before purchasing, such as looking for holes or weevils in seeds. Unfortunately, this suggests that the respondents do not fully understand the nature of the problem. The visual signals of seed quality, for example, are somewhat reliable, but only indicate whether a seed is likely to germinate or not. Whether or not the product is genuine is a wholly separate matter – the issue is whether, for example, they are advertised to be a certain brand but are actually a counterfeit version. The seeds could appear fine yet still technically be counterfeit. Perhaps this is an indicator that the farmers are less interested in whether the product is counterfeit and more interested in whether it will perform; however, sub-standard quality is typically built into counterfeit products, which should also matter to these farmers. Additionally, while the respondents cited several attributes of seed quality that they look for, there were no specific strategies for identifying counterfeit agricultural chemicals, save examining the label. Anecdotally, the counterfeit chemical packaging can be very convincing, and difficult to identify on sight.

Similarly, checking the expiration date and testing the germination rate of seeds were frequently mentioned. It is of course good practice to check the expiration date on the product, but counterfeit products can have expiration dates as well. And testing the germination rate is, once again, a signal of quality that can be misleading. Generally speaking, counterfeit seeds have a lower germination rate than genuine products, so this could be one way of identifying counterfeit seeds. However, the farmer would have to know the advertised/expected germination rate for the genuine product and compare their results against it – merely testing whether the seeds germinate is not enough.

Finally, a number of respondents said they rely on personal experience, such as whether a product has performed well before. This is reasonable, but not a guarantee – new counterfeit products are arriving on the market all the time, and the farmer may encounter counterfeits of the well-performing product they are looking for. Interestingly, a few respondents cited proper storage techniques as their strategy, which has nothing to do with counterfeits and instead is essential for maintaining the quality of seeds that were stored from the previous season. This suggests that somehow these respondents fundamentally misunderstood the question, which unfortunately casts some doubt over the other responses that we received. Lastly, respondents said they ask someone else for advice, such as friends and other farmers, which is reasonable but again not a guarantee.

Table 2.7: Qualitative Results: Counterfeit Avoidance Strategies Reported by Respondents

	Number of responses	Percentage
Buy from trusted source	29	13.4
Don't know	28	13.0
Examine the product	23	10.6
Don't buy inputs	19	8.8
Ask input dealer	18	8.3
Check expiration date	17	7.9
Personal experience	14	6.5
Test germination rate	13	6.0
Ask someone else	12	5.6
Storage techniques	11	5.1
Can't be avoided	5	2.3
Miscellaneous	27	12.5

Next, we were curious whether the responses differed between households that did or did not report purchasing inputs. Though not used in our analysis, the respondents were asked whether they had purchased the seeds they used in either of the two previous seasons. We also know whether they used agricultural chemicals. This breakdown is shown in Table 2.8.

There were several counterintuitive results. For example, of the 28 respondents who said they did not know how to avoid counterfeits, 18 went on to purchase seed and 12 purchased chemicals – the risk of counterfeits did not produce enough of a deterrent effect, or they did not think the risk was that high, or they felt they did not have a choice. In a similar vein, those that said that counterfeits cannot be avoided still largely purchased inputs. Puzzlingly, even those that said that their strategy was not purchasing inputs still reported purchasing them anyway, perhaps having resigned themselves to the fact that they might inadvertently purchase a counterfeit product. Otherwise of note is the fact that the highest levels of input purchase came from those who reported buying from a trusted source.

2.6.4.2 Further Evidence

As part of the fieldwork described in Paper 3, the respondents were asked several questions about counterfeit products, which provides another limited sample to draw inference from. Of the 32

Table 2.8: Qualitative Results: Counterfeit Avoidance Strategies by Input Purchase

	Number of responses	Purchased Seed	Purchased Chemicals
Buy from trusted source	29	23	15
Don't know	28	18	12
Examine the product	23	15	7
Don't buy inputs	19	6	11
Ask input dealer	18	12	7
Check expiration date	17	10	7
Personal experience	14	8	8
Test germination rate	13	9	5
Ask someone else	12	4	9
Storage techniques	11	4	3
Can't be avoided	5	4	4
Miscellaneous	27	17	16

farmers interviewed, 28 answered affirmatively that they were aware of the counterfeits issue (though at least one seemed to consider products past their expiration date as "fake" products and therefore counterfeit). This is interesting in and of itself, as only two communities were interviewed, and one would expect that the knowledge about counterfeits would have spread to everyone in the community. However, farmers have different social networks and neighbors that they interact with, and so it is possible that some farmers simply remain unaware. The only characteristics that those unaware had in common was that they were all 60+, though there were others in that age group who were aware of the issue.

When asked how they learned about the problem, thirteen reported they had personal experience with counterfeits, while eight had heard from neighbors or other farmers. One had learned in school, one mentioned learning from an agrodealer, and one also mentioned that there are reports on the radio – but rightly pointed out that "the challenge is also the culprits also listen and improve their packaging too." Farmers with less than 10 years of farming experience were more likely to have learned about the problem from someone else than from personal experience, which makes some sense as they have had fewer chances of purchasing counterfeit products. It is difficult to know whether the farmers truly had an experience with a counterfeited product or whether they purchased a product that was poor quality or expired – or whether the product was improperly used, as the dosage and timing of agricultural chemicals are crucial to success. As one respondent described, "When you buy counterfeit products, in most cases they don't germinate. As for pesticides, after spraying, the pests don't die and sometimes it burns the crop." It is impossible to know from statements such as this whether the farmer actually purchased what is officially defined as a counterfeit. Nevertheless, the farmers believe that what they purchased were counterfeit products (even if their definition of "counterfeit" is more expansive and includes poor quality products) and this is what matters when it comes to making the risk management calculation as to whether to purchase inputs.

The farmers were also asked what they did to avoid purchasing counterfeits. The most commonly reported strategy was to go to a trusted agrodealer. As one respondent explained, "I got knowledge through experience when I bought inputs and the yield was very low. When a friend asked me where I had bought my inputs and I directed her, she informed me that that particular agrodealer sells fake products. She directed me to a trusted agrodealer." Several also mentioned that they abandon products that they have deemed to be counterfeit. Three respondents said that they relied on their own abilities to identify counterfeit products, which included looking at manufacturing and expiry dates, which are once again more signals of product quality than of whether a product is genuine: "When it comes to pesticides I look at the manufacturing and expiry date before I buy and for the seeds like beans, I first look and examine them before I buy." Three others said they consulted with other farmers or agricultural extension workers. Four said there was nothing they could do – they had not identified a strategy for avoiding counterfeits (there were no clear common characteristics for these respondents). One reported relying on pricing as a strategy: "As for me any inputs sold cheaper are suspect to be counterfeit so I opt for inputs which are expensive but good." One relied on home-saved seeds, buying pesticides when necessary, while another relies exclusively on local seeds.

2.6.4.3 Role of Agrodealers

Given the important role that trusted agrodealers seem to play in these markets as a bulwark against counterfeits, we explore the relationship between farmers and agrodealers a bit further. Overall, 373 households reported having purchased inputs in the previous year, and 82.0% of these purchases were made at an input shop. The share was slightly higher for agrochemicals – 95.3% were purchased from an input shop. This means that nearly 75% of the households in our sample interacted with an input shop in the previous year. This is despite the fact that only 42.8% of sample households reported having one nearby, as discussed above. Of the households with an input shop nearby, 89.7% reported having purchased from the shop, with 46.1% reporting they purchase from this shop every time they buy inputs. Crucially, of those who had purchased from their nearby shop, 75.9% said they definitely trusted the shop owner, the highest option on our Likert scale. Likewise, when asked why they purchased from their local shop, 43 respondents specified that it was because the shop had a good reputation; when asked to specify further, seven respondents specifically used the word "genuine" to describe the products on offer, while 13 mentioned the quality of the products in general.

The figures were similar for those households that had reported awareness of counterfeits. In total 149 of these households reported having made an input purchase in the previous year, 83.9% of which came from an input shop (or 95.5% of chemical purchases). 50.1% of these respondents reported an input shop nearby, and 90.7% of those with a shop nearby had made a purchase there. 47.7% of those who purchased from the shop said they shop there every time they buy inputs. The number of those who had purchased at the shop and said they trusted the shop owner was higher than for the full sample, at 81.2%.

Overall, we learned that a majority of the inputs purchased by these households came from agrodealers, and that households with an input dealer nearby were very likely to have shopped there. Furthermore, there was a high level of reported trust in these local agrodealers. All of this bolsters the idea that these households are using trusted agrodealers as their strategy for avoiding counterfeits, and that this may be what gives them the confidence to continue to purchase even when they are aware of the risk of counterfeit products.

We have a bit more evidence from agrodealers themselves, again from the fieldwork that is discussed in detail in Paper 3. Given the possibility that farmers gain awareness of counterfeit products through their interaction with agrodealers, and that some continue to purchase because they trust their agrodealers to supply quality products, it was worth exploring the strategies being employed by agrodealers when it came to counterfeits. Thirteen agrodealers were interviewed about their experience with counterfeit products.[15]

All thirteen were aware of the problem with counterfeits, and several mentioned having been sensitized by the Ministry of Agriculture. Indeed, most seemed eager to talk about it. Their most popular strategy for avoiding counterfeits was to buy directly from the companies that import and manufacture the products, which makes sense given the market environment they are facing and their inability to trust agents that do not come directly from the original product wholesalers. As one agrodealer stated, "We go directly to the companies and they deliver, we

[15]Twelve were in Mbale town proper, in the downtown market, while one was in a trading center about 45-50 minutes outside Mbale. The downtown market has dozens of agrodealers selling similar products; respondents were selected in two areas of the market based on their willingness to be interviewed. This is by no means a representative sample, but rather a glimpse into how these agrodealers are handling the counterfeits issue. The questionnaire is included in the Appendix for Paper 3.

don't involve in other parties, for us here we just contact the company itself." Another gave a similar response: "Sometimes people who bring the counterfeit are not direct from the company so we get direct from the company." A third described:

> "Am very confident due to the updates I always get from our suppliers of the seeds because they always question us to get from a recognized places or institution because their shops and companies which are recognized and registered for example the LASEKO, INSANGI etc. When it comes to BUKOLA and OSHO they have their branch in Mbale."

Crucially, almost all said they were confident in their ability to identify counterfeit inputs. When asked how they identify counterfeit products, several mentioned looking for registration numbers on the packaging, and others mentioned manufacturing and expiration dates, serial numbers, and overall branding. As one described, "In most cases, they have what is called the Q-mark which identifies right and wrong products most of them are not in the right branded packages." Similarly, another explained that "I look for registration number, seal packaging and the date of manufacture those are the key factors then the logo for example every company puts a logo sign in a bottle and if its counterfeit, they cant put a logo for example notes of Uganda with a crested crane so they only photo copy and seal but they cant print the logo." Another agrodealer mentioned calling the manufacturers to ensure that products were genuine: "First of all as I told you, the batch number and in case there is something like we are not certain of we contact and ask if its part of their company products since they had not introduced it to us before so when it's not, they let us know. When there is a new product in the market they inform us." Unfortunately in some cases this confidence may be misplaced, as anecdotal evidence suggests that the counterfeit products on the markets are very convincing fakes; in fact, a program called KAKASA (discussed in Section 2.7.1.3) was piloted with special labeling that would help agrodealers identify genuine products (unfortunately this project did not last very long). Nevertheless, the agrodealers are following recommended best practices by scrutinizing the packaging and checking with the manufacturers. As such they are acting as a bulwark against the spread of counterfeit products.

Of relevance to this study, almost all of the agrodealers also said that they provide information to their customers about counterfeit products. They describe instructing farmers in how to identify counterfeit products: "You tell them to always look for the seal and it if has a serial number then buy and if not don't that generally what I tell them." Similarly, "Yeah after knowing like now, for example Naseco maize seed company, their package is different, there is a package which came to the market but the color was light red and that from the company was pure red so I was able to differentiate so I tell farmers to note that and at times I write down for them the difference." One mentioned advising customers not to be lured in by a deal that seemed too good to be true: "The differences in prices of the same commodity show that cheaper ones are always counterfeits and also tell them to look for registration numbers and so on."

Several also mentioned receiving feedback from customers about counterfeit products. For example, "We get feedbacks from farmers and share their feedback with fellow agrodealers and we inform the companies too and at times stop getting supplies from them." Some also have to deal with complaints from farmers who purchased substandard products:

> "Before even providing, they come with complaints for example "I took this but didn't germinate" and I also ask where they got the product from and ask them to bring a container to do assessment and ask them whether they checked the expiry date, serial number and from there I inform the farmer that what you bought is not good so I give them one to find out and if it does well, they automatically come back."

Overall, based on a brief exploration of the situation in Mbale, it would appear that the agrodealers are well aware of the issue with counterfeit products and actively working to ensure that they are providing genuine products, as well as arming their customers with information on identifying counterfeit products. These may not be a representative sample, particularly if they have benefited from sensitization by the Ministry of Agriculture or other programs, but it adds some weight to the notion that farmers are aware of counterfeits precisely because they are interacting with their agrodealers, and that they purchase anyway because they have confidence in either their own or their agrodealer's ability to spot counterfeit products.

2.7 Discussion

As mentioned above, there are several possible explanations for these results. Given the lack of available evidence on this issue, we had two possible priors: either the awareness of counterfeit inputs acts as a deterrent, or the farmers who are aware of counterfeits are the same farmers who use inputs in the first place. We did not find evidence that the presence of counterfeits is discouraging or acts as a barrier to purchase. This could of course be the case for individual farmers, but it does not seem to hold for the sample at large. In fact, when asked why they had not purchased agrochemicals in either of the prior two seasons, none of the non-adopting respondents specified that it was out of concern over purchasing counterfeit products.

Instead we see that farmers who are aware of counterfeits are more likely to use agrochemicals; these farmers likely learned about the issue from their input dealer or through personal experience, but choose to take the risk of purchasing poor quality products anyway. We note that it is also possible that awareness of counterfeits may have limited the quantities of inputs that farmers purchase at the intensive margin – even for those who do make positive purchases. Our survey data do not allow us to address this question; perhaps the effect is to diminish the *levels* of use, rather than to alter the binary decision.

Interestingly, Ashour et al. (2019) had a similar result in their study, finding that there was no significant relationship between herbicide quality and herbicide usage, and further that the farmers with higher rates of usage were those who believed that a higher fraction of bottles in their local market were adulterated. They downplay these results, suggesting that rates of quality had changed between when the farmers purchased and when the survey was conducted, or that farmers had updated their beliefs based on their experience. However, it is possible that this result is in fact consistent – the farmers who are best informed about the prevalence of counterfeits in their local market may be those who purchase most frequently, and thus either have more interactions with their input dealer or more personal experience with the products. It is also possible that counterfeits and adulteration are more prevalent in those markets where farmers are most likely to purchase inputs, as adulteration may be more profitable in active markets where farmers have already demonstrated a willingness to pay for inputs. Either way, their results are remarkably similar to ours.

What could explain this behavior? There is not much evidence that farmers are choosing to gamble on possibly buying counterfeits rather than pay a premium for high-quality products. Both Bold et al. (2017) and Ashour et al. (2019) found that prices in the Ugandan market were not adjusting to reflect quality, and it is not clear that price differentiation for high-quality products is possible. In any case, it could be that precisely those high-quality products are the ones being targeted by counterfeiters. It is possible, though unlikely, that the farmers weighed their expected yield gains (and therefore income gains) against what they believe to be the rate of counterfeiting in the market, and made the calculation that it was worth the risk. It is also possible that some farmers are miscalculating the risk of purchasing a counterfeit product, especially when there are no reliable estimates of how widespread they are. As discussed above, many of the respondents who said they did not know how to avoid counterfeits still went on to purchase inputs anyway. In the absence of a particular strategy, perhaps they are relying on a belief that their risk is actually low. Which in fact it could be: it is possible that the estimates of the prevalence of counterfeits are in fact overstated, and farmers are responding rationally based on the amount of actual evidence they have gathered. Or they are not correctly interpreting the evidence of counterfeits they do have, if for example they are not informed about the expected yield gains from a particular product and therefore are unable to tell if it has underperformed. They may misattribute poor yields to weather outcomes or other stochastic realizations rather than to the quality of the inputs they used (though as discussed below, there is evidence that the misattribution runs in the opposite direction). Or it could be that the overall quality on the market is so low that counterfeit products are nearly indistinguishable from “genuine” ones, in which case the risk of buying a counterfeit is not quite as pronounced.

Perhaps, however, it is not a question of understanding why there are farmers who are willing to take the risk of a poor quality product. Instead, it is possible that the farmers who are aware of counterfeit products still purchase because they do not believe they are taking a risk at all – they believe they have found a strategy for avoiding counterfeits altogether. Recall the number of farmers who said they had confidence (misplaced or not) in their ability to identify a counterfeit product. Or there could be some other measure they have deemed to insure them against the risk (such as purchasing an unopened bag). The most commonly reported strategy was finding an agrodealer they believed they could trust, and we posit that, when viewed through the framework of credence goods, this explains our empirical evidence.

2.7.1 Credence Goods

2.7.1.1 Theory

Agricultural inputs are classic examples of experience goods, and in some cases are actually credence goods. Experience goods, as defined by Nelson (1970), are those whose quality cannot be determined prior to purchase – the consumer faces an information deficit that is only rectified after the product is purchased and used. They are described in contrast to search goods, whose qualities are observable prior to purchase. Even though, as discussed above, farmers are often attentive to the physical attributes of inputs, such as the appearance of seeds, these are not always reliable indicators of the quality of the product or its expected performance – rendering them experience goods. For example, Michelson et al. (2021) found that farmers relied on the physical appearance of fertilizer to assess its quality, which is not a reliable indicator of the underlying nutrient content.

In reality, though, given the stochastic production environment that most smallholder farmers face, many inputs are more appropriately classed as credence goods. Credence goods, as distinguished by Darby and Karni (1973), are those whose qualities cannot be evaluated even after use by the consumer, without costly additional information. For improved seed and fertilizer in particular, the most reliable indicator of performance and therefore quality is yield. Unfortunately, it is extremely difficult for farmers to disentangle the effect of inputs from the impact of all of the other variables that can affect yield, such as soil quality, the timing and duration of rainfall, and farmer effort. As Bold et al. (2017) point out, some of these variables are functionally unobservable by the farmer, such as soil fertility, creating a very difficult inference problem. And this is assuming that the inputs were used optimally – as Michelson et al. (2022) point out, the farmer must have used the right input, in the right formulation, at the right time. When two or more inputs are combined, the difficulties are multiplied, and it may be impossible to isolate a quality signal for an individual product – assuming once again that the inputs are used properly and in the right combination. It may be easier to assess the quality of other inputs such as herbicides and pesticides, as Michelson et al. (2023) point out, as for example farmers can immediately tell whether they addressed weeds or an infestation.

Domínguez et al. (2022) provide a useful taxonomy of search, experience, and credence attributes in the case of hybrid maize seed. As they describe, search attributes include physical characteristics such as brand, packaging, color, and size, while experience attributes include yield, drought tolerance, and germination rate. Credence attributes, meanwhile, can include yield stability, nutritional value, and genetic makeup. Though as the authors point out, the categorization of input attributes is not always straightforward, particularly when the product is used in combination with other inputs of uncertain quality.

This feature of agricultural inputs has implications for input adoption: if farmers are unable to reliably learn about the quality of a product, they are unlikely to continue to adopt it in future seasons. As Tyack et al. (2025) point out, a proliferation of low quality seed could contribute to keeping Uganda in a "low productivity trap," if for example farmers purchase poor quality improved seed, it performs badly, and they determine therefore that improved seed is not worth the investment going forward. Beaman et al. (2018) highlight the difficulty of learning about returns to inputs such as fertilizer in a noisy production environment. Similarly, Hoel et al. (2024) spoke to farmers in Tanzania and found that many respondents determined that they purchased poor quality fertilizer based on the performance of their crop. Based on this, they developed a model to demonstrate how misattribution can explain how farmers persist in incorrect beliefs about product quality – they assume that poor outcomes are a signal of a bad quality product, rather than bad weather, misapplication, etc. Crucially, this misattribution can occur when there is substantial overlap between the expected yield distributions using good and bad quality fertilizer. Bold et al. (2017) use a Bayesian learning framework to model a farmer's ability to learn about fertilizer profitability in the presence of adulterated products, finding that unless the level of dilution is high, farmers must experiment with fertilizer up to ten times to determine whether it is profitable or not. This serves to limit the amount of highly diluted fertilizer on the market, but leaves room for a range of poor quality products. As Bold et al. (2017) suggest, the fact that the market for fertilizer has not collapsed entirely, despite what they find to be a proliferation of low-quality products, suggests that farmers do have some ability to learn about its benefits; however, the variations in quality are not correlated with price, indicating that farmers are not able to completely determine which products are higher quality, under which circumstances the market would adjust.

In the case of counterfeit inputs, there is an additional credence dimension, as what were previously search attributes (packaging, branding) are transformed into credence ones. Even if a farmer has previously experimented with a particular product and determined it to be profitable, she cannot be certain that the product on the shelf at her local agrodealer is genuine, unless she trusts the shop owner, as discussed above. If the agrodealer knows the product is counterfeit (or even that it is genuine but expired) we would tip into lemon goods territory, as per Akerlof (1970). As Michelson et al. (2021) point out, farmers are likely aware of the possibility for lemon goods on the market, given the quality of inputs is unobservable, and this may act as a deterrent to purchase. Furthermore, given that counterfeit products are often substandard but not completely ineffective, farmers end up in a scenario where the expected distribution of yields for counterfeit and genuine products may overlap, leading to misattribution of results as per Hoel et al. (2024) and the kind of challenging learning environment described by Bold et al. (2017).

Overall, the information asymmetry inherent in credence goods (which in some cases can become full-blown adverse selection), combined with sensational news reports about counterfeit products, leads farmers to distrust the products available in local markets. As described by Michelson et al. (2022), several studies have found evidence that farmers believe that there are quality problems with the fertilizer (specifically urea) in their local markets, despite the finding that most urea in these markets is of good quality. Similarly, Michelson et al. (2021) found pessimism about the quality of fertilizer among farmers in Tanzania (43% suspected adulterated fertilizer was being sold), despite consistently high quality as measured by laboratory tests. The authors concluded that incorrect beliefs about fertilizer quality were impacting demand. Although Ashour et al. (2019) found that Ugandan farmers' beliefs about herbicide quality were correlated with actual measured quality in their local markets, prices had only partially adjusted to address differences in quality across markets. And Ashour et al. (2015) reported that many of the Ugandan farmers they interviewed did not buy inputs because they were unsatisfied with the quality: 78.1% for hybrid maize, 79.1% for herbicide, and 69.2% for fertilizer.

2.7.1.2 Reducing Information Asymmetry

Fortunately, as Maredia and Bartle (2023) describe, there are two strategies that can be used to overcome this information asymmetry and signal product quality: certification and reputation. As Auriol and Schilizzi (2015) point out, a certification program can transform a credence attribute into a search attribute, by guaranteeing certain unobservable aspects of product quality. Unfortunately, there is limited literature examining the use of certification programs in sub-Saharan Africa. Auriol and Schilizzi (2015) use seed certification as their example case, finding that when certification is costly, third-party certification is most efficient, possibly by aid agencies or NGOs when the government is incapable of credibly providing this service. There are often also limitations to the effectiveness of certification programs, as documented for example by Hasibuan et al. (2021) in Indonesia.

Nevertheless, there is an appetite among farmers for products with guaranteed quality. Hoel et al. (2024) found that farmers in Tanzania were willing to pay a premium for fertilizer that had been tested to have the appropriate nitrogen content, and the premium was higher when they believed the fertilizer in their local market was poor quality. Michelson et al. (2021) also found that farmers in Tanzania were willing to pay considerably more for fertilizer that had been tested, while Michelson et al. (2024) conducted an RCT that demonstrated that when farmers were provided with trusted information that the fertilizer in their local markets met quality standards, they increased their probability of using fertilizer, driven primarily by new users. Gharib et al. (2021) find that farmers in Kenya are willing to pay a 15% premium for hybrid maize seed purchased directly from the seed company. Companies in Kenya have been investing in innovative packaging to signal quality and authenticity, including e-verification labels (discussed further below), but the farmers needed training to appreciate the significance of compromised packaging, such as labels that had already been scratched off. As discussed above, we asked our respondents how much more they would be willing to pay for pesticides that were certified as genuine and effective, and found that 47.4% would pay at least a 25% premium. We also asked about seeds that were guaranteed to have a germination rate of 85-90%, which is ideal, and found that 52.6% were willing to pay at least a 25% premium. However, based on an RCT in Uganda, Mastenbroek et al. (2021) find that although the provision of information sessions led to greater awareness of the benefits of purchasing certified seed, farmers' willingness to pay for certified seed did not change, suggesting other barriers to adoption.

2.7.1.3 Certification in Uganda

There is a certification regime for seed in Uganda; to the best of our understanding, agricultural chemicals are not officially certified in any way. As described in the Seeds and Plant Regulations of 2016, the seeds for most major crops sold on the formal market are under compulsory certification, including maize (MAAIF, 2016).[16] Certified seed carries blue government-issued labels, a process that is managed by the National Seed Certification Service (NSCS), part of the Ministry of Agriculture, Animal Industry, and Fisheries (MAAIF). Unfortunately, the NSCS is underfunded and lacks the capacity to carry out comprehensive inspections of seed multiplication. According to The African Seed Access Index, as of 2022, there were 21 government seed inspectors in Uganda (compared to 35 in Kenya and 45 in Tanzania). Though NSCS maintains that this number is sufficient, the inspectors often lack the vehicles and fuel needed to carry out their work, and local seed companies say this often leads to uninspected fields (Mabaya et al., 2023). Mastenbroek and Ntare (2016) cite a government figure from 2015 indicating that only 10% of maize seed was inspected by NSCS. Additionally, as the government has acknowledged, the approved labels are easily replicated (MAAIF, 2017), though there are plans to introduce tamper-proof labels (Mabaya et al., 2023). As a result, the blue government certification labels

[16]This does not include vegetable seed, most of which is imported.

do not carry much weight.

Two certification-style programs were tested recently in Uganda, to address the dual problems of poor quality and counterfeit seeds. Both were introduced by a USAID-funded activity; a thorough treatment written by our team is available (Blair et al., 2018). The first, called KAKASA (which loosely translates to "verify" in Luganda), was an e-verification program: single-use, scratch-off labels that are difficult to replicate were affixed to input packaging, and farmers would send the unique authentication code to a USSD number that would confirm whether the product was genuine and had not expired. The labels were launched in 2016 on both seeds and agrochemical products, and were initially broadly successful. Gilligan et al. (2019) found that, when paired with an information campaign, KAKASA was successful in encouraging higher adoption of hybrid maize seed and glyphosate herbicide, and led to positive beliefs about the quality of KAKASA-labeled products. They found that the farmers continued to purchase these products even after the program had ended. We also found that some agrodealers reported that their customers accused them of selling "fake" products, as not all companies participated in the program, and farmers had been sensitized not to accept products without the label. Crucially, the labels also guarded against two of the main types of counterfeits, imitation packaging and genuine packaging that had been reused. Unfortunately the initiative was discontinued after a few seasons in favor of the second program, AgVerify; we were told that one of the reasons was that although the KAKASA labels guaranteed the product was genuine, the initiative did nothing to address the quality on the market, such that KAKASA-labeled products could end up being genuine yet poor quality. Nevertheless, we found that some companies continued to use the labels after the program ended, and Bagamba et al. (2023) reports that there are other e-verification labels in use in the market.

The second program that was attempted, AgVerify, went a step further than KAKASA by providing independent third-party inspection services to seed companies. Companies participating in the program would put an AgVerify label on their products as a quality marker; the label also included an e-verification component. Though the program ran for several seasons, and the business model appeared viable, AgVerify ultimately foundered in the face of industry resistance and political economy pressures. First, although some companies were interested in proving that their seed met the prescribed quality standards, others were content to continue operating in the status quo lax enforcement environment that allowed sub-standard seed to be sold, and felt threatened by the prospect of AgVerify becoming an industry-wide standard.

This is some evidence of a market for lemons-style equilibrium, as developed by Akerlof (1970). The second major roadblock came from the government: its officials did not appreciate AgVerify's implicit message that the blue government certification labels could not be trusted, and maintained that certification was an inherently governmental function that should not be outsourced (even though the government had initially supported the program, and the plan was for AgVerify to receive accreditation to provide inspection services). The seed sector is also very politically connected, which may have influenced the government's response. Unfortunately, the introduction of yet another label caused confusion in the market, as the quality control aspect of the AgVerify program was not well publicized, and the subsequent withdrawal of both labels caused even more confusion, potentially forcing agrodealers to have uncomfortable conversations with their customers about why their products are not labeled. The whole exercise may also have undermined consumer trust in e-verification labels, which is unfortunate as they are effective when deployed correctly, as has been done in Kenya.

2.7.1.4 Reputation

As mentioned above, Maredia and Bartle (2023) also point to reputation as a strategy that can be used to overcome information asymmetry. They refer to the Shapiro (1983) conceptualization of reputation, which he argues only makes sense in a context of imperfect information, where consumers rely on prior product quality as a signal of present or future quality, allowing firms to build a reputation and charge a premium for their products. There seems to be a business case for this in Uganda, as evidenced by the seed industry: despite the momentum towards a market for lemons equilibrium, there are still some companies committed to producing quality products, such as those who participated in AgVerify.

Reputation is a tool that can also be used by Uganda's agrodealers, who are the most exposed to the effects of the information asymmetries in this market. There is some evidence that it can be effective: researchers from IFPRI conducted an RCT in Uganda that introduced a public rating system for agrodealers, and found that as a result agrodealers reported more business and more purchased maize seed was being planted (Miehe et al., 2023). They suggest that this intervention reduced some of the information asymmetry inherent in input purchasing through crowd-sourced quality signals. Unfortunately, as Bold et al. (2017) point out, given the long period of experimentation required to determine the profitability of inputs, it would take time for agrodealers to establish a reputation for selling quality products; in fact, they have incentives to dilute their products, given the difficulty in learning about them. The agrodealers also face a challenging environment in which to establish a positive reputation: they bear the immediate reputational costs of selling a poor quality or counterfeit product, knowingly or unknowingly. They themselves must find trusted brands and wholesalers, and constantly synthesize the feedback from their customers. They will have challenging conversations with farmers who commit the kind of misattribution described by Hoel et al. (2024), assuming that their poor harvest was the fault of the input they purchased.

Nevertheless, our results suggest that some agrodealers have been successful in cultivating a positive reputation with their clientele. Recall that the most commonly reported counterfeit avoidance strategy (13.4% of respondents asked) was to purchase from a trusted source, and that a further 8.3% reported asking their input dealer for advice. This question was open-ended, so even unprompted, trust was top of mind for many respondents. Those who said they purchase from a trusted source were also most likely to purchase inputs. Similarly, in the qualitative results reported from the fieldwork described in Paper 3, the most common counterfeit avoidance strategy was to go to a trusted agrodealer, and 26 of the 32 respondents said that they trusted their local agrodealer. Recall as well that 75.9% of respondents who had purchased from their nearby input shop said that they definitely trusted the shop owner, and 46.1% said they purchase from this shop every time they buy inputs. Similarly, when asked why they purchased from their local shop, 22.5% specified that it was because the shop had a good reputation. Those who had not patronized their nearby shop were asked why; none cited its reputation, while two (about 9%) said it was because they did not trust the shop owner and one specified that it was because the shop sometimes sold counterfeit inputs.

It would appear that among the farmers we spoke to, agrodealer reputation is working to reduce the information asymmetry inherent in credence goods the way the theory would suggest. Despite the fact that nearly 40% of our sample expressed awareness of counterfeit products, some from personal experience, and likely more are aware that there are broader quality issues in the inputs market, some of these farmers are still purchasing inputs anyway. They have decided to trust their input dealers (warranted or not), which is essential in what is functionally a minimally regulated market. This seems the most plausible explanation for the patterns we found in our data.

This may also go some way towards explaining a phenomenon we have observed in the larger market centers such as Mbale. In the villages and smaller towns, there are usually only one or two input dealers, if any. Yet in the medium- to large-size towns, there can be dozens, usually congregated in the same area, following Hotelling's law (Hotelling, 1929). By and large, these agrodealers are all selling the same set of products, which raises the question of why there are so many in a seemingly stable equilibrium. It is possible that they are able to differentiate themselves by cultivating relationships and building trust with a particular subset of customers. We have not been able to test this hypothesis, but it is one possible explanation.

2.7.2 Other Drivers of Input Adoption

Finally, it is worth briefly addressing the evidence we uncovered that contributes to the broader literature on input adoption. We were able to identify some key factors that seem to be drivers of agrochemical adoption in these districts. For the full sample, the affordability constraint was the most binding, with significant coefficients on non-farm income, whether or not a portion of the harvest was sold, and livestock owned. This tracks with our own anecdotal experience and with the responses from farmers in our survey, where 76.2% of respondents said they did not purchase agricultural chemicals because they could not afford to. Access to credit was not a significant predictor of adoption, and does not seem to have driven adoption for our sample, though there were farmers who took out loans specifically for agricultural inputs. Receiving credit from a business, such as an input shop, was however a strong predictor of adoption.

As for the other constraints, transport means was a significant predictor of adoption, speaking to the accessibility constraint, while mobile phone ownership indicated the importance of access to information. The farmers' ability to bear risk seems to play a significant role in adoption, as the number of acres planted was significant (with district dummy variables) and the level of food security was strongly significant with large coefficients. As food security is a proxy for the household's wealth, this also speaks to the affordability of inputs. As discussed above, the results were very similar when run with a linear probability model.

There were some differences from the other literature on Uganda, such as a lack of significance for distance to markets, though as discussed before our dataset is not meant to be nationally representative. Our R^2 values remained below 50% (except for Models 6 and 12, focused on larger farmers), suggesting that other factors are implicated in explaining the adoption of agrochemicals, or that the data is just noisy. Even the intercepts on the district-specific dummy variables were relatively large, suggesting that they are picking up a bundle of factors that vary across districts and agroecological zones, beyond the differences in access and farm size that we would expect to see.

When it came to the subsets of our sample that represent smallholder and larger farmers, the profile of significant variables shifted somewhat. Affordability was somewhat less significant for smallholders (selling portion of harvest, livestock, receiving credit), while for larger farmers membership in a savings group emerged as newly significant and representative of access to credit. In terms of accessibility, access to transport means was not important for smallholders, only for larger farmers, for whom distance to the nearest road also emerged as strongly significant. Mobile phone ownership was still significant under some specifications, and membership in a cooperative was newly significant for each of the sub-samples (though not for the sample as a whole).

Perhaps the biggest differences emerged when considering the households' ability to bear risk. Food security status remained strongly significant with large coefficients for the smallholder farmers, but was only weakly significant for the larger farmers. Larger farmers, meanwhile, seemed more sensitive to shocks to the household or to the farm, such as crop disease or Fall Armyworm. Larger farmers were no more likely to purchase inputs, so it should not be the case that the variation we see is driven by their response to shocks; it is curious that their usage is more strongly driven by shocks to the household or farm, a result we cannot easily explain. Indeed, we expected household shocks to bear larger weight on the input adoption decision for all households. The district dummy variables also had far larger coefficients for larger farmers, suggesting that perhaps the nature of more commercial farming varies more widely across districts than that of subsistence farming.

2.8 Conclusion

This paper provides new evidence as to the drivers of agricultural technology adoption in Uganda, and in particular provides evidence as to the possible influence of counterfeit inputs on farmers' decision to intensify production. As we found across our analysis, awareness of counterfeits is positively and significantly related to farmers' use of agricultural chemicals.

It is not possible to imply causality from our analysis, but it strongly suggests an association between the decision to purchase and use agrochemicals and a farmer's awareness of the problem with counterfeit inputs. It also suggests that the presence of counterfeits does not serve as a binding constraint on adoption, as could have been the case; rather it appears that farmers are making risk calculations and deploying the strategies that are available to them for avoiding counterfeit products, which seem to center on trust of their input dealer.

There are some limitations to our analysis. Our sample is drawn from Feed the Future districts, which may be better developed than other districts and have benefited from USAID programming, including an anti-counterfeit initiative. We may as a result have over-sampled larger farms relative to the distribution of landholdings in the country at large. This did allow us to split the sample and consider small and large farms separately, though with fewer than 250 observations in each category. We also acknowledge that we elicited farmers' willingness to pay through a crude self-report, which might be a noisy or biased measure. It may be possible to elicit this information more reliably through an experiment; this was not possible under our budget constraints. We also would have liked to focus on improved seed as well as agrochemicals, as seed is another important investment for farmers and one of the more easily accessible technologies.

We would recommend expanding on our study and the other recent studies on counterfeits with larger samples, as there may be substantial national heterogeneity in input usage and presence of counterfeits. For example, Bold et al. (2017) only sample from two of the main maize-growing regions, which may attract more counterfeiters; as discussed, our sample was specifically chosen from USAID Feed the Future districts, which have particular characteristics. There is still much to be learned about how and where counterfeits enter the supply chain. There is also still much to be learned from farmers about how they learn about and respond to the risk of counterfeits. We are also interested in better understanding how agrodealers are able to establish a positive reputation in this particular context. However, though there is much work to be done by governments, NGOs, and the private sector in combating this problem, it is some comfort to learn that it does not appear to be hindering the adoption of agricultural inputs.

2.9 Acknowledgments

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2.10 Appendix A

Courtney Blair, DPhil Candidate, Oxford Department for International Development,
courtney.blair@sant.ox.ac.uk

Understanding Ugandan Smallholder Farmers' Perspectives on Risk in the Context of Input Adoption

Phase 1: Smallholder Farmer Household Interview

Survey Questionnaire

Section 1:

First we will ask some questions about the head of your household:

1. What is his or her age?
2. What is his or her highest level of education?
3. How long has he or she been farming?

Section 2:

Now we will ask some questions about your household:

1. How many household members are there?
2. How many acres does your household regularly farm?
3. Does anyone in your household belong to a savings group?
4. Does anyone in your household own or have access to a mobile phone?
5. Does your household own any livestock?
6. Does your household have income from something besides farming? What is the source of the income?

Section 3:

These questions will be about your use of agricultural inputs:

1. Is there an agrodealer nearby, or somewhere you can purchase agricultural inputs?
    a. If yes:
        i. How far away?
2. Do you trust this person?
3. Did you purchase agricultural inputs in the last year? This includes improved seed, fertilizer, pesticides, herbicides, and other chemicals.
    a. If yes:
        i. What did you purchase for the first season?

    ii. What did you purchase for the second season?
    iii. Why did you decide to purchase these inputs?
    iv. What would have prevented you from buying inputs?
  b. If no:
    i. Why didn't you purchase agricultural inputs?
4. Are you concerned that using improved seed or fertilizer would create more risk for your harvest?
5. Certain inputs such as seed and fertilizer can be purchased in very small quantities. Have you considered buying a small quantity, such as would cost 2,000 or 5,000 shillings, to test the product on your farm?
  a. If no:
    i. Why not?
6. Do you feel confident in your knowledge of how to use improved seed? What about fertilizer?
7. How did you learn about how to use improved seed? What about fertilizer?
8. If you had questions about agricultural inputs, who would you ask for help?
9. Do you have access to credit?
  a. If yes:
    i. Could you have purchased inputs on credit?
      1. If yes:
        a. Did you purchase inputs on credit this past year?
      2. If no:
        a. Why not?
10. What do you know about the problem with counterfeit inputs?
11. How did you find out about the problem with counterfeit inputs?
12. What do you do to avoid counterfeit inputs?

Section 4:

Now we will ask about some of the bad events that your household may have faced in the past year:

1. Which of these did you experience in the last year:
  a. Was there poor rainfall or drought?
  b. What about floods, landslides, or erosion?
  c. Did you experience any pests or crop diseases?
  d. Did you experience any livestock disease?
  e. Were the costs of agricultural inputs higher than usual?
  f. Were the prices for your crops lower than usual?
  g. Were there any other problems with your farm? What were they?
  h. Did your income from outside your farm decrease?
  i. Did anyone in your household experience illness?
  j. Has there been a death in your household?
  k. Have you contributed money or other resources to help pay for a wedding?
  l. Have you contributed money or other resources to help pay for a funeral?
  m. Did you experience theft or violence?

    n. Did you experience any other problems that we have not mentioned?

2. Which of these was the biggest problem for you?
3. Which cost you the most money?
4. Did you expect any of these bad things to happen, even if they didn't occur?
    a. If yes:
        i. What did you expect would happen?
5. Are there other bad events that you expect could happen to you? What are they? Which is the most serious / would cause the biggest problem?
6. How did these bad events influence your decision to purchase agricultural inputs?

Courtney Blair, DPhil Candidate, Oxford Department for International Development,
courtney.blair@sant.ox.ac.uk

Understanding Ugandan Smallholder Farmers' Perspectives on Risk in the Context of Input Adoption

Phase 2: Agrodealer Interview

Survey Questionnaire

Section 1:

First we will ask some questions about your business:

1. How long has this business been operating?
2. Why did you decide to enter into this type of business?
3. What is the most popular product that you sell?
4. Do you have regular clients that return every season or every time they purchase inputs? What percentage of your clients would you say are regular?
5. Do you conduct outreach to gain new clients? What do you do?
6. How do you get new information about the products you sell and how to use them?

Section 2:

Now we will ask some questions about your relationship with your customers:

1. Do you provide information to your clients? What type of information?
2. Do you provide product recommendations? How do you decide which products to recommend?
3. Do your clients rely on you to recommend products, or do they know what they want already?
4. Do you provide different information or recommendations to new vs. established clients?
5. Do you provide credit to your clients?
    a. If yes:
        i. How do you decide which customers to offer credit to?
6. Do you ever encourage farmers to sample small amounts of the products, so they can test them on their farms?
7. Do your clients know about how to use inputs properly? Do you provide them with this information?
8. Do you think that most farmers in your area understand the benefits of using inputs?
    a. If no:
        i. Why not?
9. Why don't more farmers purchase inputs?

Section 3:

Now we would like to ask some questions about your experience with counterfeit inputs:

1. Are you aware of the problem with counterfeit inputs?
    a. If yes:
        i. How did you come to know about it?
2. How do you get new information about which products are counterfeit?
3. Where do you think the counterfeit products are coming from?
4. What steps do you take to avoid purchasing counterfeit products?
5. Do you feel confident in your ability to identify counterfeit products?
6. What do you look for to know if a product is counterfeit?
7. Do you provide information to farmers about counterfeit products?
    a. If yes:
        i. What information do you provide?

2.11 Appendix B

Table 2.9: Impact of Counterfeit Awareness on Agrochemical Adoption (Full Sample)

Variable	(7) With Clustered SE	(8) With Clustered SE & Dummy Variables
Anti-Counterfeit Variables		
Awareness of Counterfeits	0.115***	0.110***
	(0.037)	(0.038)
Pesticides Willingness to Pay	0.015	0.042
	(0.039)	(0.035)
Accessibility Constraint		
Nearby Input Shop	0.075	0.045
	(0.049)	(0.042)
Distance to Nearest Road (km)	-0.002	-0.006
	(0.007)	(0.005)
Distance to Nearest Town (km)	-0.002	0.002
	(0.002)	(0.002)
Transport Means	0.068*	0.094***
	(0.040)	(0.036)
Affordability Constraint		
Non-farm Income	0.013	-0.071*
	(0.046)	(0.041)
Sold Portion of Harvest	0.137***	0.122**
	(0.054)	(0.052)
Livestock Owned (TLUs)	0.008**	0.006*
	(0.003)	(0.003)
Number of Adults	-0.002	-0.007
	(0.013)	(0.014)
Borrowed Money	-0.024	-0.019
	(0.052)	(0.046)
Received Credit	0.328***	0.261***
	(0.075)	(0.065)
Belong to Savings Group	-0.022	0.076
	(0.054)	(0.053)
Access to Information Constraint		
Age[a]	-0.001	-0.002
	(0.002)	(0.002)
Education[a] (Years)	-0.000	0.003
	(0.007)	(0.006)
Mobile Phone Ownership	0.275***	0.104**
	(0.047)	(0.043)
Member of Cooperative	-0.091	0.013
	(0.072)	(0.057)

OLS regressions.
***, **, and * represent significance at the 1%, 5%, and 10% level.
TLU stands for tropical livestock units; UGX stands for Ugandan Shillings.
[a] Note: The respondent was not necessarily the household head.
[b] Note: The full sample includes 498 records; some were excluded due to missing values.
Source: Authors' calculations using data collected by the USAID/Uganda Market System Monitoring Activity.

Variable	(7) With Clustered SE	(8) With Clustered SE & Dummy Variables
Ability to Bear Risk		
Acres Planted (total Seasons A & B)	0.009	0.016**
	(0.007)	(0.007)
Acres Planted Per Capita	-0.007	-0.009
	(0.015)	(0.016)
Food Security Status	-1.696*	-2.193***
	(0.972)	(0.813)
Household Shock	-0.066	-0.016
	(0.053)	(0.048)
Experienced Crop Disease	0.002	0.062
	(0.043)	(0.046)
Experienced Drought	-0.041	-0.082
	(0.064)	(0.052)
Experienced Fall Armyworm	0.037	0.032
	(0.043)	(0.040)
District Dummy Variables		
Gulu		0.082
		(0.088)
Ibanda		0.227***
		(0.072)
Iganga		0.608***
		(0.072)
Mubende		0.549***
		(0.078)
Summary Statistics		
R^2	0.2440	0.4045
N[b]	431	431

OLS regressions.
***, **, and * represent significance at the 1%, 5%, and 10% level.
TLU stands for tropical livestock units; UGX stands for Ugandan Shillings.
[a] Note: The respondent was not necessarily the household head.
[b] Note: The full sample includes 498 records; some were excluded due to missing values.
Source: Authors' calculations using data collected by the USAID/Uganda Market System Monitoring Activity.

Table 2.10: Impact of Counterfeit Awareness on Agrochemical Adoption (Smallholder Farmers)

Variable	(9) With Clustered SE	(10) With Clustered SE & Dummy Variables
Anti-Counterfeit Variables		
Awareness of Counterfeits	0.106*	0.105*
	(0.057)	(0.060)
Pesticides Willingness to Pay	0.030	0.042
	(0.061)	(0.056)
Accessibility Constraint		
Nearby Input Shop	0.053	0.007
	(0.053)	(0.051)
Distance to Nearest Road (km)	0.012	0.001
	(0.009)	(0.007)
Distance to Nearest Town (km)	-0.004	-0.000
	(0.003)	(0.002)
Transport Means	-0.003	-0.006
	(0.053)	(0.047)
Affordability Constraint		
Non-farm Income	-0.005	-0.086
	(0.074)	(0.074)
Sold Portion of Harvest	0.096	0.111*
	(0.059)	(0.059)
Livestock Owned (TLUs)	0.021	0.028
	(0.020)	(0.017)
Number of Adults	-0.015	-0.023
	(0.017)	(0.017)
Borrowed Money	-0.056	-0.054
	(0.076)	(0.070)
Received Credit	0.202	0.183*
	(0.122)	(0.108)
Belong to Savings Group	-0.096	-0.013
	(0.073)	(0.074)
Access to Information Constraint		
Age[a]	-0.002	-0.001
	(0.002)	(0.002)
Education[a] (Years)	0.015	0.021**
	(0.011)	(0.010)
Mobile Phone Ownership	0.171***	0.049
	(0.063)	(0.066)
Member of Cooperative	0.157	0.260***
	(0.120)	(0.090)

OLS regressions.
***, **, and * represent significance at the 1%, 5%, and 10% level.
TLU stands for tropical livestock units; UGX stands for Ugandan Shillings.
[a] Note: The respondent was not necessarily the household head.
[b] Note: The sample includes 273 smallholder farmers; some were excluded due to missing values.
Source: Authors' calculations using data collected by the USAID/Uganda Market System Monitoring Activity.

Variable	(9) With Clustered SE	(10) With Clustered SE & Dummy Variables
Ability to Bear Risk		
Acres Planted (total Seasons A & B)	0.027	0.049
	(0.033)	(0.032)
Acres Planted Per Capita	-0.009	-0.032
	(0.058)	(0.051)
Food Security Status	-2.138**	-2.126***
	(0.876)	(0.677)
Household Shock	-0.005	-0.006
	(0.080)	(0.072)
Experienced Crop Disease	-0.007	0.045
	(0.058)	(0.057)
Experienced Drought	-0.046	-0.094*
	(0.067)	(0.055)
Experienced Fall Armyworm	-0.007	-0.073
	(0.059)	(0.055)
District Dummy Variables		
Gulu		0.059
		(0.105)
Ibanda		0.101
		(0.110)
Iganga		0.519***
		(0.134)
Mubende		0.507***
		(0.142)
Summary Statistics		
R^2	0.1851	0.3461
N[b]	229	229

OLS regressions.
***, **, and * represent significance at the 1%, 5%, and 10% level.
TLU stands for tropical livestock units; UGX stands for Ugandan Shillings.
[a] Note: The respondent was not necessarily the household head.
[b] Note: The sample includes 273 smallholder farmers; some were excluded due to missing values.
Source: Authors' calculations using data collected by the USAID/Uganda Market System Monitoring Activity.

Table 2.11: Impact of Counterfeit Awareness on Agrochemical Adoption (Large Farms)

Variable	(11) With Clustered SE	(12) With Clustered SE & Dummy Variables
Anti-Counterfeit Variables		
Awareness of Counterfeits	0.134**	0.108**
	(0.051)	(0.053)
Pesticides Willingness to Pay	-0.021	-0.012
	(0.072)	(0.055)
Accessibility Constraint		
Nearby Input Shop	0.057	0.026
	(0.073)	(0.056)
Distance to Nearest Road (km)	-0.011*	-0.013**
	(0.006)	(0.006)
Distance to Nearest Town (km)	-0.002	0.004
	(0.003)	(0.003)
Transport Means	0.067	0.099**
	(0.064)	(0.045)
Affordability Constraint		
Non-farm Income	0.039	-0.054
	(0.057)	(0.057)
Sold Portion of Harvest	0.324**	0.079
	(0.099)	(0.074)
Livestock Owned (TLUs)	0.007*	0.003
	(0.004)	(0.003)
Number of Adults	0.047	0.040
	(0.037)	(0.030)
Borrowed Money	0.013	0.023
	(0.083)	(0.064)
Received Credit	0.419***	0.270***
	(0.094)	(0.095)
Belong to Savings Group	0.047	0.118**
	(0.067)	(0.057)
Access to Information Constraint		
Age[a]	-0.001	-0.006***
	(0.002)	(0.002)
Education[a] (Years)	-0.020**	-0.015*
	(0.009)	(0.008)
Mobile Phone Ownership	0.382***	0.096
	(0.076)	(0.058)
Member of Cooperative	-0.238***	-0.114
	(0.082)	(0.077)

OLS regressions.
***, **, and * represent significance at the 1%, 5%, and 10% level.
TLU stands for tropical livestock units; UGX stands for Ugandan Shillings.
[a] Note: The respondent was not necessarily the household head.
[b] Note: The sample includes 225 large farms; some were excluded due to missing values.
Source: Authors' calculations using data collected by the USAID/Uganda Market System Monitoring Activity.

Variable	(11) With Clustered SE	(12) With Clustered SE & Dummy Variables
Ability to Bear Risk		
Acres Planted (total Seasons A & B)	-0.001	0.003
	(0.008)	(0.008)
Acres Planted Per Capita	0.013	0.002
	(0.023)	(0.025)
Food Security Status	-0.326	-2.011
	(1.897)	(1.548)
Household Shock	-0.154**	-0.024
	(0.075)	(0.070)
Experienced Crop Disease	-0.011	0.089*
	(0.054)	(0.045)
Experienced Drought	-0.014	-0.081
	(0.123)	(0.107)
Experienced Fall Armyworm	0.070	0.122**
	(0.062)	(0.058)
District Dummy Variables		
Gulu		0.104
		(0.115)
Ibanda		0.523***
		(0.158)
Iganga		0.809***
		(0.114)
Mubende		0.669***
		(0.078)
Summary Statistics		
R^2	0.4023	0.5944
N[b]	202	202

OLS regressions.
***, **, and * represent significance at the 1%, 5%, and 10% level.
TLU stands for tropical livestock units; UGX stands for Ugandan Shillings.
[a] Note: The respondent was not necessarily the household head.
[b] Note: The sample includes 225 large farms; some were excluded due to missing values.
Source: Authors' calculations using data collected by the USAID/Uganda Market System Monitoring Activity.

Chapter 3

Examining the Impact of Idiosyncratic Shocks on Input Adoption in Uganda

Smallholder farmers in Africa face innumerable risks. One set of risks that is under-researched in the technology adoption literature are idiosyncratic shocks, such as illness or a death in the household. This paper uses four waves of the Uganda National Panel Survey to test whether the incidence of idiosyncratic shocks influences farmers' input purchases. I find little evidence of an effect on the input purchase decision at the extensive margin, and some limited evidence of an impact at the intensive margin – farmers continue to purchase inputs, but slightly less. This result is suggestive of full insurance in the farming communities, and an examination of the coping strategies employed by households shows that they have insurance mechanisms in place to buffer the impact of idiosyncratic shocks.

3.1 Introduction

Smallholder farming is a risky proposition. Farmers in developing countries face numerous threats that endanger their livelihoods, from drought and pests to illness and deaths. Although much has been written about the impact of production risks (such as weather shocks, pests, and diseases) on smallholder farmers, comparatively less research has focused on the impact of personal shocks such as the illness and death of family members. This paper contributes to the literature by focusing on the impact of idiosyncratic shocks on smallholder farmers in

Uganda. I specifically focus on smallholder farmers' investments in agricultural inputs. It is well established in the literature that investments in modern inputs can have a dramatic impact on agricultural productivity, with corresponding effects on overall economic growth (de Janvry and Sadoulet (2002), Sanchez et al. (2009), McArthur and McCord (2017), Bonilla-Cedrez et al. (2021)). There is also an extensive literature on the barriers to adoption of these technologies – for a thorough treatment please see Paper 1. However, there is little documented evidence of the impact of personal risk on households' investment in modern inputs such as improved seed and fertilizer.

I define idiosyncratic shocks, often described as personal risk, to be those that affect a single household, such as illness, death, and theft. These differ from so-called covariate shocks, which impact multiple households or a whole community, such as drought. When a household experiences an idiosyncratic personal shock, there are two main avenues via which the decision to invest in agricultural inputs is impacted. First, a shock such as illness can have a negative impact on labor productivity at the intensive margin, which may reduce the amount of labor available for the farm. This could impact a household's ability to use a technology, such as applying fertilizer. Alternatively, it may change the investment calculus, reducing the returns to investment in technology when there will not be enough labor to ensure a successful season. Second, personal shocks can have a negative direct impact on a household's cash flow and/or asset position, as many shocks have associated expenditures, such as for health care. Put together, there is a strong possibility that these shocks have a negative impact on investment in agricultural inputs.[1] This paper explores the hypothesis that, controlling for various factors that typically influence purchasing decisions, idiosyncratic shocks negatively impact households' probability of investing in agricultural inputs.

Despite an extensive literature on risk and agriculture, including a subset that focuses on the role of risk in technology adoption, personal risk (risk of experiencing idiosyncratic shocks) is under-represented in the literature. Similarly, there is a broad literature examining the impact of various idiosyncratic shocks on households, as discussed in Section 3.3, but very few papers extend this analysis to consider the impact on agricultural input adoption. My paper is closest to work by Gebremariam and Tesfaye, one of the few papers that analyze personal risk in the context of input adoption (Gebremariam and Tesfaye, 2018). They find a negative relationship

[1]The shocks do not have to be *realized* to have an impact on investment decisions, either; the risk of illness or other shocks may lead households to manage their cash flow/assets accordingly, a strategy that may preclude investment in agricultural inputs.

between shocks and investments in seed and inorganic fertilizer.

The analysis makes use of the Uganda National Panel Survey, a nationally representative household survey that is conducted by the Uganda Bureau of Statistics and supported by the World Bank Living Standards Measurement Study – Integrated Surveys on Agriculture. Specifically, it focuses on data from the four most recent waves of the survey, conducted in 2013-14, 2015-16, 2018-19, and 2019-20, each of which covers two agricultural seasons. The survey includes a module on the shocks experienced by the household in a given year. Although the data are intended to provide a panel structure, some features of the shock reporting limits the usefulness of the panel. In two waves, however, I am able to use information on the timing of specific shocks to link them to subsequent household input purchase decisions.

Contrary to my hypothesis that idiosyncratic shocks negatively impact households' input purchasing decisions, I find no clear evidence that idiosyncratic shocks influence the binary decision to invest. There is limited evidence that the shocks reduce the amount that is spent on inputs, which would correspond to the hypothesis that one of the main channels through which shocks impact these households is by reducing their available liquid assets. One explanation for the limited impact on the extensive margin of input purchases lies in the coping strategies reported by the households: support from friends and relatives was the most common coping strategy, followed by relying on savings and "doing nothing." These raise the possibility that the households were able to absorb the idiosyncratic shocks thanks to their coping strategies, so that the shocks had no *ex post* impact on their input purchasing decision. This does not preclude the possibility, of course, that households' *ex ante* livelihood strategies are themselves shaped by costly risk-coping strategies (as suggested by Dercon and Krishnan (2000) and Dercon (2002)).

If correct, this hints at evidence of (nearly) full insurance in the survey communities. Best known from Townsend (1994), this model predicts consumption smoothing in the face of idiosyncratic shocks through various local "risk-bearing institutions," similar to those mentioned as coping strategies by the respondents. However, with the full insurance model it is notoriously difficult to distinguish the null results of full insurance from a lack of power to detect the consumption effects of individual income. As discussed in Section 3.4, in some cases the incidence of reported shocks is very low; it is entirely possible that my analysis lacks the power to identify small negative impacts of idiosyncratic shocks.

The paper is organized as follows: Section 3.2 discusses the relevant literature on risk and technology adoption, while Section 3.3 provides context on the types of idiosyncratic shocks that are considered, drawing on insights from previous literature. Section 3.4 presents the data and some descriptive statistics, while Section 3.5 describes the methodology of the analysis. The main analytical results are presented in Section 3.6 and discussed in Section 3.7. Section 3.8 concludes.

3.2 Literature

The relevant literature on risk and technology adoption in developing countries is primarily focused on three topics. First, there are a number of studies that investigate the relationship between risk and technology adoption, though these are primarily focused on production risk. Second, there is a substantial literature on index-based weather insurance, which is seen as a potential tool for reducing the risk of investing in agricultural technology. Finally, there is an extensive literature analyzing the individual risk preferences of farmers and the impact these preferences can have on technology adoption. What is noteworthy, and provides motivation for this paper, is that this literature gives little attention to risks other than those related to production, such as prices and weather.[2]

3.2.1 Risk and Technology Adoption

There is a long history of investigating the role of risk and uncertainty in technology adoption, as summarized by Marra et al. (2003). Much of this literature is focused on farmers' responses to production risk, such as rainfall variability or pests and diseases. For example, Amare et al. (2018) consider the impact of rainfall shocks on agricultural productivity in Nigeria, while Emerick et al. (2016) and Lamb (2003) consider the impact of production risk on technology adoption in India. Newman and Tarp (2020) find that weather shocks in Vietnam lead to lower investment in productive assets, while Bold et al. (2017) consider the behavior of risk-averse farmers in the presence of counterfeit products in Uganda. Van Campenhout and Bizimungu (2018) explore the relationship between intensification and risk management strategies among Ugandan rice and potato farmers, including investment in risk-reducing technologies, crop diversification, precautionary savings, and access to credit. In a highly technical analysis, Mukasa

[2]Indeed, implicit in the existing literature is the belief that weather shocks are the major source of risk for farmers – arguably giving rise to the recent proliferation of interventions aimed at providing farmers with weather-based index insurance. Yet this insurance has the potential to generate substantial basis risk if weather shocks are not the primary source of risk that rural farmers face.

(2018) explicitly considers the relationship between production risks and modern input usage in Uganda, finding that the mean, variance, skewness, and kurtosis of production all significantly explain farmers' probability of adopting modern inputs.

3.2.2 Insurance

The second strand of literature, an area of risk that has received ample attention in the literature, is the use of index-based insurance to mitigate the risk of weather shocks. Carter et al. (2017) provide a review of the literature as well as the constraints to adoption. There have been multiple experiments and RCTs attempting to understand the reasons why farmers are reluctant to adopt weather insurance (e.g. Cole et al. (2017), Karlan et al. (2014), Falco et al. (2021), Visser et al. (2020), Tadesse et al. (2015), Babcock (2015), among many others). Despite many years of research and experimentation, uptake of insurance remains low (Ali et al. (2020)), suggesting that the products do not adequately address farmers' perceived needs, particularly when it comes to reducing basis risk. (See Clarke (2016) for a discussion of the impact of basis risk on demand for index insurance). In fact, index insurance may actually compound the risk faced by farmers, if the index is poorly correlated with the shocks that actually end up mattering to a household in a particular season.

The literature on index insurance is linked to the literature on weather shocks. There has been much research on the impact of covariate weather shocks on households in Uganda, and the types of responses that result, with ambiguous and sometimes contradictory results. Agamile et al. (2021) provide evidence for Uganda showing that in the event of a rainfall shock (drought), men responded by shifting labor to non-farm activities, while women shifted from subsistence to cash crops. Agamile and Lawson (2021) find that negative rainfall shocks reduce school attendance by almost 10%. Another analysis by Asfaw et al. (2015) did not find significant welfare effects of weather shocks, which they attribute to consumption smoothing. Asiimwe and Mpuga (2007) find that higher than average rainfall in the first planting season leads to lower incomes but not reduced consumption, again suggesting consumption smoothing. Yet Amare et al. (2021) find that a 10% increase in variability in agricultural productivity due to rainfall shocks leads to 5.2% decrease in household consumption.

3.2.3 Risk Preferences

The third strand of the literature on risk focuses on the types of risk preferences displayed by farmers, and the way these preferences deviate from standard expected utility theory (such as displaying risk aversion or ambiguity aversion). There have been extensive experimental studies attempting to characterize and quantify farmers' risk preferences, starting with Binswanger (1980). Several focus specifically on Uganda: Clot et al. (2017) find that impatient farmers are more risk averse, while Tanaka and Munro (2014) find regional variation in risk and time preferences. Ihli et al. (2016) and Mosley and Verschoor (2005) research risk aversion, while Harrison et al. (2010) compares expected utility theory and prospect theory, and Humphrey (2004) assess deviations from expected utility theory. There are also some studies that specifically look at risk aversion vis-a-vis technology adoption, including Verschoor et al. (2016), who research the relationship between risk preferences and fertilizer adoption in Uganda. Elsewhere, Brick and Visser (2015) explore the relationship between risk aversion in modern technologies in South Africa, Simtowe (2006) considers fertilizer use in Malawi, Abedullah and Pandey (2004) focus on fertilizer use in the Philippines, and Sanou et al. (2018) research the relationship between risk and ambiguity aversion and fertilizer use in Niger. Others have conducted similar research in Burkina Faso (Le Cotty et al. (2018)) and Vietnam (Khor et al. (2018)).

3.2.4 Idiosyncratic Risk

Personal or idiosyncratic risk is under-represented in the literature. Komarek et al. (2020) conducted an extensive literature review of the types of risks mentioned in the literature. They found more than 3,200 articles that mentioned one of five types of risk: production risk, market risk, institutional risk, personal risk, and financial risk. The overwhelming majority (66%) focused only on production risk, and only 15% of studies considered more than one type of risk. Only 60 of the studies they found focused on personal risk. Studies about Africa represented fewer than 20% of the studies they reviewed. Similarly, a survey of recent literature on technology adoption mentions only index insurance under the category of risk (Magruder (2018)).

Despite being under-represented in the literature, there is ample evidence that personal shocks negatively impact households and can impact agricultural productivity. For example, in a seminal article, Dercon et al. (2005) use data on a broad set of covariate and idiosyncratic shocks to estimate their impact on per capita consumption, finding that drought and illness were the only shocks to have a statistically significant negative impact on consumption. Almost all households in their sample reported experiencing a shock during the survey period, and they named drought, death, and illness as the most important shocks. In one of the few papers to consider multiple types of risk, Osiemo et al. (2021) build on Komarek et al. (2020) to consider the five types of risk (with the addition of a sixth type, consumption risk) in their analysis of risk perceptions and attributes, in the context of Kenyan smallholder farmers.

My paper is closest to work by Gebremariam and Tesfaye, which similarly considers personal risk in the context of input adoption (Gebremariam and Tesfaye, 2018). Focusing on Ethiopia, they also use data that was collected with support from the World Bank Living Standards Measurement Study – Integrated Surveys on Agriculture. They consider a broader portfolio of innovations and farming practices: crop rotation, chemical fertilizer, organic fertilizer, irrigation, and improved seeds. However, they focus solely on maize production. They use three types of shocks as their primary independent variables: production shocks (drought, disease, etc.), price shocks (rise in the price of inputs), and health shocks (serious illness in the household). The shocks are self-reported, exposing them to the same potential issues that I discuss in Section 3.4.5 below. They do not address this issue, but do acknowledge the potential endogeneity of the health shocks, indicating that it is not a serious problem because their estimation strategy allows for error terms to be correlated. In order to allow for complementarity among the innovations, and the adoption of more than one simultaneously, they utilize a pooled multivariate probit model, which is econometrically more sophisticated than what I have done here. Of relevance to this paper, they find that the production shocks have a negative effect on usage of chemical fertilizer and improved seed, while the health shocks similarly reduce the probability of using these inputs. They also find that the price shock led to greater adoption of improved seed, a counterintuitive result that is not explored. I consider this work complementary to theirs, focusing on a different country context, a broader set of idiosyncratic shocks, and a different estimation strategy.

3.2.5 Full Insurance

Another important literature to consider when assessing the impact of shocks is the extensive work on the full insurance model, best known from Townsend (1994). This model predicts consumption smoothing in the face of shocks through various local "risk-bearing institutions," including borrowing and support from family networks. Townsend was motivated by the theoretical observation that, under complete markets, idiosyncratic shocks should not influence consumption, because individual consumption would be fully insured – and thus would be determined by aggregate income, rather than individual shocks. Taking the village as the potential locus of risk-sharing, Townsend tested this hypothesis of full risk-sharing using data from India. Townsend's analysis did not reject the full-insurance hypothesis, and he concluded that it serves as a useful benchmark. Although Townsend focused on consumption, the implications arguably hold for input spending as well.

A sub-literature developed in the 1990s that tested the hypothesis of full insurance. In an earlier paper, Cochrane (1991) finds that certain shocks are insured, specifically short-term illness, unemployment from involuntary job loss, strikes, and involuntary moves. Mace (1991) reports mixed results depending on the specification used. Townsend (1995) examines results from India, Thailand, and Cote d'Ivoire, finding that full insurance is rejected in all three cases. Hayashi et al. (1996) reject full risk sharing in American families. Ravallion and Chaudhuri (1997) revisit Townsend's findings from India, finding that the comovement of consumption he observed is not due to risk sharing at the village level. Jalan and Ravallion (1999) test for full insurance in China and reject the model, further finding that the existing institutions of consumption insurance work less well for asset poor households. For further explorations see Attanasio and Davis (1996), Ligon (1998), Ham and Jacobs (2000), Dercon and Krishnan (2000), Ligon et al. (2002), and Kazianga and Udry (2006). Overall, as discussed by Morduch (1999), the results suggest that informal insurance exists but is not perfect. However, there is a recurring criticism of this literature: the test for full insurance is satisfied by a null result on individual income, so it is difficult to distinguish between full insurance and a lack of power to detect the consumption effects of individual income. Townsend's test for full insurance is in some sense biased in favor of finding that insurance is effective.

A later literature has also emerged that specifically looks at the impact of one type of idiosyncratic shock, namely health shocks, on consumption, and the extent to which this consumption is insured. The results are mixed as to whether full insurance exists in the wake of a health shock. Dercon et al. (2005) find that illness shocks reduce per-capita consumption in Ethiopia. Asfaw and Von Braun (2004) find that consumption of nonfood items is vulnerable to health shocks in Ethiopia. Wagstaff (2007) analyzes the impact of health shocks on consumption in Vietnam, finding no evidence of consumption smoothing for food consumption, and mixed evidence for non-food consumption, which suggests a reallocation of food consumption towards expenditures on home care for the ill household member. Gertler and Gruber (2002) explore the impact of major illness on households in Indonesia, finding limited evidence of consumption insurance. Lim (2017) finds that health shocks have a significant effect on food consumption in Indonesia. In a further study of Indonesia, Genoni (2012) finds that although illness events reduce earnings, there are no statistically significant effects on consumption, due to increased labor supply by other household members and transfers from relatives. Mbugua et al. (2020) find that health shocks had a negative effect on food purchases in Kenya, but found that households were partially insured via their social networks. Ajefu (2017), analyzing data from Nigeria, find that health shocks do not affect households' consumption expenditure, suggesting that risk-sharing mechanisms are successful in smoothing consumption. Hangoma et al. (2018) find a negative association between injury and consumption in Zambia.

There is also evidence about coping strategies in the literature, which mirrors to a certain extent the results I find below. Looking at findings across five countries, Skoufias and Quisumbing (2005) generally find that food consumption is better insured than non-food expenditures, with the results suggesting that the impact of the shocks is absorbed by changes to non-food expenditures. For four of the countries, remittances from friends and relatives were one of the coping strategies. Sparrow et al. (2014) find that rural and poor households in Indonesia are likely to experience reduced consumption after a health shock, and poor households' coping strategies included borrowing, support from family members, and using savings and assets. Wagstaff and Lindelow (2014), in an analysis of multiple shocks experienced by households in Laos, find that health shocks are more common, more likely to happen to poorer households, and generate larger costs than non-health shocks. The most common coping strategies were using savings and borrowing. De Weerdt and Dercon (2006) analyze data from Tanzania that suggests that households cope with health shocks through transfers and savings, though the shocks are not fully insured. Mitra et al. (2016), in a study of health shocks in Vietnam, find that rural households and female-headed households are least able to maintain consumption levels following a health shock, and that common coping strategies included loans and asset sales. Yilma et al. (2014) found limited evidence of gifts from family and friends in the wake of idiosyncratic health shocks, finding instead that households relied on savings and borrowing. Powell-Jackson and Hoque (2012) focus specifically on maternal illness in Bangladesh, finding that households are able to maintain consumption levels thanks largely to access to informal credit. Finally, Kijima et al. (2006) find for Uganda in particular that households increase off-farm labor allocation following agricultural shocks, particularly asset-poor households.

3.3 Context

Uganda was selected as the case country owing to both the availability of data on idiosyncratic shocks and the relatively low usage of agricultural inputs: according to the most recent official statistics from 2019, 25.3% of agricultural households used improved seed in the first agricultural season, and 18.3% used it in the second season. Similarly, for the first season, 9.1% of agricultural households used fertilizer and 22.6% used pesticides, while for the second growing season, 10.1% used fertilizer and 22.7% reported using pesticides (UBOS, 2022).

This section reviews some of the most important idiosyncratic shocks that households in Uganda face. It provides evidence as to the incidence of these shocks, based on the 2019-20 Uganda National Panel Survey (UNPS), and summarizes the research on the impact of these shocks on Ugandan households. Overall, according to the 2019-20 UNPS, 12.2% of respondents reported experiencing a (negative) idiosyncratic shock during the previous year. As defined by the survey, this does not include pregnancy or social expenditures. When I add in the additional shocks of pregnancy and spending on funerals or other social functions, the percentages increase considerably – to 64.2% of households. This is compared to 25.7% who reported experiencing a covariate shock during the same period.

3.3.1 Health

Illness was the most commonly reported idiosyncratic shock in the 2019-20 Uganda National Panel Survey, with 152 out of 2,363 households reporting a serious illness or accident in the previous year.

It seems obvious that there is a positive relationship between a farmer's health and his or her level of agricultural output – the healthier the farmer is, the more labor they are able to devote to farming, making higher output per acre more likely. Researchers have tested this relationship and indeed found a linkage between farmer health and productivity. There is a long-established macroeconomic relationship between health, total factor productivity, and economic growth (see for example Cole and Neumayer (2006)).

There is much evidence across countries that demonstrates this linkage between health outcomes and productivity. In a seminal paper, Pitt and Rosenzweig (1984) find a positive relationship between health and labor productivity in Indonesia. Similarly, Antle and Pingali (1994) find a positive relationship between health and agricultural productivity in the Philippines. More recently, Ulimwengu (2009) finds a positive relationship between health and output and therefore income in Ethiopia, while Gkiza and Nastis (2017) find a relationship between agricultural productivity and female health in particular in Greece. Audibert and Etard (2003) demonstrate the positive impact of schistosomiasis treatment on labor productivity in Mali, while Gilgen et al. (2001) find a negative relationship between parasitic helminth infections and labor productivity.

Researchers have been analyzing the link between nutrition and agricultural productivity for decades, such as Strauss (1986) finding a significant effect of caloric intake on productivity and Behrman et al. (1997) showing a similar income-calorie relationship in Pakistan. More recently, Agulanna et al. (2013) find a linkage between nutrition and health and therefore agricultural productivity in Nigeria. Berha et al. (2021) find a relationship between nutrition and labor productivity in Ethiopia for households with low levels of nutrition, reinforcing earlier findings by Croppenstedt and Muller (2000) of a link between nutrition and agricultural productivity in Ethiopia.

Nutrition affects the physical and cognitive capabilities of farmers, but health shocks may affect productivity through other channels. Asenso-Okyere et al. (2011) conceptualize three impacts of illness: it decreases the time spent available to work, increases the time spent by others on caregiving (reducing their time available to work), and incurs costs in money or assets that are lost to managing the disease. Treatment costs include both the cost of treatment itself and the cost of transportation to the clinic, as well as the opportunity cost of traveling what could be long distances. As Ssewanyana and Kasirye (2020) point out, most health expenditures in Uganda are paid for privately (i.e. not covered by insurance). The cost of treatment can sometimes be prohibitive. Russell (2004) reviewed studies focused on the costs of malaria, tuberculosis, and HIV/AIDS, and found that the direct and indirect costs of malaria accounted for less than 10% of household income, while the costs of tuberculosis and HIV/AIDS were more than 10% of household income, deemed catastrophic. Many families are forced to borrow or sell productive assets to cover the cost of treatment. Beyond the impact on labor productivity, illness can also lead to changes in farming practices, such as reducing the area under cultivation, planting less labor-intensive crops, reducing the variety of crops planted, and altering the usage of farm inputs (Asenso-Okyere et al. (2009), Asenso-Okyere et al. (2011)).

There is also evidence from Uganda suggesting that health shocks can lead to poverty. In a study of poverty trajectories in 36 Ugandan villages, Krishna et al. (2006) found that ill health and health-related costs were cited by more than two-thirds of households as the main reason for their descent into poverty over the period studied. Death of income earners was the second most important cause. They also cite earlier research that found ill health and expenses on dowries and funerals to be among the important reasons for descending into poverty.

There is limited literature on the impact of health shocks on investment in agricultural inputs. Osei-Akoto et al. (2013) find a negative relationship between ill health and agricultural input usage in Ghana. Isoto et al. (2017) find that access to microcredit can mitigate the impact of health shocks on investment in farm inputs. However, all three of the impacts described by Asenso-Okyere et al. (2011) (decreased labor availability for farming due to illness and caregiving, costs incurred for treatment) could be expected to have an impact on a household's ability to purchase and use inputs. The most direct impact may be the costs incurred in treating an illness, as this reduces the funds available for purchasing inputs. However, if the impact on labor availability is great enough, to the point that there is insufficient labor available to actually apply the inputs to the farm, households may defer input purchases as well. The effect may well also depend on whether inputs act as a substitute or a complement for labor – one could imagine circumstances in which, with limited labor available for weeding, farmers choose to purchase and apply herbicides as a substitute. The impact may thus depend on the input purchased; fertilizer, for example, could be seen as a complement to farm labor.

3.3.1.1 HIV/AIDS

The UNPS does not disaggregate illness statistics by the cause of illness, so it is not possible to determine the incidence of HIV/AIDS in this sample population.

HIV/AIDS is on the decline in Uganda – the prevalence of HIV among the population aged 15-49 was 5.4% in 2020, down from 10.1% in 1990 (World Bank, 2022). However, HIV/AIDS is still positioned to have a substantial negative impact on Ugandan farmers, given the lasting effects that a diagnosis can have on generations of family members.

There is an extensive literature on the impact of HIV/AIDS on African households. A study in Tanzania found that households impacted by AIDS deaths spend less on food and are more likely to fall below the poverty line (Mwakalobo, 2007). Fox et al. (2004) found a negative relationship between HIV/AIDS and labor productivity in Kenya. Further studies have looked at Rwanda (Gillespie, 1989), Malawi (Dorward et al., 2022), and dozens of other countries.

There is some evidence of the impact of HIV/AIDS on agricultural practices as well. In a study of AIDS-affected households in Zambia, Chapoto and Jayne (2008) find that the death of a prime-age household member leads to a decline in the value of crop output and a reduction in livestock assets. They also find that the death of a male prime-age household member leads to a reduction in land under cultivation. Yamano and Jayne (2004) similarly find a reduction in livestock assets among Kenyan households impacted by working-age adult male mortality.

In Uganda, a study by the National Agricultural Advisory Services (NAADS) found that households sold assets to cope with HIV/AIDS-related illness and death (NAADS, 2003). A study in southeastern Uganda found that illness and caregiving led to labor shortages; the authors also observed that households lost land tenure and other assets after deaths (Parker et al., 2009). This study further found that the death of an adult male was associated with a reduction in land under cultivation and that the impact on the household depends on who is affected by illness or dies. Another study found that the ability of Ugandan households to absorb HIV-related illness or death may depend on may depend on household composition and the presence and number of working-age adults (Amurwon et al., 2015).

3.3.1.2 Malaria

The UNPS does not disaggregate illness statistics by the cause of illness, so it is not possible to determine the incidence of malaria in this sample population.

Malaria is one of the major public health issues in Uganda and generates a large economic and health burden. As described by Sachs and Malaney (2002), "where malaria prospers most, human societies have prospered least." Malaria is endemic in Uganda, which has one of the 20 highest incidence rates in the world (World Bank, 2022). Malaria is reported to be one of the leading causes of death in Uganda, if not the leading cause of death (MoH (2016), PMI (2015)). About 90% of the population is at risk, and estimates put the economic cost of malaria in Uganda at upwards of $500 million each year (Target Malaria (2020), Orem et al. (2012)). Uganda accounts for 5.4% of global malaria cases as well as 3.5% of global malaria deaths, with more than 27 million suspected cases estimated for 2020 in a population of nearly 46 million people (World Health Organization, 2021).

Since the pioneering effort of Gallup and Sachs (2001) to measure the economic burden of malaria, our understanding of the impact of the disease has improved. Numerous studies have tried to estimate the cost of malaria, as detailed in Willis and Hamon (2019). For example, Somi et al. (2007) find a negative relationship between the presence of malaria parasites in the blood and household socioeconomic status in Tanzania. Analysis from Nigeria found that farmers lose 22 days a year to malaria (Ajani and Ashagidigbi, 2008). One study looked at differential productivity effects in Ethiopia and found that the impact on labor productivity is greatest when women and children under 14 fall sick, and that households that did not experience malaria spent more on inputs than those that did (Diiro et al., 2022).

As with HIV/AIDS, malaria has an impact on agricultural production in Uganda. An estimate found that farmers lose on average 31 days to illness each year, of which 7 days are lost to malaria (along with 10 days spent on caregiving) (Badiane and Ulimwengu, 2013). This study found a negative relationship between crop production and the number of days lost to malaria, as would be expected. The seasonality of malaria in Uganda is a problem as well, as cases peak following the rainy seasons – during harvest time, when labor productivity needs to be high (Tusting et al. (2016), Asenso-Okyere et al. (2009)).[3]

3.3.1.3 Pregnancy

The UNPS does not ask if a woman is currently pregnant, but it is possible to ascertain whether a woman was pregnant at some time in the previous year, by measuring the number of infants in the household between zero and 11 months old. This measure does not capture all pregnancies, but gives a rough measure of the number of women who were pregnant in the previous year. For 2019-20, 11.7% of households had experienced a birth in the previous year.

Pregnancies represent another health event that incurs healthcare costs and generates a loss of labor productivity, both of which could lead to a reduction in input purchases. In Uganda, Van Campenhout (2016) finds a negative relationship between the number of children in a household and the number of days spent in the field, though he found no impact of fertility on yields. There is evidence from Kenya that women reduce the time allocated to subsistence agriculture during the third trimester and while breastfeeding (Baksh et al., 1994). There is further evidence that women do not reduce labor-intensive work during pregnancy, as time-use patterns were the same (Peterman et al., 2013) – though the study did not assess whether the women were equally productive during the time spent in the field.

[3]The impact of malaria is also bi-directional, as agricultural practices such as crop choice can impact malaria incidence (Asenso-Okyere et al. (2009), Wielgosz et al. (2012), Wielgosz et al. (2014)).

3.3.2 Death

Death was the third most common idiosyncratic shock reported by respondents to the 2019 UNPS, with 2.2% of households experiencing a death in the previous year.

The death of a household member can have negative impacts on the household and its agricultural productivity. In the strictest sense, the household may have lost agricultural labor, which will negatively impact its ability to cultivate crops. Yamano and Jayne (2004) consider the negative impacts of working-age adult mortality on household outcomes in Kenya, finding persistent effects on agricultural incomes in certain cases. There are other potential impacts of death on surviving households, such as a loss of farming knowledge and relevant social connections (Asenso-Okyere et al., 2011). In some cases, depending on which household member has died, the family may also be facing the loss of land tenure as well (Parker et al., 2009). In terms of input purchases, if a household has experienced a death, it may not have sufficient labor available to apply inputs, and therefore may forego them. The household will also have incurred the expense of a burial which will impact its ability to afford inputs, though burial expenses are usually supported by the community, as discussed below.

3.3.3 Social Expenditures

Spending on funerals and other social functions was very common in the 2019 UNPS – 54.1% of households reported this expenditure in the previous year. The level of this spending was also quite high – an average of more than UGX 135,000 per household per year at the national level, among those who reported expenditures. This amount represents more than the median monthly wage of UGX 120,000 in rural areas, according to the Uganda Bureau of Statistics (UBOS, 2018). This suggests that social expenditures form a substantial part of household budgets. The size of these social expenditures in a given year may exceed expectations, possibly by a large amount; if so, it will represent a shock to a household's expenditures in a given year.

There is a lack of data available on the average cost of weddings and funerals, but these can represent substantial outlays. Ugandans are expected to contribute to the cost of weddings and burials within their social circle. Funerals can be an expensive proposition in Uganda – in some cases requiring households to sell land to cover expenses (Segawa (2019), Monitor (2021a)). They can often be mass gatherings (Lubega et al., 2022).[4] In response, burial societies are common in Africa, including in Uganda. These provide support to the family after a death

[4] In fact, the COVID-19 restrictions on the number of people at burials led to notable savings (Monitor, 2021b).

(Twesigye et al., 2019).

Weddings can also be an expensive proposition – both when someone in the household is wed and when households need to make socially expected contributions to others' weddings (CGTN, 2019). Dowries or "bride price" vary with local culture and context, but in either case, the expenses are high (Lindrio (2019), Kalokwera (2022), Anderson (2007)). Together, the impact of spending on funerals, weddings, and other social obligations reduces the liquid assets available to the household for spending on inputs, which may therefore have an impact on input purchases.

Social expenditures are special case, however, because in a sense they are the "insurance payouts" that households are receiving from the community when they experience a shock such as a death. In this way, the shock that occurs following death of a household member is propagated through the community, as other households are expected to contribute to the funeral expenses. This is why I treat social expenditures as a type of shock – but they are shocks that are reducing the losses of other households at the same time. They are also not strictly idiosyncratic, since the costs are spread across the community. I acknowledge that this is a bit muddled, but as will be seen in the results, spending on funerals and other social functions is predictive of input spending, and appears to signal a wealth effect, rather than impacting the input purchase on either the extensive or intensive margin.

3.3.4 Other Idiosyncratic Shocks

The 2019 UNPS also collects data on a few other idiosyncratic shocks: reduction in off-farm earnings, loss of employment, theft, conflict or violence, and fire. Of these, theft was the most prevalent, and in fact the second most common shock overall, with 2.7% of respondents reporting a theft of household or agricultural assets. One can imagine that households that have experienced a loss through theft may face difficulties in financing input purchases – though it is also possible that they will seek to further intensify their production to compensate for the loss (assuming they can still afford the inputs).

3.4 Data

3.4.1 Data Overview

The analysis makes use of the Uganda National Panel Survey, a nationally representative household survey that is conducted by the Uganda Bureau of Statistics and supported by the World Bank Living Standards Measurement Study – Integrated Surveys on Agriculture. Specifically, it focuses on data from the four most recent waves of the survey, conducted in 2013-14, 2015-16, 2018-19, and 2019-20. The surveys include both household-focused and agriculture-focused questionnaires, conducted over two visits. Each survey covers one year of agricultural production, or two agricultural seasons.[5] Starting with the 2013-14 survey, one-third of the sample was refreshed in each wave, with each household visited for three consecutive waves. This means that households in the dataset appear at most four times. Households residing in the districts in the Karamoja region were excluded from this analysis, given how much the agro-pastoralist system in Karamoja differs from the agricultural practices in the rest of the country. The analysis includes only those households that reside in rural areas and that engaged in agriculture during the survey period.

3.4.2 Relevant Variables

Of relevance to this study, the survey contains questions on standard demographic and health indicators. These include indicators that are traditionally used to explain technology adoption, such as age, education, household size, livestock ownership, remittances, off-farm income, access to credit, ownership of transportation assets, mobile phone ownership, food security, number of acres planted, amount harvested, access to extension services, access to markets, etc. The survey also asks about input usage, including organic and inorganic fertilizer, pesticides/herbicides, and seed.

There is also a section of the survey specifically dedicated to shocks, which are defined as "events that happen suddenly." The module asks about each of the following types of shocks:

- Drought
- Irregular rains

[5] The majority of Uganda is characterized by bimodal rainy seasons, which allow for two relatively equal growing seasons. The first rainy season occurs from March to June, with harvest from the first growing season (Season A) beginning in June. The second rainy season runs from August through November, with the Season B harvest beginning in November. See https://fews.net/east-africa/uganda for more.

- Floods
- Landslides
- Erosion
- Unusually high level of crop pests and disease
- Unusually high level of livestock disease
- Unusually high costs of agricultural inputs
- Unusually low prices for agricultural output
- Reduction in the earnings of currently (off-farm) employed household member(s)
- Loss of employment of previously employed household member(s) (not due to illness or accident)
- Serious illness or accident of income earner(s)
- Serious illness or accident of other household member(s)
- Death of income earner(s)
- Death of other household member(s)
- Theft of money/valuables/non-agricultural assets
- Theft of agricultural assets/output (crop or livestock)
- Conflict/violence
- Fire
- Other

The list includes both covariate and idiosyncratic shocks, and both production shocks and personal shocks. It is relatively comprehensive: I used a similar list of shocks for the interviews I conducted in Paper 3, and when asked if they had experienced any shocks that were not on the list, the respondents did not volunteer any actual shocks. The section asks whether the shock was experienced during the previous 12 months, when it occurred, whether there was a decline in income, assets, or food production, and which coping mechanisms the household used in response to the shock. Elsewhere in the survey, the household is asked about the number of children under one year of age, and expenditures on healthcare and funerals and other social functions, both of which are also used as shock variables in the subsequent analysis.

There are a few caveats concerning the way these shocks are defined and how they will be used in the analysis. First, although the module asks about serious illness, the threshold for what is considered a "serious illness" is not defined in the questionnaire. As such, it is possible that the survey under-reports illnesses that could be relevant to this analysis. For example, a bout of malaria, if poorly timed, could have interfere with the farmer's ability to purchase or apply inputs – or at least have an impact on the farmer's ability to earn off-farm income that is needed to pay for the inputs. Yet the respondents may not consider malaria as rising to the level of a "serious illness," especially since the disease is frequent and ubiquitous. Similarly, the module asked about "unusually high" levels of crop pests/disease, livestock disease, and input costs, and "unusually low" output prices. "Unusually high" is also not defined and is open to interpretation by the respondents, who may consider different lookback windows when considering what is "usual".

Second, the definition of conflict is not provided; it could be that households interpret conflict to mean disagreements within the household itself, or with another household, while it is also possible that a conflict could impact the whole community. For purposes of this analysis, I choose to treat conflict as an idiosyncratic shock. The incidence of conflict is so low that it is unlikely to influence the analysis one way or another. Third, I choose to treat spending on social functions, such as weddings and funerals, as an idiosyncratic shock, as I am interested on the impact of this spending on household liquidity. It is possible to consider this a covariate shock, if the social function happened within the community and therefore required contributions from other community members. This would matter if the shock to the community meant that the households were unable to rely on each other for support in coping with the shock. As we shall see later, the most common coping strategy for the households in the sample is to rely on friends and family members for support, which suggests that even if the social spending is a covariate shock, its impact is limited. Finally, I treat births in the household as an idiosyncratic shock, even with the understanding that births are anticipated and the households could therefore take actions to plan for the impact of the birth on household labor and spending.

Several composite variables were constructed for purposes of the analysis: *Idiosyncratic* represents whether a household experienced an idiosyncratic, personal shock as defined by the survey, which includes death, illness, loss of earnings, loss of employment, theft, conflict, and fire. I considered births and funeral and other social expenditures separately. *Covariate* represents whether a household experienced a covariate shock, including drought, irregular rains, floods, landslides, erosion, unusually high level of pests and disease, unusually high prices for inputs, and unusually low prices for outputs. An *Income shock* is defined as occurring if the household experienced the death of an income earner, illness of an income earner, loss in non-farm earnings, or loss of employment. An *Asset shock* is defined as occurring if the household experienced a theft, either of agricultural or non-agricultural assets, or a fire.

Table 3.1 provides definitions of the variables used in the analysis.

3.4.3 Descriptive Statistics

As discussed above, the dataset contains entries that represent rural households that engaged in agriculture in at least one of two annual growing seasons. In 63.2% of the responses, the households indicated that either subsistence or commercial agriculture was their most important source of income in the previous twelve months. The average age of the household head was 47.8 years, and the average household contained 2.97 adults. A majority of households (62.2%) had at least one member who earned non-farm income. Just under half (48.3%) reported owning a means of transportation, whether a bicycle, motorcycle, or motor vehicle. On average, households cultivated a total of 4.07 acres of land over both seasons (note that the amount cultivated was not available for certain households in the 2018-19 wave). Households on average owned 1.78 Livestock Units of livestock.[7] Only 12.8% of households received extension services of some sort.

As for the outcome of interest, usage of inputs, 26.5% of respondents purchased an input of some kind in either Season A or Season B. This included 6.0% of households who purchased inorganic fertilizer, 14.4% who purchased pesticides, and 15.5% of households who used improved seeds. Some households used multiple inputs. This tracks with the most recent statistics: 25.3% of agricultural households used improved seed in the first agricultural season for 2019, and 18.3% used it in the second season. Similarly, for the first season, 9.1% of agricultural households used fertilizer and 22.6% used pesticides, while for the second growing season, 10.1% used fertilizer

[7]LSU was calculated using the figures provided by `https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Livestock_unit_(LSU)`.

Table 3.1: Variable Descriptions

Variable	Type	Description
Input Variables		
Inputs	Binary	Represents whether the farmer purchased seed and/or fertilizer prior to the most recent growing season.
Input spending	Continuous	Total amount (in Ugandan Shillings) spent on seed and fertilizer prior to the most recent growing season.
Shock Aggregates		
Idiosyncratic	Binary	Whether a household experienced a personal shock as defined by the survey, which includes death, illness, loss of earnings, loss of employment, theft, conflict, and fire.
Covariate	Binary	Whether a household experienced a covariate shock, including drought, irregular rains, floods, landslides, erosion, unusually high level of pests and disease, unusually high prices for inputs, and unusually low prices for outputs.
Income Shock	Binary	A composite that represents whether a household experienced the death of an income earner, illness of an income earner, loss in non-farm earnings, or loss of employment.
Asset Shock	Binary	A composite that represents whether a household experienced a theft, either of agricultural or non-agricultural assets, or a fire.
Individual Shock Variables		
Death total	Binary	Indicates whether the household experienced either the death of an income earner or the death of an other household member in the previous 12 months.
Death of income earner	Binary	Indicates whether the household experienced the death of an income earner in the previous 12 months.
Death of other household member	Binary	Indicates whether the household experienced the death of an other household member in the previous 12 months.
Illness total	Binary	Indicates whether the household experienced a serious illness or accident of an income earner or a serious illness or accident of an other household member in the previous 12 months.
Illness of income earner	Binary	Indicates whether the household experienced a serious illness or accident of an income earner in the previous 12 months.

Variable	Type	Description
Illness of other household member	Binary	Indicates whether the household experienced a serious illness or accident of an other household member in the previous 12 months.
Theft total	Binary	Indicates whether the household experienced the theft of agricultural or non-agricultural assets in the previous 12 months.
Theft of agricultural assets	Binary	Indicates whether the household experienced the theft of agricultural assets in the previous 12 months.
Theft of non-agricultural assets	Binary	Indicates whether the household experienced the theft of non-agricultural assets in the previous 12 months.
Conflict	Binary	Indicates whether the household experienced conflict or violence in the previous 12 months.
Fire	Binary	Indicates whether the household experienced fire in the previous 12 months.
Reduction in off-farm earnings	Binary	Indicates whether the household experienced a reduction in off-farm earnings in the previous 12 months.
Loss of employment	Binary	Indicates whether the household experienced the loss of employment (not due to illness or accident) in the previous 12 months.
Social expenditures	Binary	Indicates whether the household spent money on funerals and other social functions in the previous 12 months.
Spending on social expenditures	Continuous	Represents the amount spent (in Ugandan Shillings) by the household on funerals and other social functions in the previous 12 months.
Birth	Binary	Represents whether the household experienced a birth in the previous 12 months, based on whether the household reported any members between 0 and 12 months of age.
Household Characteristics		
Age	Continuous	Age of the household head.
Number of adults	Continuous	Number of adults in the household.
Education level	Continuous	Represents the maximum education level reported for the household (not necessarily that of the household head). Higher numbers represent more years of education.
Employment	Binary	An indicator of whether a member of the household had off-farm employment. Note that the survey asks whether the individual worked for payment, ran a business, or had an apprenticeship in the previous seven days, and/or had a business or job they will return to.

Variable	Type	Description
Transport	Binary	This variable indicates whether any household member had ownership or part ownership of a means of transportation, including bicycles, motorcycles, motor vehicles, boat canoes, or other transport equipment.
Total acres cultivated	Continuous	Represents the total number of acres cultivated by the household across the two growing seasons, either on land owned by the household or land that the household had access to. Note that the plot sizes were estimated by the respondent.
Livestock Owned (LSU)	Continuous	Respondents reported how many of each type of livestock they owned at the time of survey administration. These figures were then converted into Livestock Units (LSU) using conversion factors from Eurostat, and combined to generate a total number of LSU for the household.[6]
Extension services	Binary	Respondents were asked whether they had received advice or information about agricultural or livestock activities in the previous 12 months. Sources included the National Agricultural Advisory Services (NAADS) and Operation Wealth Creation, two government programs, as well as input suppliers, NGOs, cooperatives or farmers' associations, and large scale farmers.
Use of credit	Binary	Respondents were asked whether they had borrowed money or goods or received goods on credit in the previous 12 months.
Food insecurity	Binary	Households were classified as food insecure if they reported having been faced with a situation in which they did not have enough food to feed the household in the previous 12 months.

and 22.7% reported using pesticides (UBOS, 2022).

Basic descriptive statistics for each wave are provided in Table 3.2.

Table 3.2: Descriptive statistics: Household characteristics and input usage

Variable	2013-14 n=1910	2015-16 n=2122	2018-19 n=2081	2019-20 n=1971
Input Usage				
Any input[a]	0.26	0.25	0.27	0.27
Improved seed	0.16	0.16	0.14	0.15
Fertilizer	0.06	0.05	0.07	0.07
Pesticides	0.13	0.12	0.19	0.18
Household Characteristics				
Age of household head	46.77	46.65	48.31	49.32
Number of adults	2.57	2.70	3.96	2.60
Education level[b]	19.82	19.90	20.03	19.90
Employment	0.60	0.60	0.64	0.69
Transport means	0.53	0.51	0.45	0.45
Total acres cultivated	4.46	3.95	3.03	4.11
Livestock owned (LSU)[c]	1.84	1.69	1.62	1.97
Received extension	0.21	0.12	0.10	0.08
Received credit	N/A	N/A	0.49	0.48
Food insecurity	0.26	0.20	N/A	0.17

[a]Includes improved seed, fertilizer, and pesticides.
[b]Education level achieved corresponds to "Attending Secondary 1" for all four waves
[c]LSU stands for Livestock Unit
Note that seed, fertilizer, and pesticide usage are dummy variables.
Source: Author's calculations using the UNPS data.

3.4.4 Farming and Input Usage

To give a portrait of the farming practices in the sample, consider the 1,971 rural households that farmed in Season A 2019. The most commonly planted crops were maize (1,001 households), cassava (1,018 households), beans (1,039 households), matooke (a kind of plantain banana; 835 households) and sweet potato (470 households). The average total area cultivated was 2.2 acres. Given this is a nationally representative sample, and given the wide variety of farming systems across Uganda, it is challenging to say more about the farming practices in the sample, except to mention that maize is usually grown for sale to the market in addition to home consumption, while cassava, beans, matooke, and sweet potato are more commonly reserved for home consumption.

A total of 354 households purchased improved inputs of some kind for Season A 2019, or approximately 18%. This figure likely encompasses a broad range of regional variation in input usage, driven in part by proximity to market centers and the availability of local input dealers. There were higher rates of input usage reported by the respondents interviewed in Paper 3, for example, who had a local input dealer and were close to a major market center: 47% had purchased fertilizer, and 63% had purchased pesticides. Indeed, the most recent official statistics from 2019 show considerable regional variation in usage of improved inputs (UBOS, 2022).

There was substantial variation in the amount spent – the average was UGX 106,202, or approximately GBP 21.60, while the median was UGX 31,250, or approximately GBP 6.40. The breakdown of input purchases, including traditional seed, is provided in Table 3.3. The analysis in Section 3.6 specifically focuses on the combined purchase of seed or fertilizer for Season A 2019; these figures are included in Table 3.3 as well. Note that the average spent on traditional seed is lower than the amount spent on improved seed – this is logical both because improved seed is more expensive and because households purchasing traditional seed are usually less well-off and therefore unable to afford as much.

Table 3.3: Descriptive statistics: Input Purchases for Season A 2019

	Number of households	Average spending	Median spending
Total	354	UGX 106202.20	UGX 31,250.00
Improved seed	193	UGX 65,684.20	UGX 30,000.00
Fertilizer	92	UGX 155,117.40	UGX 47,500.00
Pesticide	210	UGX 50,703.55	UGX 22,500.00
Seed and fertilizer	248	UGX 108,660.7	UGX 34,250.00
Traditional seed	645	UGX 41,800.73	UGX 24,000.00

Source: Author's calculations using the UNPS data.

In terms of the types of seed purchased, the most commonly purchased improved seeds were maize (92 households), cotton (41), tomato (17), and sunflower (12). Cotton is notable as it is a commercial crop – together more than 60% of the improved seeds purchased were for crops typically grown for the market. This could have implications for the analysis in terms of the types of households that purchase improved inputs – more commercially-oriented households tend to be further from subsistence and better insulated against shocks. The most commonly purchased traditional seeds were beans (271), maize (159), groundnuts (99), and soya (80).

The prices of inputs vary depending on where in the country the market is located (and how well it is linked to Kampala, where most of the inputs originate from). In the downtown Kampala markets, the price of hybrid maize seed can range from UGX 8,000 to UGX 17,500 per kilogram, while traditional maize seed retails for around UGX 5,000 per kilogram. One acre of maize usually requires around 10 kilograms of seed, so a farmer planting one acre would spend between UGX 80,000 to UGX 175,000 on hybrid seed and UGX 50,000 on traditional varieties. Traditional bean seed retails for around UGX 10,000 per kilogram, and an acre requires 40 kilograms of bean seed, or UGX 400,000.00. Given the figures on input spending provided above, it would appear that the average farmer is not planting full acres of purchased seeds. As for agricultural chemicals, the price of fertilizer in Kampala can range from UGX 15,000 to UGX 30,000 per liter, while pesticide prices can range from UGX 30,000 to UGX 35,000 per liter. Agrochemical use is difficult to generalize, as they are applied to plants throughout the different stages of plant growth. However, as a rough estimate, pesticide application for maize is approximately 0.2-0.4 liters per acre; fertilizer is recommended at 0.5 liters per acre.

3.4.5 Incidence of Shocks

A summary of the shocks experienced by the sample is provided in Table 3.4. It is worth noting that in several cases the incidence of the shocks is very low. For example, there were only six instances of household members losing their employment across the entire sample, and only seventeen instances of households experiencing a reduction in off-farm earnings. The most commonly occurring shocks were expenditures on funerals and other social functions, and births (though the number of births reported in 2015-16 is inexplicably low).

Table 3.4: Descriptive statistics: Incidence of Shocks

Variable	2013-14 n=2,100	2015-16 n=2,183	2018-19 n=2,098	2019-20 n=1,971
Shock Aggregates				
Idiosyncratic	217	160	245	242
Covariate	778	509	697	530
Income shock	74	52	94	87
Asset shock	61	51	54	63
Individual Shocks				
Death of income earner(s)	22	13	10	9
Death of other household member(s)	48	31	31	32
Serious illness or accident of income earners(s)	51	35	75	71
Serious illness or accident of other household member(s)	35	22	58	52
Theft of agricultural assets	31	22	35	32
Theft of non-agricultural assets	24	19	14	28
Conflict	10	7	17	16
Fire	9	13	7	7
Reduction in off-farm earnings of employed household member(s)	2	2	7	6
Loss of employment of household member(s)	0	3	2	2
Funerals and other social functions	1,139	1,296	1,055	1,080
Average expenditure on funerals and other social functions (UGX)[ab]	90,376	N/A	137,401	138,752
Birth	325	21	254	231

[a]UGX stands for Ugandan Shillings

[b]Average amount spent on funerals and other social functions was calculated using the subset of households that reported an expenditure.

Source: Author's calculations using the UNPS data.

Given the shocks are self-reported, it is possible that they are unreliable – this type of data, especially when recall is involved, is ripe for inaccuracies. There are concerns with the subjectivity of self-reported responses (Andrews et al. (1976), Headey and Ecker (2013)), the potential for measurement error (Blattman et al. (2015), Brenner and DeLamater (2016), Ottaviani et al. (2024)) and overestimated effects (Krezanoski et al., 2018), possible social desirability bias (Teh et al. (2023), Contzen et al. (2015)), and possible recall bias (Bruxvoort et al., 2015). Relevant to this analysis, issues have been found with reporting on weather shocks (Nguyen and Nguyen, 2020), health issues (Butler et al. (1987), Burgard and Chen (2014)) and food insecurity (Tadesse et al., 2020).

Though there is unlikely to be any social desirability bias when it comes to reporting shocks, there is definitely a possibility for recall bias (did the shock happen within the last twelve months or earlier, for example) and room for interpretation of how the shocks are defined (what counts as a serious illness, for example). Unfortunately there is not much that can be done to correct for these possible measurement errors, and they need to be borne in mind when considering the external validity of my results.

It is also worth interrogating whether there are any patterns to the way shocks are reported; participant characteristics can be correlated with answers, generating measurement errors (Horner et al. (2002), Subramanian et al. (2010)). For example, are poorer or less educated households more likely to report shocks, given the potential for an outsize impact on households that are already struggling? Or is the opposite the case, that better educated respondents are more capable of identifying and recalling shocks? To test for the possibility that shocks are correlated with respondent characteristics, I conducted simple regressions of several demographic variables on an aggregate self-reported shock variable, *Idiosyncratic*. The results for the 2019-20 wave of data are shown in Table 3.5. As indicated in the table, I tested whether the addition of clustered standard errors and parish-level fixed effects changed the results. Further, for regressions (5) through (8), I expanded *Idiosyncratic* to include births reported spending on social functions.

As can be seen in Table 3.5, there is no significant correlation between shocks reported in 2019-20 and self-reported measures of wealth from 2018-19 (livestock owned, total acres cultivated, and ownership of transport means) for the first four specifications. Nor is there a correlation between education level and *Idiosyncratic*. I do find, however, a correlation between age of the household head and reported shocks; I hypothesized that this could be due to the fact that households with older members are more likely to experience illness, but in separate tests I found no statistically significant relationship between age and reported illness. It is difficult to explain why this relationship exists; it is possible that, with more years of experience, older household heads are better able to identify a shock as a deviation from the norm. Regardless, I do not believe that this relationship is enough to fully discount the validity of the self-reported data.

The results are slightly different when births and spending on social functions are included in *Idiosyncratic*, as seen in columns (5) through (8). There we see a that ownership of transport means and education level are significantly associated with reporting of a shock. However, if we consider that wealthier households are more likely to have made expenditures on funerals and other social functions, this is consistent with signalling a wealth effect – households with a better educated household head or with the wherewithal to afford means of transportation are also more likely to have the resources to contribute to social events. Overall, there are no strong signals suggesting that the self-reported shock data is skewed by either a wealth or education effect.

Table 3.5: Testing for relationships between shock variables and respondent characteristics (2019-20 wave)

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Livestock (LSU) (2018-19)	0.0007	0.0007	0.0025	0.0025	0.0028	0.0028	0.0046	0.0046
	(0.400)	(0.337)	(0.621)	(0.611)	(0.276)	(0.277)	(0.165)	(0.215)
Total acres cultivated (2018-19)	-0.0033	-0.0033	-0.0043	-0.0043	0.0024	0.0024	0.0014	0.0014
	(0.247)	(0.188)	(0.689)	(0.721)	(0.575)	(0.562)	(0.834)	(0.842)
Transport means (2018-19)	-0.0033	-0.0033	-0.0273	-0.0273	0.0417*	0.0417	0.0835***	0.0835***
	(0.726)	(0.720)	(0.451)	(0.452)	(0.058)	(0.102)	(0.002)	(0.008)
Age	0.0007**	0.0007**	0.0022**	0.0022*	-0.0034***	-0.0034***	-0.0043***	-0.0043***
	(0.016)	(0.022)	(0.044)	(0.074)	(0.000)	(0.000)	(0.000)	(0.000)
Age^2	0.0000**	0.000**	0.0000*	0.0000*	0.000***	0.000***	0.0000***	0.0000***
	(0.024)	(0.029)	(0.060)	(0.090)	(0.000)	(0.000)	(0.000)	(0.000)
Education level	-0.0005	-0.0005	0.0008	0.0008	0.0069***	0.0069***	0.0055***	0.0055***
	(0.350)	(0.348)	(0.719)	(0.764)	(0.000)	(0.000)	(0.000)	(0.001)
With clustered SE	No	Yes	No	Yes	No	Yes	No	Yes
With fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
With births & funerals	No	No	No	No	Yes	Yes	Yes	Yes

Coefficients reported are marginal effects at the mean.
***, **, and * represent significance at the 1%, 5%, and 10% level.
LSU stands for Livestock Unit.
Source: Author's calculations using the UNPS data.

Unfortunately, owing to the timing of survey administration, most of the shocks reported over the four waves of the panel are not relevant for the analysis. For the 2019-20 wave, for example, the two growing seasons that are included in the survey are Season B 2018 (July-December 2018) and Season A 2019 (January-June 2019). If we assume that the input purchasing decision occurred at the beginning of planting (as would be typical in Ugandan agriculture), this would be in August 2018 (for Season B 2018) and March 2019 (for Season A 2019). As such, I am interested in shocks that occurred prior to March 2019 at the latest. However, the 2019-20 wave was administered from March 2019 to February 2020, and the shock module asked respondents to recall shocks from the prior year. This would include shocks from March 2018 up to February 2020. Upon inspection of the data, a large number of the shocks that were reported occur after March 2019, and are therefore not relevant for the analysis. For example, only 82 shocks (affecting a slightly smaller number of households; some households reported multiple shocks) occurred between the planting period for Season B 2018 and the planting period for Season A 2019; only 13 shocks occurred between Season A 2018 and Season B 2018. I have included timelines for the four survey waves in the Appendix which show the discrepancy between the period covered by the survey recall window and the timing of input purchases.

Because of the issue with the timing of shocks, which leaves so few shocks implicated for any given wave, I am unable to take full advantage of the panel nature of the data. This limits my ability to reduce the influence of confounding variables on the outcome of interest, such as would be possible with household or year fixed effects. Unfortunately there is not much else that can be done to correct for the possibility of omitted variable bias, or to try to establish causality, and I acknowledge that this limits the applicability of the results. However, I have data that is rich in other respects, including the reporting of shocks, so I believe that the analysis is still appropriate.

3.5 Methodology

My hypothesis is that there is a negative relationship between (negative) idiosyncratic shocks and a farm household's decision to purchase agricultural inputs. I hypothesize that the effect of the shocks is mediated through liquidity constraints, as many of the shocks require households to incur expenses or involve the loss of assets. This means less cash is available on hand, and in an environment where credit is not always readily available, this limits the household's ability to purchase inputs. I test this hypothesis by regressing the household's input purchase decisions on the incidence of a shock in the period leading up to the purchasing decision, along with a set of controls. I consider the input purchase decision both as a binary and as a continuous variable in the amount spent.

3.5.1 Model Specification

In order to maximize the number of shocks that are implicated in the analysis and thereby make full use of the available statistical power, I use the waves of data in pairs. The first pair includes the waves from 2018-19 and 2019-20, while the second pair focuses on 2013-14 and 2015-6. The basic underlying model that is used in the analysis is shown below (1). The main dependent variable (*Inputs*) is a binary indicator of input purchase that represents whether the farmer purchased seed and/or fertilizer prior to the most recent growing season in the pairs of surveys (Season A 2019 and Season A 2015). I do not include pesticides in this measure as they are often purchased during the growing season, usually as the result of a production shock taking place. I also estimate the same regression using the natural logarithm of the amount spent on seed and fertilizer in place of the indicator of input purchase.

$$Inputs_i = \beta_1 * Idiosyncratic_i + \epsilon_i \tag{3.1}$$
$$i = 1, ..., N$$

The independent variable *Idiosyncratic* represents whether or not the household experienced an idiosyncratic shock in the period prior to the purchase decision. For each pair of waves, I use all reported shocks prior to the corresponding planting period. For example, for the 2018-19 and 2019-20 waves, I include all shocks that occurred prior to March 2019 (the planting period for Season A 2019) from both the 2019-20 wave and the 2018-19 wave. This is based on the presumption that some shocks can have lasting effects on the household's income/asset position, and therefore could continue to impact input purchasing decisions even a year later. I repeat the same analysis for Season A 2015, using shocks prior to the purchasing period from the 2015-16 wave as well as the shocks reported in the 2013-14 wave.[8]

My second set of specifications adds a few exogenous controls, as seen in Equation (2): age

[8]Because there is an extra year's gap between these waves, it is possible that the effects of shocks in 2013-14 are not felt in Season 2015A, a possibility I consider when interpreting the analysis.

of the household head, number of adults in the household, education level of the household head, and whether a covariate shock was experienced. The covariate shock variable is constructed similarly to *Idiosyncratic*, accounting for all shocks from the two waves that occurred prior to the input purchasing decision of interest. The age of the household head is included as both a proxy for access to information (older farmers are presumed to have a more established social network) and for accumulated farming knowledge (though it is also possible that older farmers are less likely to engage in new agricultural practices such as purchasing inputs). Similarly, the highest education level attained by the household is included as a proxy for access to information about inputs, including their proper application and usage. The number of adults in the household is included to represent the amount of labor available for farming. Covariate shocks include weather and production shocks such as droughts, pests, and diseases.

$$
\begin{gathered}
Inputs_i = \beta_1 * Idiosyncratic_i + \beta_2 * Age_i + \beta_3 * Adults_i \\
+\beta_4 * Education_i + \beta_5 * Covariate_i + \epsilon_i \\
i = 1, ..., N
\end{gathered} \tag{3.2}
$$

Finally, my third specification (3) adds in a few additional controls that cannot be considered strictly exogenous: off-farm employment, ownership of transport means, total acres cultivated, livestock owned, access to extension services, use of credit, and food insecurity.[9] In order to try to control for reverse causality, I use the values of these variables for the first wave in each pair (2013-14 and 2018-19), such that they are lagged by one wave. I then limit the shocks included in *Idiosyncratic* to only those that were reported in the later wave (2015-16 and 2019-20) prior to the season of interest. Unfortunately this reduces the number of shocks that are included in the analysis, but it allows for an exploration of the effect of additional controls.

[9]Note that credit usage is not available for the 2013-14 wave and is not used.

$$Inputs_i = \beta_1 * Idiosyncratic_i + \beta_2 * Age_i + \beta_3 * Adults_i + \qquad (3.3)$$
$$\beta_4 * Education_i + \beta_5 * Covariate_i + \beta_6 * Employment_i +$$
$$\beta_7 * Transport_i + \beta_8 * TotalAcres_i + \beta_9 * Livestock_i$$
$$+\beta_{10} * Extension_i + \beta_{11} * Credit_i + \beta_{12} * FoodSecurity_i + \epsilon_i$$
$$i = 1, ..., N$$

My choice of controls reflects previous literature; I have included those variables that have previously been found to influence household purchases of inputs. Whether someone in the household had off-farm employment in the previous year, for example, is a potential source of financing for inputs. Owning a method of transportation represents both the household's level of wealth and the household's ease of accessing an input dealer. The number of livestock owned by the household (normalized in Tropical Livestock Units) is included as a proxy for the household's wealth, while access to extension services in the previous year serves as a proxy for access to information about inputs. The number of acres cultivated is yet another proxy for wealth, as is whether the household was food insecure.

3.5.2 Analytical Approach

Using *Inputs* as the dependent variable, I estimate Equations (1)-(3) above using a standard probit model with standard errors clustered at the sub-county level. As mentioned above, only rural households were included in the analysis. I also repeat each estimation using parish-level fixed effects, which soaks up a large set of time-invariant geographic variables that might affect input purchasing decisions, such as agro-ecological zone, distance to major markets, and malaria incidence.[10] I then repeat the analysis using the amount spent on inputs as a dependent variable. In this case, Equations (1)-(3) are estimated using a linear probability model with standard errors clustered at the sub-county level, and the analysis is repeated to include fixed effects.

For each specification, I first include *Idiosyncratic* as the regressor of interest, which is a

[10]Note that when fixed effects are included in the probit estimations, at least half of the sample is dropped. This is reported in the results tables. This is due to the fact that a) a number of parishes only contained one household and b) given the low incidence of shocks and the low number of households purchasing inputs, there were many parishes where there was no within-group variation for these variables. This is unfortunate, but there were still enough observations included so the fixed-effects specifications were reported.

dummy indicating whether the household experienced any of the set of idiosyncratic shocks in the period prior to the input purchase decision. I then replace *Idiosyncratic* with the other composite shock variables *Income shock* and *Asset shock* as defined in Section 3.4.5. Finally, I cycle through the full list of shocks that are available in the dataset, using each as an independent variable in place of *Idiosyncratic*.[11] This allows me to see whether the pattern of incidence of any specific shock is driving the results generated using the composite variables.

3.6 Analysis

3.6.1 Input purchases

The first set of results are displayed in Table 3.6. As described above, the dependent variable, *Inputs*, represents whether the household purchased seed or fertilizer prior to Season A 2019. The independent variable of interest, *Idiosyncratic*, includes all shocks from the 2018-19 wave as well as shocks from 2019-20 that occurred prior to the purchasing decision. Columns (1) and (2) show the results for the basic regression outlined in Equation (1) above: using *Idiosyncratic* as the only regressor. *Idiosyncratic* is not statistically significant in either specification, with or without fixed effects.[12] Columns (3) and (4) add in the exogenous controls for Equation (2) above – again *Idiosyncratic* is not statistically significant for either specification. We see that age of the household head is significant at the 1% level for both; as suggested above this is potentially a proxy for access to information and accumulated farming knowledge. However, the coefficient on age is negative, implying that younger farmers are more likely to purchase inputs; there is another interpretation of the role of age that suggests that older farmers are less likely to adopt new farming practices, which could be the case here. Number of adults is significant at the 5% level when fixed effects are added, while education level and experiencing a covariate shock are significant without fixed effects. Again, as discussed above, more adults could represent more labor available for farming, which could translate to greater income from farming and thus a larger budget to spend on inputs; if some of the adults have off-farm income, this could also contribute to the budget. Having more labor available for farming also makes it easier for the household to engage in more labor-intensive tasks such as applying fertilizer. The education level of the household head is a proxy for access to information about inputs and ability to interpret and accurately apply said information.

[11]Note that spending on social functions is not available for 2015-16, and is not used.
[12]Note that the number of households is reduced when fixed effects are added – in this case from 1,971 to 844.

Perhaps the most surprising result is that the coefficient on *Covariate* is positive, with coefficients ranging from 0.03 to 0.09, implying that there is a positive relationship between experiencing a covariate shock and purchasing inputs. This is counterintuitive, as we would expect a covariate shock to have a negative impact on the household's income and thus its ability to purchase inputs. However, if the household has enough resources, perhaps experiencing a shock to production in the prior seasons is impetus to invest more heavily in production for Season A 2019 in order to recover lost income.

Finally, columns (5) and (6) display the results of the regression described in Equation (3) above: limiting the shocks included to only those experienced in the 2019-20 wave prior to purchase, and then adding non-exogenous controls from the 2018-19 wave. As can be seen in the table, age, number of adults, education level, and covariate shock are once again significant. Off-farm employment, a potential source of funds for inputs, was significant in the specification without fixed effects, though with a positive coefficient, which could represent a substitution effect between on-farm and off-farm income. Ownership of transport means, often essential for accessing inputs, was statistically significant for both specifications. So was the total number of acres cultivated, a proxy for the wealth of the household, though interestingly livestock ownership, another proxy, was not. Neither access to extension services nor use of credit was statistically significant, which is surprising, as extension services are an important source of information and encouragement for input usage and access to credit is widely cited as a key enabler of input purchases.

Though not reported here, I replicated this analysis by separating out seed, fertilizer, and pesticide purchases, and using each as the dependent variable in the regressions reported in columns (1) to (6). For seed and fertilizer, *Idiosyncratic* was not statistically significant in any of the specifications. However, for pesticide purchases, it was significant for all six regressions, with significance ranging from the 1% to 10% levels, and with positive coefficients in all cases. At first glance, this seems peculiar, as it suggests a positive relationship between (negative) idiosyncratic shocks and pesticide purchases. However, as we will see below, this relationship appears driven by a particular type of shock.

I further replicated the analysis in Table 3.6 for the 2013-14 and 2015-16 waves, which can be found in the Appendix in Table 3.14. For these regressions, the dependent variable was

Table 3.6: Probit regressions with ex-ante input purchases of seed and fertilizer in Season A 2019 as dependent variable

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Idiosyncratic shock	0.0021	-0.0261	0.0098	-0.0120	-0.0177	0.0241
	(0.925)	(0.603)	(0.667)	(0.812)	(0.640)	(0.784)
Age			-0.0014***	-0.0042***	-0.0015***	-0.0043***
			(0.004)	(0.000)	(0.002)	(0.001)
Number of adults			0.0087	0.0318**	0.0068	0.0284**
			(0.203)	(0.018)	(0.339)	(0.045)
Education level			0.0024**	0.0019	0.0020**	0.0009
			(0.014)	(0.394)	(0.040)	(0.712)
Covariate shock			0.0344**	0.0520	0.0547***	0.0917**
			(0.050)	(0.135)	(0.005)	(0.031)
Employment (2018-19)					-0.0406***	-0.0320
					(0.007)	(0.380)
Transport (2018-19)					0.0328*	0.0818**
					(0.057)	(0.028)
Total acres cultivated (2018-19)					0.0054*	0.0152*
					(0.078)	(0.087)
Livestock owned (LSU) (2018-19)					0.0008	0.0008
					(0.598)	(0.812)
Extension services (2018-19)					0.0205	0.0371
					(0.347)	(0.461)
Use of credit (2018-19)					-0.0060	-0.0234
					(0.676)	(0.499)
With fixed effects	No	Yes	No	Yes	No	Yes
Summary Statistics						
Log-likelihood Ratio	-745.76	-420.92	-732.24	-406.51	-720.39	-397.46
N[a]	1,971	844	1,971	844	1,971	844

Coefficients reported in columns (1), (3), and (5) are marginal effects at the mean; coefficients in (2), (4), and (6) are average marginal effects.
***, **, and * represent significance at the 1%, 5%, and 10% level.
LSU stands for Livestock Unit.
[a] Note: The sample is reduced when fixed effects are added.
Source: Author's calculations using the UNPS data for 2018-19 and 2019-20.

whether seed or fertilizer was purchased prior to Season A 2015. Once again, *Idiosyncratic* is not statistically significant for any of the specifications. Age is significant for all four regressions in which it is included, once again with a negative coefficient; education level is significant for three of the specifications, with a positive coefficient. Experiencing a covariate shock was not significant at all. Total acres cultivated in 2013-14 was significant for both specifications in which it was included, with a positive coefficient, as was access to extension services in 2013-14. Overall, the results for both Season A 2019 and Season A 2015 suggest that there was no impact of idiosyncratic shocks on seed and fertilizer purchases.

I expanded the analysis in Table 3.6 by breaking down *Idiosyncratic* into its component parts, to see if any of the shocks were individually significant. As with *Idiosyncratic*, these variables include all shocks of the particular type that were experienced either in the 2018-19 wave or in the 2019-20 wave prior to the input purchasing decision. I further tested three independent variables that do not form a part of *Idiosyncratic*: whether or not the household engaged in spending on funerals and other social functions, how much was spent on funerals and other social functions, and whether the household experienced a birth. I test these separately for the 2018-19 wave and the 2019-20 wave. The results can be seen in Table 3.7. I replicated the regressions in Table 3.6, but swapped out *Idiosyncratic* for each of the individual shocks in turn. Columns (1) to (6) in Table 3.7 represent the same regressions described above.

Neither of my other two aggregate variables, *Income shock* or *Asset shock*, was statistically significant for any of the specifications. In fact, the only component of *Idiosyncratic* that is statistically significant in any of the specifications is conflict, which is significant for the first three specifications – but with an unexpected positive coefficient. As mentioned above, it is not entirely clear from the data documentation how conflict is defined, nor how it was interpreted by the respondents; it also was reported very rarely. The other significant results in Table 3.7 come from the variables on social expenditures and births. For example, having engaged in social expenditures in 2018-19 was statistically significant for three of the specifications, though the significance disappears when fixed effects are added. Spending on social functions in 2018-19 was significant for the first two specifications, but dropped out once additional controls were added. For 2019-20, having spent on funerals and other social functions was statistically significant across all six specifications at the 1% level, and spending level was also significant for all six of the specifications at the 1% level. Interestingly, the coefficients on all of these variables were positive – households that engaged in spending on social functions were more likely to buy seed and fertilizer, and the more they spent on these functions the more likely they were to purchase inputs. I would hypothesize that this is picking up a wealth effect – wealthier households are more likely to have the means to contribute to social functions. However, the coefficients are only moderate for spending, ranging from 0.05 to 0.14, and very small for the amount spent, between less than 0.01 and 0.01. Finally, experiencing a birth in the 2019-20 wave was a statistically significant predictor of input purchase in two of the specifications, with a negative coefficient; this would support the theory described in the literature that a birth represents both a labor shock and an expenditure shock to the household, both of which could plausibly affect the household's willingness and ability to invest in production the following season.

Once again, I repeated this analysis for each of the input types separately. For both seed purchase and fertilizer purchase, when used as the dependent variable, the same general pattern of significance emerges – *Idiosyncratic* as a whole does not appear to be significant, either positive or negative. However, conflict, spending on funerals and other social functions, and the amount spent on social functions (for both 2018-19 and 2019-20) were significant across many of the specifications, all with positive coefficients. The main differences arose when pesticide purchase was used as the dependent variable. In that case, *Idiosyncratic* was statistically significant across all six specifications, with a positive coefficient. In all six specifications, this relationship was accompanied by significant and positive coefficients on theft of agricultural assets and death of an income earner. One could imagine that after either of these shocks the household would be interested in boosting production by using pesticides, though it is also curious that the association is positive, given we would expect these shocks to reduce the purchasing power of the household. There was also a similar pattern of significance for social expenditures and amount spent for both 2018-19 and 2019-20, again with positive coefficients – the amount spent on spending and other social functions was statistically significant with a positive coefficient for all of the specifications. Birth is significant with a positive coefficient for one specification and a negative coefficient for another. Total illness also appears as significant once, with a positive coefficient. It would appear from these results that pesticide purchases are more sensitive to shocks than spending on seed and fertilizer.

I also replicated the analysis in Table 3.7 for the 2013-14 and 2015-16 waves, once again

Table 3.7: Probit regressions with ex-ante input purchases of seed and fertilizer in Season A 2019 as dependent variable, with breakdown of *Idiosyncratic*

Primary Regressor	(1)	(2)	(3)	(4)	(5)	(6)
Aggregate variables						
Idiosyncratic	0.0021	-0.0261	0.0098	-0.0120	-0.0177	0.0241
	(0.925)	(0.603)	(0.667)	(0.812)	(0.640)	(0.784)
Income shock	-0.0174	-0.0615	0.0010	-0.0140	-0.0324	0.0491
	(0.582)	(0.389)	(0.975)	(0.852)	(0.545)	(0.710)
Asset shock	-0.0079	-0.0435	-0.0120	-0.0495	0.0434	-0.0004
	(0.844)	(0.538)	(0.758)	(0.495)	(0.449)	(0.997)
Individual shocks						
Death total	-0.0333	-0.0944	-0.0243	-0.0598	-0.0742	0.0666
	(0.484)	(0.361)	(0.597)	(0.530)	(0.443)	(0.726)
Death of income earner	N/A	N/A	N/A	N/A	N/A	N/A
Death of other	0.0058	-0.0228	0.0122	0.0156	-0.0294	0.1212
household member	(0.908)	(0.846)	(0.798)	(0.885)	(0.777)	(0.570)
Illness total	-0.0125	-0.0442	-0.0020	-0.0078	-0.0554	0.1350
	(0.642)	(0.495)	(0.941)	(0.909)	(0.285)	(0.832)
Illness of income earner	-0.0009	-0.0187	0.0178	0.0383	-0.0110	0.0825
	(0.980)	(0.811)	(0.601)	(0.642)	(0.843)	(0.558)
Illness of other	-0.0235	-0.0828	-0.0265	-0.0844	N/A	N/A
household member	(0.5888)	(0.426)	(0.537)	(0.422)		
Theft total	-0.0048	-0.0487	-0.0101	-0.0575	0.0252	-0.0520
	(0.909)	(0.503)	(0.804)	(0.437)	(0.694)	(0.681)
Theft of agricultural assets	0.0283	0.0039	0.0236	0.0023	0.0945	0.0292
	(0.552)	(0.961)	(0.610)	(0.979)	(0.191)	(0.837)
Theft of non-agricultural	-0.0494	-0.0622	-0.0472	-0.0714	-0.0032	0.0006
assets	(0.525)	(0.670)	(0.539)	(0.626)	(0.977)	(0.998)
Conflict	0.1215**	0.3278*	0.1239**	0.3170	0.1422	0.4093
	(0.034)	(0.093)	(0.029)	(0.112)	(0.154)	(0.110)
Fire	-0.0492	-0.0961	-0.0441	-0.0821	0.0983	0.1504
	(0.649)	(0.618)	(0.684)	(0.666)	(0.424)	(0.443)
Reduction in off-farm	0.0371	N/A	0.0457	N/A	N/A	N/A
earnings	(0.769)		(0.735)			
Loss of employment	N/A	N/A	N/A	N/A	N/A	N/A
Social expenditures	0.0402***	0.0307	0.0345**	0.0218	0.0331**	0.0266
(2018-19)	(0.007)	(0.352)	(0.020)	(0.506)	(0.023)	(0.411)
Spending on social	0.0042***	0.0037	0.0035***	0.0028	0.0033**	0.0031
expenditures (2018-19)	(0.002)	(0.231)	(0.010)	(0.385)	(0.014)	(0.318)
Birth (2018-19)	0.0072	0.0623	-0.0069	0.0181	-0.0087	0.00163
	(0.745)	(0.210)	(0.760)	(0.715)	(0.697)	(0.741)
Social expenditures	0.0584***	0.1414***	0.0484***	0.1204***	0.0466***	0.1108***
	(0.001)	(0.000)	(0.004)	(0.001)	(0.005)	(0.002)
Spending on social	0.0056***	0.0142***	0.0045***	0.0121***	0.0044***	0.0112***
expenditures	(0.000)	(0.000)	(0.003)	(0.000)	(0.004)	(0.001)
Birth	-0.0435	-0.0281	-0.0576**	-0.0808	-0.0561**	-0.0833
	(0.102)	(0.628)	(0.031)	(0.156)	(0.038)	(0.168)
N[a]	1,971	844	1,971	844	1,971	844

Each row represents six regressions, for which the “Primary Regressor” is the main independent variable of interest.
Specification (1) uses this as the only regressor; (2) adds fixed effects.
Specification (3) includes exogenous controls; (4) adds fixed effects.
Specification (5) includes exogenous and lagged endogenous controls; (6) adds fixed effects.
Coefficients reported in columns (1), (3), and (5) are marginal effects at the mean.
Coefficients in (2), (4), and (6) are average marginal effects.
***, **, and * represent significance at the 1%, 5%, and 10% level.
[a] Note: The sample is reduced when fixed effects are added.
Source: Author’s calculations using the UNPS data for 2018-19 and 2019-20.

available in the Appendix in Table 3.15. Illness of an ‘other household member’ was significant for two specifications with a positive coefficient; theft of agricultural assets was significant for three specifications with negative coefficients. Conflict and fire were each significant for one specification with positive coefficients. Once again, spending on social functions and the amount spent were significant across multiple specifications with positive coefficients, although the amount on social expenditures is not available for the 2015-16 wave. A birth in 2015-16 was also statistically significant with a positive coefficient across all six specifications; this is a counterintuitive result.

3.6.2 Input spending

The next set of results arises from a set of specifications that replace the binary dependent variable with a continuous variable that represents the amount spent on seed and fertilizer in Season A 2019. The same set of six regressions are reported, except ordinary least squares is used in place of a probit regression. The results are shown in Table 3.8. In this case, *Idiosyncratic* is not statistically significant for any of the specifications. Age is once again significant with a negative coefficient for all four specifications where it is included, while number of adults is significant with a positive coefficient when fixed effects are added. Education level is positively associated with input spending for Columns (3) and (5), but the significance disappears when fixed effects are added. A covariate shock is associated with increased spending for Column (5), though again the effect disappears when fixed effects are added. Of the non-exogenous controls, loss of employment is statistically significant with a negative coefficient, though again the effect is erased when fixed effects are added, and ownership of transport means is positively associated with greater input spending in both specifications where it is included.

I once again supplemented this analysis by examining the impact of *Idiosyncratic* on spending on each type of input separately. *Idiosyncratic* was not statistically significant for any of the specifications for either seed spending or fertilizer spending. Pesticide spending yielded significant, positive coefficients for *Idiosyncratic* for four of the specifications.

I also repeated the analysis on input spending for the 2013-14 and 2015-16 waves, reported in Table 3.16 in the Appendix. Once again, *Idiosyncratic* was not statistically significant for any of the specifications. Age was statistically significant for all four specifications where it was

Table 3.8: OLS regressions with ex-ante input spending on seed and fertilizer in Season A 2019 as dependent variable

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Idiosyncratic shock	-0.0064	-0.1546	0.0582	-0.0636	-0.2230	-0.0650
	(0.979)	(0.621)	(0.813)	(0.840)	(0.471)	(0.895)
Age			-0.0135***	-0.0227***	-0.0150***	-0.0228***
			(0.002)	(0.001)	(0.001)	(0.001)
Number of adults			0.0957	0.1597*	0.0757	0.1471*
			(0.216)	(0.055)	(0.351)	(0.092)
Education level			0.0273***	0.0158	0.0233**	0.0085
			(0.008)	(0.236)	(0.028)	(0.537)
Covariate shock			0.2991	0.3164	0.5812**	0.5135
			(0.111)	(0.117)	(0.022)	(0.106)
Employment (2018-19)					-0.4606***	-0.2132
					(0.006)	(0.344)
Transport (2018-19)					0.3458*	0.4445**
					(0.068)	(0.050)
Total acres cultivated (2018-19)					0.0834	0.0882
					(0.135)	(0.144)
Livestock owned (LSU) (2018-19)					0.0102	0.0019
					(0.615)	(0.943)
Extension services (2018-19)					0.3509	0.4705
					(0.220)	(0.203)
Use of credit (2018-19)					-0.0521	-0.1067
					(0.730)	(0.608)
With fixed effects	No	Yes	No	Yes	No	Yes
Summary Statistics						
R-squared	0.0000	0.3725	0.0141	0.3854	0.0283	0.3932
N	1,971	1,971	1,971	1,971	1,971	1,971

***, **, and * represent significance at the 1%, 5%, and 10% level.
LSU stands for Livestock Unit.
Source: Author's calculations using the UNPS data for 2018-19 and 2019-20.

included, again with a negative coefficient. Education was significant with a positive coefficient in Columns (3) and (5), but the significance disappears when fixed effects are added. The only other significant variables were total acres cultivated, with positive coefficients, and access to extension services, again with positive coefficients.

As above, I then proceeded to analyze the impact of each of the individual shocks in turn, to see if any were significant on their own. The results are shown in Table 3.9. Death of an income earner is statistically significant with a negative coefficient for the first five specifications, with coefficients ranging from -1.11 to -1.32. This is a large effect size. Illness of an other household member was significant with a negative coefficient for Columns (5) and (6). Both reduction in off-farm earnings and loss of off-farm employment were statistically significant with negative coefficients for several specifications. A birth in the 2019-20 wave was significant with a negative coefficient for three specifications. Spending on social functions is consistently significant with a positive coefficient for the 2019-20 wave, and was significant for the 2018-19 wave as well, though the significance disappears when fixed effects are added. There appear to be several shocks that have a negative impact on the amount spent, even if they didn't impact the purchasing decision. And the apparent wealth effect of spending on funerals and other social functions persists – it would seem that households with more resources to spend on social functions are also better positioned to spend more on inputs.

Next I considered spending on the input types individually. There were a few patterns of significance. For seed spending, for example, death of an income earner was statistically significant for a negative coefficient for five specifications, with coefficients ranging from -0.65 to -1.01, while both reduction in off-farm earnings and loss of employment were statistically significant with negative coefficients for three specifications each. The binary indicator of spending on funerals and other social functions for 2019-20 (as well as the amount spent) was consistently significant across all six specifications, with larger coefficients than above (ranging from 0.33 to 0.54 for spending and from 0.04 to 0.05 for amount spent), while this spending for 2018-19 was significant and positive for three. For fertilizer spending, once again the death of an income earner was statistically significant with a negative coefficient for five specifications, as was the death of another household member. Furthermore, illness of another household member, fire, reduction in off-farm earnings, loss of employment, and a birth in the 2019-20 wave were sig-

Table 3.9: OLS regressions with ex-ante input spending on seed and fertilizer in Season A 2019 as dependent variable, with breakdown of *Idiosyncratic*

Primary Regressor	(1)	(2)	(3)	(4)	(5)	(6)
Aggregate variables						
Idiosyncratic	-0.0064	-0.1546	0.0582	-0.0636	-0.2230	-0.0650
	(0.979)	(0.621)	(0.813)	(0.840)	(0.471)	(0.895)
Income shock	-0.2013	-0.3543	-0.0461	-0.1678	-0.3134	-0.0771
	(0.499)	(0.391)	(0.880)	(0.693)	(0.489)	(0.910)
Asset shock	-0.1005	-0.1570	-0.1349	-0.1236	0.3587	0.1245
	(0.302)	(0.746)	(0.736)	(0.799)	(0.548)	(0.883)
Individual shocks						
Death total	-0.4005	-0.5530	-0.3534	-0.4432	-0.6763	-0.0688
	(0.302)	(0.349)	(0.354)	(0.440)	(0.153)	(0.939)
Death of income earner	-1.3225***	-1.1805**	-1.1732***	-1.1147**	-1.2716***	-0.3794
	(0.000)	(0.015)	(0.000)	(0.020)	(0.000)	(0.155)
Death of other	-0.0511	-0.2084	-0.0319	-0.0762	-0.3957	0.1089
household member	(0.919)	(0.797)	(0.948)	(0.923)	(0.554)	(0.938)
Illness total	-0.1288	-0.2964	-0.0421	-0.1648	-0.4989	-0.4927
	(0.631)	(0.432)	(0.877)	(0.669)	(0.195)	(0.458)
Illness of income earner	-0.0217	-0.1554	0.1452	0.0753	-0.1119	0.0343
	(0.951)	(0.756)	(0.683)	(0.883)	(0.832)	(0.966)
Illness of other	-0.2257	-0.4729	-0.2596	-0.5155	-1.3536***	-1.8288**
household member	(0.579)	(0.401)	(0.522)	(0.364)	(0.000)	(0.012)
Theft total	-0.0538	-0.1711	-0.0910	-0.1553	0.1899	-0.2180
	(0.902)	(0.730)	(0.834)	(0.754)	(0.758)	(0.807)
Theft of agricultural assets	0.2359	0.0518	0.2043	0.0807	1.0233	0.2841
	(0.670)	(0.926)	(0.711)	(0.89)	(0.272)	(0.825)
Theft of non-agricultural	-0.3352	-0.2130	-0.3338	-0.1770	-0.1900	-0.0245
assets	(0.629)	(0.838)	(0.629)	(0.863)	(0.839)	(0.987)
Conflict	1.5062	1.3987	1.5331	1.3638	1.6549	2.3131
	(0.106)	(0.252)	(0.100)	(0.274)	(0.306)	(0.371)
Fire	-0.5482	-0.5958	-0.5622	-0.4672	0.9241	0.9917
	(0.461)	(0.601)	(0.463)	(0.691)	(0.556)	(0.585)
Reduction in off-farm	0.1074	-0.6982*	0.0674	-1.1063**	-2.3703***	-2.3182***
earnings	(0.934)	(0.085)	(0.963)	(0.013)	(0.000)	(0.000)
Loss of employment	-1.3144***	-0.5997	-1.3123***	-0.5678	-1.2089***	-0.1470
	(0.000)	(0.301)	(0.000)	(0.367)	(0.000)	(0.704)
Social expenditures (2018-19)	0.4367***	0.1786	0.3800**	0.1419	0.3711**	0.1327
	(0.009)	(0.392)	(0.022)	(0.491)	(0.026)	(0.518)
Spending on social	0.0466***	0.0227	0.0395**	0.0179	0.0380**	0.0164
expenditures (2018-19)	(0.004)	(0.268)	(0.012)	(0.378)	(0.016)	(0.417)
Birth (2018-19)	0.0323	0.3070	-0.1431	0.0515	-0.1675	0.0220
	(0.892)	(0.311)	(0.563)	(0.867)	(0.490)	(0.942)
Social expenditures	0.6551***	0.7227***	0.5413***	0.6043***	.5198***	0.5627***
	(0.000)	(0.001)	(0.004)	(0.006)	(0.005)	(0.010)
Spending on social	0.0639***	0.0760***	0.0521***	0.0643***	0.0506***	0.0602***
expenditures	(0.000)	(0.000)	(0.002)	(0.002)	(0.003)	(0.004)
Birth	-0.4265*	-0.0905	-0.5977***	-0.3460	-0.5940**	-0.3447
	(0.055)	(0.756)	(0.010)	(0.239)	(0.014)	(0.255)
N	1,971	1,971	1,971	1,971	1,971	1,971

Each row represents six regressions, for which the "Primary Regressor" is the main independent variable of interest.
Specification (1) uses this as the only regressor; (2) adds fixed effects.
Specification (3) includes exogenous controls; (4) adds fixed effects.
Specification (5) includes exogenous and lagged endogenous controls; (6) adds fixed effects.
***, **, and * represent significance at the 1%, 5%, and 10% level.
Source: Author's calculations using the UNPS data.

nificant with negative coefficients for three specifications, though this significance disappears when fixed effects are added (except in one case for reduction in off-farm earnings). Once again, spending on social functions is significant with a positive coefficient for all six specifications. When it comes to pesticides, *Idiosyncratic* was statistically significant with a positive coefficient in several cases; this seems to be driven by a positive coefficient on theft of agricultural assets, which is associated with higher input spending. Reduction in off-farm earnings is statistically significant with a negative coefficient for all six specifications, and a few other shocks are significant with negative coefficients for two or three specifications, such as loss of off-farm employment. Spending on social functions is statistically significant with positive coefficients for four of the specifications.

Finally, I repeated the spending analysis for 2013-14 and 2015-16, which is reported in Table 3.17 in the Appendix. Death of an income earner is significant with a negative coefficient for the first five specifications, with coefficients ranging from -0.70 to -1.04, while death of an other household member is significant for the final two. Theft of agricultural assets is negatively associated with input spending for the first four specifications, while theft of non-agricultural assets is significant with a negative coefficient for the final two. Reduction in off-farm earnings is significant for three specifications, with very large coefficients (two of them positive and one negative), while loss of employment is significant and negative for four specifications. Spending on social functions and the amount spent in 2013-14 is once again significant with positive coefficients for the first five specifications, with coefficients ranging from 0.29 to 0.45 for spending and 0.03 to 0.05 for amount spent. Interestingly, a birth in the 2015-16 wave is significant with a positive coefficient for all six specifications.

Overall, it would appear that although *Idiosyncratic* is not a significant predictor of input spending, several of the individual shocks are significant with negative coefficients, some of them quite large – a result that is consistent across the different input types and across the two waves. This suggests there is some effect of shocks at the intensive margin, if not at the extensive margin – the households that intended to purchase inputs appear to be continuing to do so, but are purchasing reduced quantities. We will see this result echoed in Paper 3.

3.6.3 Traditional Seeds

Out of interest, I also analyzed the impact of the idiosyncratic shocks on traditional seed purchases. Traditional seeds, as opposed to hybrid or improved seeds, are typically open-pollinated varieties that are a more affordable option for farmers. Many farmers save and reuse seeds from the previous season, but some choose to purchase traditional seeds for planting. More farmers opted to purchase traditional seeds than improved seeds – 647 farmers for Season A 2019. This gives the analysis slightly more power. It is worth considering these farmers because it is possible that they are more sensitive to shocks – as seen above, the improved seeds that were purchased tended to be for commercial crops, and we could expect farmers with a more commercial orientation to have higher incomes that insulate them from the impact of shocks.

I repeated the analysis above for traditional seed purchases in Season A 2019. *Idiosyncratic* was statistically significant with a positive coefficient for specification (3), which includes exogenous controls but no fixed effects; the significance disappeared when fixed effects were added. It was also statistically significant at the 10% level with a negative coefficient for specification (6), which includes non-exogenous controls from 2018 and fixed effects. However, none of the individual shocks was statistically significant for this specification, save for births in 2018, which is not included in *Idiosyncratic*. Incidentally, a birth in 2018 was a statistically significant predictor of traditional seed purchase for five of the specifications, with a positive coefficient in each case (a birth in 2019 was also significant with a positive coefficient for the first two specifications). It could be that the households chose to invest more heavily in farming as a result of the expenses incurred from bringing in a new family member. Several other variables were statistically significant, including notably thefts, with a puzzling positive coefficient, but the significance disappeared when fixed effects were added. Overall, the results for traditional seeds do not differ markedly than those for improved seeds and other inputs – there does not appear to be a strong impact of idiosyncratic shocks on the input purchasing decision.

I also repeated the analysis on the amount spent on traditional seeds. In this case, *Idiosyncratic* was statistically significant with a positive coefficient for the fourth specification. This seems to be driven by positive, significant coefficients on theft of both agricultural and non-agricultural assets; theft of agricultural assets was statistically significant for two of the specifications, theft of non-agricultural assets for three. Experiencing a birth in the 2018-19 wave was statistically significant with a positive coefficient for three specifications, while a birth in the 2019-20 wave was significant and positive for one. Loss of off-farm employment was significant with negative coefficients for the final two specifications, while a reduction in off-farm earnings was significant for both but with mixed coefficients. There was no detectable impact of spending on funerals and other social functions; if true that this is picking up a wealth effect, this would make sense, as in general the farmers purchasing traditional seeds are poorer

Despite the possibility that purchases of traditional seeds were more sensitive to shocks than purchases of improved seed and other inputs, this does not appear to be the case. Rather, the results are broadly similar to the results found above. This is an interesting result, as it would seem that there is not a strong wealth effect in households' responses to shocks – households with more resources do not appear better insulated to shocks. This suggests something else is enabling households to respond to shocks, which is discussed in the following section.

3.7 Discussion

Overall, the results suggest almost no impact of idiosyncratic shocks on the decision to purchase inputs. The results for input spending indicate a limited effect of shocks, with a few turning up as consistently significant in the direction we would expect (experiencing the death of an income earner or reduction in off-farm earnings having a negative impact on spending, for example). The fact that more shocks ended up as having a statistically significant impact on input spending suggests that the input purchase decision is relatively immune to shocks, while there is more responsiveness in the amount spent. A similar pattern emerged in the interviews captured for Paper 3: there was seemingly no impact at the extensive margin (all households reported purchasing inputs of some kind) but almost every respondent said they had purchased fewer inputs as a result of the shocks they experienced.

Writ large, the analysis does not strongly bear out the predictions of the theory outlined in Section 3.3, which suggests that the idiosyncratic shocks experienced by a household will have a negative effect on immediate liquidity and therefore a negative effect on input purchasing. How might one interpret these results? One possibility is that the data is simply too noisy to draw any firm conclusions. Indeed, many of the shocks only impacted a few households in the sample, making it difficult to assess their impact on input purchases with any real power. It is possible that, given the improved seeds are in the majority purchased for more commercially-oriented crops, the results are picking up a wealth effect for commercially-oriented households.

It is also possible that the results, while not overwhelmingly confirming the theory that idiosyncratic shocks impact input purchases, have nevertheless revealed some truths about how households respond to shocks. One explanation is that the households that purchase inputs are wealthy enough to absorb shocks and still purchase inputs the following season. It is also possible that households have anticipated that a shock will occur in any given year, and have budgeted appropriately. This seems unlikely, given how many households in the sample are cultivating at subsistence levels, but it is theoretically plausible.

Another explanation is that the households' recovery following a shock was facilitated by support from their communities. There is a well-established literature showing that households rely on family, friends, and kinship networks for risk-sharing and support, as discussed in Grimard (1997), Cox and Fafchamps (2007), Fafchamps (2011), and for Uganda in particular in Takahashi (2016). Fafchamps and Lund (2003) analyze data from the Philippines and find that gifts and informal loans are very common among the surveyed households. Woldemichael and Gurmu (2018) find that family networks in rural Ethiopia respond to long-term health shocks. De Weerdt and Fafchamps (2011) find further evidence of transfers in the wake of health shocks in Tanzania.

By definition, the idiosyncratic shocks considered here only impact a single household, which means that other community members have not been affected and are in a position to provide assistance (unlike with covariate shocks, such as drought, which impact all members of a community). Indeed, the fact that so many households in the sample reported expenditures on funerals and other social functions reflects the fact that these households are frequently called upon to support members of their community. This mutual support also suggests that there is a dimension of social capital involved in the support that households receive from their family and neighbors. There is mixed evidence on the role of social capital when it comes to responding to shocks. Gertler (2006) find limited evidence that Indonesian households can rely on social capital to insure consumption in the face of health shocks, while there is more recent evidence that social capital supports consumption smoothing after idiosyncratic shocks (Wossen et al., 2016).

3.7.1 Coping Strategies

Fortunately, the survey module on shocks included questions about coping strategies, which provides some insight into how the households responded to the shocks that they experienced. If a household experienced a shock, the respondent was asked to provide the top three coping strategies they deployed, in rank order, from a list provided in the questionnaire. As can be seen in Table 3.10 below, this list included assistance from relatives/friends or from the government, changes to dietary or spending patterns, seeking additional income, and using credit or savings.

Note that these questions were not asked of households that experienced births or that reported spending on funerals or other social functions; these shocks are therefore not included in the following analysis.

Table 3.10 provides a summary of the coping strategies that were used by rural households who reported experiencing idiosyncratic shocks.[13] The most popular coping strategy, used to respond to 23.8% of shocks across the four waves, was unconditional help from relatives/friends. This tracks with the common view that households rely on their communities to cope in the face of hardships – particularly for idiosyncratic shocks, which have only impacted the individual household and not the community as a whole, making it more likely that the community is in a position to provide support (as opposed to the case of covariate shocks which impact the whole community and thus may limit the available external support). Interestingly, the second most common coping strategy was to do nothing, which was reported for 20.5% of the shocks. This could reflect two separate phenomena. First, it is possible that the household had no recourse to any of the coping strategies in the list – an explanation that seems unlikely, but is theoretically possible. Second, it is possible that the household was able to simply absorb the shock with its current resources, without having to rely on savings or external support. This would contradict the view that subsistence households are living hand-to-mouth with limited resources, and would suggest that these households are more resilient than indicated by common perception. The third most popular coping strategy was relying on savings (19.4%), which again suggests that the households in the sample had more resources at their disposal than might be commonly expected or modeled in the literature.

As can be seen in Paper 3, there was some discrepancy between the coping strategies reported here and those reported in my fieldwork. My interview respondents listed selling produce, off-farm income, and selling livestock as their top three coping strategies after "doing nothing" (which was largely the response to a drought). Selling produce or otherwise relying on income from the farm was not offered as an option in the UNPS module; I would argue that this should have been included, as some households may have the wherewithal to cope with a shock using only their farming income. It is possible that this was classed as "relying on savings," as some

[13]Note that some households experienced multiple shocks, and these figures include the coping strategies that were deployed across all of the shocks that were experienced.

Table 3.10: Coping Strategies Employed by Rural Households Facing Idiosyncratic Shocks, as Percentages

Coping Strategy	2013-14	2015-16	2018-19	2019-20	Total
Unconditional help provided by relatives/friends	23.6	22.1	24.3	25.1	23.8
Unconditional help provided by local government	0.7	0.7	1.7	2.1	1.3
Changed dietary patterns involuntarily	9.9	6.5	13.4	11.9	10.5
Changed cropping practices	1.2	0.2	1.7	0.5	1.0
Took on more non-farm employment	4.4	3.2	3.3	2.8	3.5
Took on more farm wage employment	2.8	2.0	1.9	1.2	2.0
Household member(s) migrated	1.2	0.7	0.2	0.0	0.6
Relied on savings	18.0	22.3	19.5	18.4	19.4
Obtained credit	4.4	3.0	6.7	6.3	5.1
Sold durable household assets	4.0	1.5	5.4	3.7	3.8
Sold land/building	0.0	0.7	0.6	0.2	0.4
Rented out land/building	0.7	0.0	0.8	0.2	0.5
Distress sales of animal stock	0.7	2.0	2.7	3.5	2.1
Sent children to live elsewhere	1.2	0.2	1.5	1.9	1.2
Reduced expenditures on health and education	4.7	0.5	0.8	0.7	1.9
Did nothing	17.8	32.8	13.6	20.2	20.5
Other	4.7	1.5	1.9	1.4	2.5

Source: Author's calculations using the UNPS data.

households seem to save their harvest for home consumption with the understanding that it will be sold if a need arises; this was not clear from the survey documentation.

Table 3.11 focuses specifically on the coping strategies that households indicated as their primary recourse in the face of a shock – the coping strategies that were ranked first by the households. As above, the most popular coping strategy was unconditional help from relatives/friends, in 36.5% of cases. Next most common was relying on savings, at 19.6%. Third most popular was to simply do nothing, at 15.3%. It may be the case that the households who sought community support did not have savings to rely on, or it is possible that the community norms are such that households experiencing shocks such as serious illness or death are automatically supported no matter what their financial position. Given how many households sought support from their communities, it is curious that there were still so many households that did nothing. Perhaps community support was not available for these households, though that seems unlikely given the context; perhaps again this is evidence that the households had sufficient regular income to absorb the shock without having to resort to seeking help from others or using savings. It is also possible that this kind of mutual assistance is taken for granted to the extent that households do not identify it as "support" – particularly if it was non-monetary in nature.

Table 3.11: Primary Coping Strategies Employed by Rural Households Facing Idiosyncratic Shocks, as Percentages

Coping Strategy	2013-14	2015-16	2018-19	2019-20	Total
Unconditional help provided by relatives/friends	41.3	41.2	32.9	32.6	36.5
Unconditional help provided by local government	1.1	0.6	1.7	1.4	1.3
Changed dietary patterns involuntarily	9.1	3.4	8.5	8.2	7.7
Changed cropping practices	1.9	0.0	2.7	0.4	1.4
Took on more non-farm employment	2.7	3.4	2.7	2.2	2.7
Took on more farm wage employment	1.5	1.7	1.0	0.4	1.1
Household member(s) migrated	0.8	1.1	0.3	0.0	0.5
Relied on savings	21.2	31.1	16.3	14.3	19.6
Obtained credit	3.8	1.1	3.7	3.9	3.3
Sold durable household assets	4.2	1.1	6.1	2.9	3.8
Sold land/building	0.0	0.6	0.7	0.4	0.4
Rented out land/building	0.8	0.0	0.3	0.0	0.3
Distress sales of animal stock	0.0	2.3	2.0	3.9	2.1
Sent children to live elsewhere	0.8	0.0	0.7	1.1	0.7
Reduced expenditures on health and education	0.8	0.6	0.0	0.4	0.4
Did nothing	4.2	9.0	18.0	26.9	15.3
Other	6.1	2.8	2.4	1.1	3.1

Source: Author's calculations using the UNPS data.

3.7.2 Coping Strategies by Input Purchase

Given the focus of this paper is on understanding the characteristics of households that purchased inputs, I interrogated whether there were differences in the coping strategies deployed by households that had or had not purchased inputs. Table 3.12 shows the breakdown of coping strategies that were used by households that purchased inputs compared to those that had not. I performed a simple T-test on the mean values of each, and found one statistically significant difference: households that did not purchase inputs were more likely to report receiving unconditional help from relatives/friends, at the 10% level. In the absence of other significant results, it is difficult to say much about this, as we do not have coping strategies that were more likely to be deployed by households that purchased inputs. It does suggest, however, that the receipt of support is not instrumental in facilitating input purchases – plenty of households received support from their community and yet still did not purchase inputs. It could be that receipt of support signals that households are poor and/or liquidity constrained, and are receiving assistance to support consumption, but not enough to be able to purchase inputs.

Table 3.12: Coping Strategies Employed by Rural Households Facing Idiosyncratic Shocks, as Percentages, by Input Purchase

Coping Strategy	Inputs = 1	Inputs = 0	T-Test
Unconditional help provided by relatives/friends	21.2	24.8	*
Unconditional help provided by local government	1.1	1.3	
Changed dietary patterns involuntarily	10.7	10.4	
Changed cropping practices	1.5	0.7	
Took on more non-farm employment	3.4	3.6	
Took on more farm wage employment	2.6	1.8	
Household member(s) migrated	0.6	0.6	
Relied on savings	20.6	18.9	
Obtained credit	4.3	5.4	
Sold durable household assets	4.1	3.6	
Sold land/building	0.2	0.4	
Rented out land/building	0.4	0.5	
Distress sales of animal stock	2.2	2.1	
Sent children to live elsewhere	0.7	1.4	
Reduced expenditures on health and education	2.2	1.8	
Did nothing	20.8	20.4	
Other	3.4	2.2	

Source: Author's calculations using the UNPS data.

As above, Table 3.13 looks at the coping strategies that households reported as their primary recourse, this time separated into households that did and did not purchase inputs. In this case, there were a number of statistically significant results. As in Table 3.12, households that did not purchase inputs were more likely to receive support from relatives/friends. We see here that they were also more likely to receive support from the government, more likely to sell land or buildings, and more likely to reduce expenditures on health and education. Conversely, households that purchased inputs were more likely to report changing cropping practices. Perhaps most interestingly, households that purchased inputs were statistically more likely (at the 10% level) to report doing nothing as their primary coping strategy. Again, this suggests that some households simply had enough resources on hand, not only to absorb the shock but also to continue purchasing inputs.

It is worth noting that, for the 2018-19 and 2019-20 waves, only about half (57%) of the households that used inputs in 2018-19 continued to do so in 2019-20, and only about half (56%) of the households that used inputs in 2019-20 had used them in 2018-19. In other words, about 50% of input users were different each year. This means it is not possible to explain the

Table 3.13: Primary Coping Strategies Employed by Rural Households Facing Idiosyncratic Shocks, as Percentages, by Input Purchase

Coping Strategy	Inputs = 1	Inputs = 0	T-Test
Unconditional help provided by relatives/friends	30.8	38.7	**
Unconditional help provided by local government	0.3	1.7	**
Changed dietary patterns involuntarily	8.2	7.5	
Changed cropping practices	2.7	0.8	*
Took on more non-farm employment	2.7	2.6	
Took on more farm wage employment	1.7	0.8	
Household member(s) migrated	0.3	0.6	
Relied on savings	21.6	18.8	
Obtained credit	2.4	3.7	
Sold durable household assets	4.1	3.7	
Sold land/building	0.0	0.6	**
Rented out land/building	0.3	0.3	
Distress sales of animal stock	3.1	1.7	
Sent children to live elsewhere	0.7	0.7	
Reduced expenditures on health and education	0.0	0.6	**
Did nothing	18.2	14.1	*
Other	2.7	3.2	

Source: Author's calculations using the UNPS data.

pattern of input usage by assuming that households "always" use inputs, and continue to do so no matter whether they experience a shock. Rather, there is a significant amount of churn in the households that used inputs in 2018-19 and 2019-20. It suggests that more transient factors must have some significance in explaining input purchase decisions, such as shocks or liquidity. This suggests that the households' coping strategies were that much more important in determining whether they purchased inputs in a given year. Or it is evidence of a perception (correct or incorrect) that it is not necessary to purchase inputs every year – it is true that there are some persistent effects that come from saving seed or through residual nutrients in the soils.

Overall, the households in this sample seem to demonstrate high levels of resilience, supported both by their own income/savings and by support from their communities. Indeed, the households were more resilient to shocks than might be expected from the literature reviewed in Section 3.2.

3.7.3 Full Insurance

It is possible that what I find in the data is evidence of full insurance, as discussed in Section 3.2: in other words, it is possible that households are able to smooth spending in the face of a shock and that this allows them to continue to purchase inputs, even if they may be spending less overall. However, it is possible that what I am observing is that the households that purchase inputs happen to be the ones that have relatively good "insurance," and that the households that lack full insurance do not purchase inputs, precisely because they take on the full risk of a shock. It is difficult to parse this out clearly from the data. It is also possible that there are some households that simply do not purchase inputs at all, regardless of the support they receive after a shock. As mentioned above, households that did not purchase inputs were more likely to report receiving unconditional help from relatives and friends as their primary coping strategy. Again, this suggests that support from the community (evidence of insurance) does not guarantee that a household will purchase inputs. This phenomenon is explored further in Paper 3.

How do I distinguish the possibility of full insurance from the possibility of null results? This is a challenge that plagues the literature on full insurance, and one that is difficult for me to surmount. Overall, the fact that I found some significant results for the intensive margin of input spending is surprising in itself, given there are so few shock observations, which should bias towards null results. Yet there are enough non-null results to seemingly exceed the threshold of being random chance. How much faith should we put in this set of non-null results? An exercise like this is always subject to the concern of selecting and reporting only on the results that are significant; I disciplined myself against this by using only controls that are well-motivated. However, I acknowledge the possibility that some significant coefficients could be random, and that my analysis may not be powered enough to draw a firm conclusion about full insurance.

3.8 Conclusion

Despite an extensive literature focusing on shocks and risk in the context of smallholder agriculture, analyses of idiosyncratic shocks are under-represented in the literature, as discussed by Komarek et al. (2020). This is particularly the case for the technology adoption literature, where seemingly only one extant article focuses on the impact of idiosyncratic shocks on technology adoption (Gebremariam and Tesfaye, 2018).

As reviewed in Section 3.2, there is some literature documenting the negative impact of idiosyncratic shocks on household consumption and agricultural productivity, including two studies focused on Uganda in particular (Kijima et al. (2006), Krishna et al. (2006)). Health shocks are widely documented as having a negative impact on productivity. Malaria, for example, is endemic in Uganda, and has an impact on agricultural production (Badiane and Ulimwengu, 2013). Overall, the literature suggests that it is possible that idiosyncratic shocks could have an impact on investment in agricultural inputs, given the costs incurred by households in responding to these shocks could force a liquidity crisis that limits spending on inputs.

I tested this proposition using data from four waves of the Uganda National Panel Survey. The analysis showed no evidence of an impact of shocks on investment in agricultural inputs. There was also limited evidence that the amount spent on inputs decreased in the face of a shock, which would be consistent with the notion that households faced a liquidity crunch after having incurred expenses to address the effects of a shock. Interestingly, this dovetails with the findings in Paper 1.

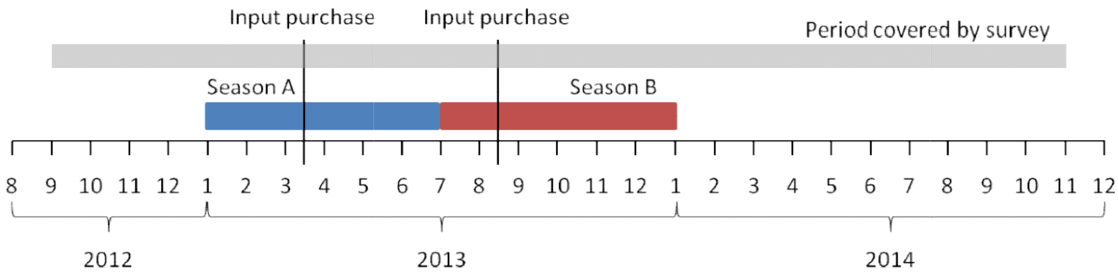
Overall, these results suggest that household input purchases are relatively resilient in the face of idiosyncratic shocks, which hints at evidence of something close to full insurance, as most famously discussed by Townsend (1994). Indeed, an analysis of the most common coping strategies employed by households shows that many relied on unconditional help from relatives and friends as their primary coping strategy, a coping mechanism that is frequently discussed in the full insurance literature. Many also relied on savings or reported doing nothing, suggesting that the asset position of these households is not as precarious as one might assume – or that it is wealthier households who engage in input purchasing in the first place. It is possible, however, that the analysis is underpowered, and therefore we cannot conclude with certainty that this is evidence of full insurance, or indeed that it is sufficient evidence of the impact of idiosyncratic shocks in general.

From a policy perspective, these findings are consistent with the idea that idiosyncratic shocks are relatively well-insured. They also support the idea that idiosyncratic shocks are not a major explanation for the low overall use of purchased inputs. As such, in order to encourage greater usage of agricultural inputs, it would likely be more fruitful to focus development programming on covariate shocks, which undermine the very community support systems that enabled these households to recover from idiosyncratic shocks. Indeed, this may be why many of the interventions aimed at reducing risk have tended to focus on production-side shocks, from index-based insurance programs, to the development of crop varieties that are resistant to diseases and pests (and therefore provide some cushion against shocks). Much less effort has gone into interventions that would protect people from other types of idiosyncratic shocks, perhaps on the assumption that informal networks would provide sufficient protection. I would also recommend further research into the impact of idiosyncratic shocks on input purchasing, in order to build the evidence base in this under-researched area of the literature.

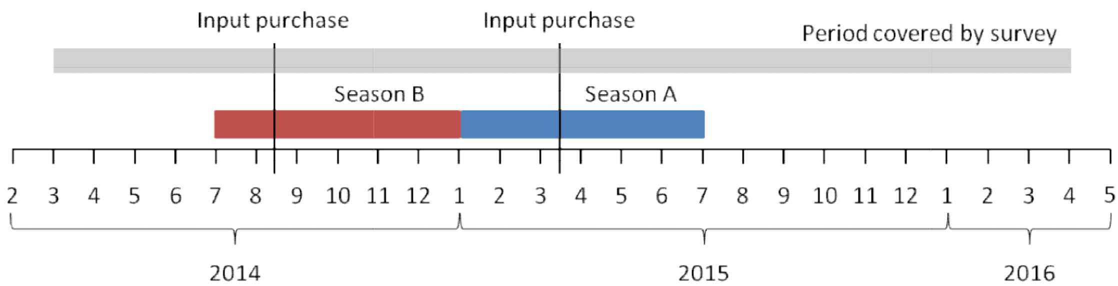
3.9 Appendix

Timeline of Survey Administration vs. Input Purchase Timing

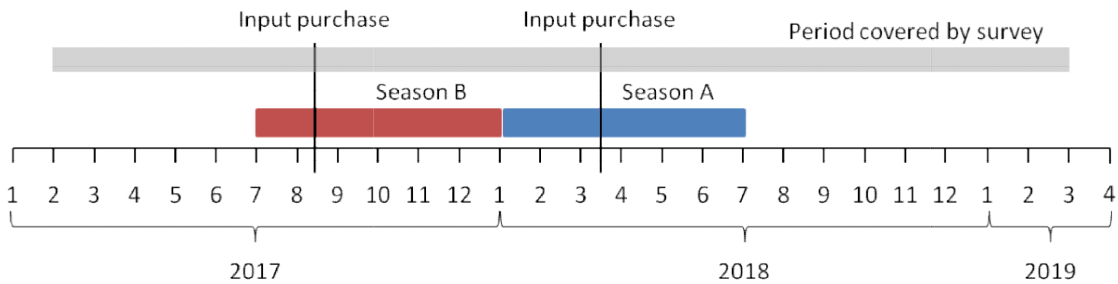
Wave 1: 2013-2014



Wave 2: 2015-2016



Wave 3: 2018-2019



Wave 4: 2019-2020

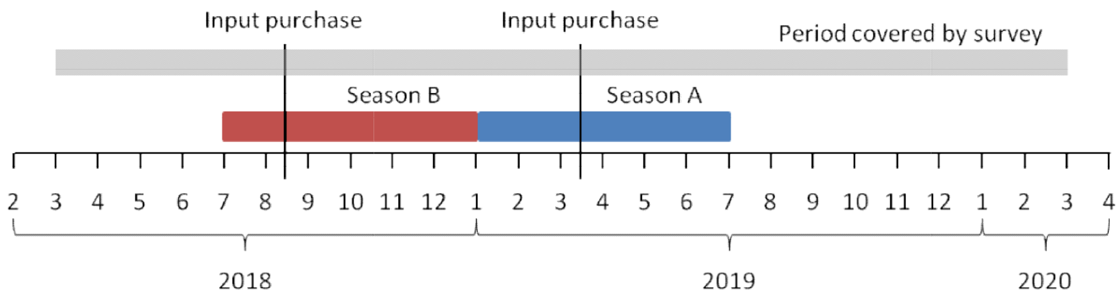


Table 3.14: Probit regressions with ex-ante input purchases of seed and fertilizer in Season A 2015 as dependent variable

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Idiosyncratic shock	-0.0025	-0.0205	-0.0052	-0.0228	0.0189	0.0254
	(0.899)	(0.671)	(0.787)	(0.625)	(0.618)	(0.755)
Age			-0.0010**	-0.0037***	-0.0014***	-0.0044***
			(0.017)	(0.001)	(0.010)	(0.000)
Number of adults			0.0065	0.0114	0.0017	-0.0083
			(0168)	(0.362)	(0.738)	(0.556)
Education level			0.0020**	0.0032*	0.0017*	0.0026
			(0.011)	(0.095)	(0.058)	(0.217)
Covariate shock			-0.0085	-0.0023	0.0085	0.0759
			(0.606)	(0.947)	(0.740)	(0.171)
Employment (2013-14)					-0.0128	0.0070
					(0.372)	(0.835)
Transport (2013-14)					-0.0004	0.0087
					(0.981)	(0.784)
Total acres cultivated (2013-14)					0.0038**	0.0085**
					(0.013)	(0.019)
Livestock owned (LSU) (2013-14)					-0.0004	0.0016
					(0.776)	(0.514)
Extension services (2013-14)					0.0580***	0.0845**
					(0.000)	(0.019)
With fixed effects	No	Yes	No	Yes	No	Yes
Summary Statistics						
Log-likelihood Ratio	-719.92	-411.38	-696.79	-396.19	-614.00	-345.83
N[a]	2,183	889	2,106	883	1,856	785

Coefficients reported in columns (1), (3), and (5) are marginal effects at the mean; coefficients in (2), (4), and (6) are average marginal effects.
***, **, and * represent significance at the 1%, 5%, and 10% level.
LSU stands for Livestock Unit.
[a] Note: The sample is reduced when fixed effects are added, and some observations were dropped for missing values.
Source: Author's calculations using the UNPS data for 2013-14 and 2015-16.

Table 3.15: Probit regressions with ex-ante input purchases of seed and fertilizer in Season A 2015 as dependent variable, with breakdown of *Idiosyncratic*

Primary Regressor	(1)	(2)	(3)	(4)	(5)	(6)
Aggregate variables						
Idiosyncratic	-0.0025	-0.0205	-0.0052	-0.0228	0.0186	0.0254
	(0.899)	(0.671)	(0.787)	(0.625)	(0.618)	(0.755)
Income shock	-0.0290	-0.0493	-0.0237	-0.0324	-0.0067	-0.0569
	(0.414)	(0.515)	(0.503)	(0.669)	(0.916)	(0.570)
Asset shock	-0.0250	-0.1303	-0.0364	-0.1563*	-0.0152	-0.0659
	(0.489)	(0.137)	(0.314)	(0.057)	(0.828)	(0.615)
Individual shocks						
Death total	-0.0160	-0.0147	-0.0201	-0.0130	N/A	N/A
	(0.676)	(0.861)	(0.601)	(0.869)		
Death of income earner	N/A	N/A	N/A	N/A	N/A	N/A
Death of other	0.0199	0.0578	0.0155	0.0520	N/A	N/A
household member	(0.621)	(0.525)	(0.700)	(0.543)		
Illness total	0.0010	-0.0205	0.0092	0.0013	0.0695	0.0872
	(0.977)	(0.758)	(0.783)	(0.985)	(0.184)	(0.399)
Illness of income earner	N/A	-0.0426	0.0046	-0.0270	0.0263	-0.0294
		(0.624)	(0.912)	(0.759)	(0.697)	(0.790)
Illness of other	N/A	0.0230	0.0120	0.0514	0.1303*	0.2957*
household member		(0.748)	(0.780)	(0.498)	(0.096)	(0.092)
Theft total	-0.0696	-.1590	-0.0817*	-0.1886**	-0.0578	-0.1895
	(0.132)	(0.100)	(0.073)	(0.034)	(0.527)	(0.183)
Theft of agricultural assets	-0.1218	-0.2684**	-0.1350*	-0.2909**	-0.0402	-0.1752
	(0.109)	(0.038)	(0.073)	(0.014)	(0.684)	(0.243)
Theft of non-agricultural	-0.0282	-0.0474	-0.0391	-0.0855	N/A	N/A
assets	(0.650)	(0.728)	(0.525)	(0.510)		
Conflict	0.1334*	0.2969	0.1206	0.2308	0.1496	0.3676
	(0.077)	(0.212)	(0.108)	(0.314)	(0.131)	(0.234)
Fire	0.0858	0.0277	0.0745	0.0275	0.0688	0.4557*
	(0.209)	(0.890)	(0.282)	(0.889)	(0.514)	(0.062)
Reduction in off-farm	0.2264	N/A	0.2042	N/A	N/A	N/A
earnings	(0.153)		(0.207)			
Loss of employment	N/A	N/A	N/A	N/A	N/A	N/A
Social expenditures (2013-14)	0.0357**	0.0839**	0.0310**	0.0602	0.0257	0.0373
	(0.028)	(0.045)	(0.050)	(0.145)	(0.103)	(0.369)
Spending on social	0.0033**	0.0095**	0.0028*	0.0074*	0.0022	0.0050
expenditures (2013-14)	(0.027)	(0.016)	(0.060)	(0.060)	(0.125)	(0.210)
Birth (2013-14)	0.0217	0.0381	0.0107	0.0023	0.0151	0.0146
	(0.219)	(0.348)	(0.550)	(0.956)	(0.389)	(0.720)
Social expenditures	0.0146	0.0217	0.0120	0.0090	0.0045	-0.0123
	(0.255)	(0.478)	(0.361)	(0.768)	(0.751)	(0.712)
Spending on social	N/A	N/A	N/A	N/A	N/A	N/A
Birth	0.1267**	0.5025***	0.1188**	0.4635***	0.1329**	0.4863***
	(0.016)	(0.002)	(0.026)	(0.002)	(0.017)	(0.001)
N[a]	2,183	889	2,106	883	1,856	785

Each row represents six regressions, for which the "Primary Regressor" is the main independent variable of interest.
Specification (1) uses this as the only regressor; (2) adds fixed effects.
Specification (3) includes exogenous controls; (4) adds fixed effects.
Specification (5) includes exogenous and lagged endogenous controls; (6) adds fixed effects.
Coefficients reported in columns (1), (3), and (5) are marginal effects at the mean.
Coefficients in (2), (4), and (6) are average marginal effects.
***, **, and * represent significance at the 1%, 5%, and 10% level.
[a] Note: The sample is reduced when fixed effects are added, and some observations were dropped for missing values.
Source: Author's calculations using the UNPS data for 2013-14 and 2015-16.

Table 3.16: OLS regressions with ex-ante input spending on seed and fertilizer in Season A 2015 as dependent variable

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Idiosyncratic shock	0.0560	0.0189	0.0367	0.0249	0.3480	0.3667
	(0.771)	(0.948)	(0.857)	(0.931)	(0.448)	(0.505)
Age			-0.0094**	-0.0174***	-0.0128***	-0.0206***
			(0.013)	(0.003)	(0.006)	(0.001)
Number of adults			0.0617	0.0577	0.0070	-0.0446
			(0.257)	(0.453)	(0.899)	(0.569)
Education level			0.0208***	0.0171	0.0164*	0.0132
			(0.010)	(0.116)	(0.088)	(0.250)
Covariate shock			-0.0797	-0.0081	0.1214	0.4530
			(0.637)	(0.966)	(0.671)	(0.172)
Employment (2018-19)					-0.1296	0.0071
					(0.388)	(0.970)
Transport (2018-19)					-0.0294	-0.0069
					(0.884)	(0.969)
Total acres cultivated (2018-19)					0.0596**	0.0773**
					(0.021)	(0.011)
Livestock owned (LSU) (2018-19)					-0.0044	0.0146
					(0.795)	(0.489)
Extension services (2018-19)					0.6799***	0.5198**
					(0.001)	(0.045)
With fixed effects	No	Yes	No	Yes	No	Yes
Summary Statistics						
R-squared	0.0000	0.3612	0.0079	0.3666	0.0256	0.3753
N[a]	2,183	2,183	2,106	2,106	1,856	1,856

***, **, and * represent significance at the 1%, 5%, and 10% level.
LSU stands for Livestock Unit.
[a] Note: Some observations were dropped for missing values.
Source: Author's calculations using the UNPS data for 2013-14 and 2015-16.

Table 3.17: OLS regressions with ex-ante input spending on seed and fertilizer in Season A 2015 as dependent variable, with breakdown of *Idiosyncratic*

Primary Regressor	(1)	(2)	(3)	(4)	(5)	(6)
Aggregate variables						
Idiosyncratic	0.0600	0.0189	0.0367	0.0249	0.3480	0.3667
	(0.771)	(0.948)	(0.857)	(0.931)	(0.448)	(0.505)
Income shock	-0.1453	-0.0791	-0.0796	0.0201	0.2229	0.1759
	(0.662)	(0.862)	(0.812)	(0.965)	(0.745)	(0.787)
Asset shock	-0.1432	-0.5452	-0.2475	-0.6529	0.0969	-0.0082
	(0.673)	(0.245)	(0.464)	(0.149)	(0.903)	(0.994)
Individual shocks						
Death total	-0.0970	0.0030	-0.1219	0.0214	-1.0344***	-0.6507**
	(0.787)	(0.994)	(0.734)	(0.954)	(0.000)	(0.023)
Death of income earner	-1.0377***	-0.8172***	-1.0239***	-0.7967***	-0.7018**	-0.6462
	(0.000)	(0.006)	(0.000)	(0.005)	(0.015)	(0.214)
Death of other	0.2905	0.3296	0.2618	0.3397	-1.1395***	-0.6522*
household member	(0.543)	(0.474)	(0.586)	(0.471)	(0.000)	(0.055)
Illness total	0.0846	0.0485	0.1596	0.1708	0.8798	0.6961
	(0.820)	(0.911)	(0.671)	(0.698)	(0.246)	(0.339)
Illness of income earner	0.1162	-0.0078	0.2179	0.1180	0.6089	0.3597
	(0.806)	(0.989)	(0.647)	(0.843)	(0.497)	(0.644)
Illness of other	-0.0021	0.1448	0.0170	0.2540	1.4272	1.7298
household member	(0.996)	(0.698)	(0.968)	(0.515)	(0.270)	(0.257)
Theft total	-0.4580	-0.6709	-0.5507*	-0.7810	-0.02013	-0.7058
	(0.149)	(0.179)	(0.077)	(0.103)	(0.819)	(0.516)
Theft of agricultural assets	-0.7086**	-1.0327**	-0.8271**	-1.1311**	-0.0550	-0.5184
	(0.041)	(0.032)	(0.016)	(0.017)	(0.964)	(0.689)
Theft of non-agricultural	-0.1604	-0.1701	-0.2362	-0.3214	-0.8993***	-1.7868***
assets	(0.778)	(0.834)	(0.672)	(0.681)	(0.008)	(0.000)
Conflict	2.0535	2.1644	1.9191	1.9028	2.8171	3.0115
	(0.171)	(0.343)	(0.196)	(0.397)	(0.211)	(0.341)
Fire	1.2065	0.1638	1.0678	0.0874	0.9245	2.0522
	(0.298)	(0.887)	(0.361)	(0.939)	(0.568)	(0.348)
Reduction in off-farm	4.5905	11.2253***	4.356	11.2594***	-1.0064***	-0.1625
earnings	(0.249)	(0.000)	(0.281)	(0.000)	(0.000)	(0.501)
Loss of employment	-1.0282***	0.0000	-1.1982***	-0.3299	-1.3727***	-0.6684**
	(0.000)	(0.229)	(0.000)	(0.449)	(0.000)	(0.013)
Social expenditures (2013-14)	0.3892**	0.4471**	0.3389**	0.3681*	0.2876*	0.2811
	(0.021)	(0.033)	(0.040)	(0.098)	(0.080)	(0.205)
Spending on social	0.0366**	0.0527**	0.0306**	0.0419**	0.0251*	0.0322
expenditures (2013-14)	(0.018)	(0.013)	(0.044)	(0.046)	(0.097)	(0.125)
Birth (2013-14)	0.2470	0.1948	0.1290	0.0317	0.1579	0.0807
	(0.211)	(0.397)	(0.520)	(0.892)	(0.427)	(0.730)
Social expenditures	0.1842	0.1421	0.1538	0.0949	0.0804	-0.0385
	(0.148)	(0.366)	(0.243)	(0.552)	(0.579)	(0.827)
Spending on social	N/A	N/A	N/A	N/A	N/A	N/A
expenditures						
Birth	1.9052*	1.8411*	1.8256*	1.6820*	2.0928*	1.8429*
	(0.067)	(0.071)	(0.079)	(0.098)	(0.066)	(0.086)
N[a]	2,183	2,183	2,106	2,106	1,856	1,856

Each row represents six regressions, for which the "Primary Regressor" is the main independent variable of interest.
Specification (1) uses this as the only regressor; (2) adds fixed effects.
Specification (3) includes exogenous controls; (4) adds fixed effects.
Specification (5) includes exogenous and lagged endogenous controls; (6) adds fixed effects.
***, **, and * represent significance at the 1%, 5%, and 10% level.
[a] Note: Some observations were dropped for missing values.
Source: Author's calculations using the UNPS data for 2013-14 and 2015-16.

Chapter 4

A Qualitative Exploration of the Impact of Idiosyncratic Shocks on Smallholder Farmers in Butebo District, Uganda

Building on the analysis I conducted in Paper 2, this paper provides a qualitative deep-dive into the impact of idiosyncratic shocks in smallholder farm communities in Uganda. It is based on interviews conducted in Butebo District, where farmers reported a variety of covariate and idiosyncratic shocks. I find that, similar to the results of Paper 2, farmers continued to purchase inputs in the aftermath of shocks, but reported purchasing less than they otherwise would have. Farmers also reported slightly different coping strategies, relying more on their own accumulated savings than on their communities.

4.1 Introduction

Smallholder farmers in developing countries face a panoply of risks. Agricultural production is an uncertain livelihood, with the prospects of drought, pests, and crop disease threatening harvests, not to mention the looming effects of climate change. Farm households must also confront the universal set of personal risks – such as illness, death, theft, and violence – but in the majority of cases must manage these risks without recourse to formal insurance. Managing risk is a central aspect of smallholder farmers' lives, particularly for subsistence farmers.[1]

The stakes are relatively high: Dercon et al. (2005) highlights the long-term poverty consequences of uninsured risk, as both a direct cause of poverty and a factor in its persistence. He also shows (Dercon, 2004) that the impact of rainfall shocks can linger for many years, impacting consumption growth, and that experiencing an illness can have long-lasting effects on per capita household consumption (Dercon et al., 2005). There is some evidence of a relationship between shocks and poverty traps, as discussed by Carter et al. (2007), Barrett et al. (2016), and Carter and Lybbert (2012). There is also a documented link between risk and agricultural input usage. In a widely cited paper, Dercon and Christiaensen (2011) show that households are less likely to adopt fertilizer if they risk the possibility of low consumption due to either poor rainfall or poor harvests. They suggest that this results in some farmers being trapped in low-return agriculture, as their inability to manage downside consumption risk forces them to forego the use of inputs that might increase yields but also involve increased risk.

Smallholder farm households employ a variety of *ex ante* coping strategies to manage risk, such as diversifying their portfolio of livelihood strategies and planting diverse crops. When negative outcomes are realized, they must often make use of *ex post* strategies to cope with the monetary costs that accompany these shocks, such as the cost of pesticides or medical treatment. Risk management strategies trade off the avoidance of downside risks with the need to generate sufficient levels of consumption and (ideally) investment in the household's set of enterprises.

As with Paper 2, the focus of this paper is on the impact of shocks on smallholder farm households, and in particular on their ability to invest in their farms. Investments in modern inputs, such as improved seed and fertilizer, can have a substantial impact on yields and can serve as one pathway out of poverty, as is well documented in the literature (de Janvry and Sadoulet (2002), Sanchez et al. (2009), McArthur and McCord (2017), Bonilla-Cedrez et al. (2021)). One concern is that negative shocks can have a cascading effect on household welfare. Not only do the shocks reduce the household's well-being in the current period, but they may also prevent the household from purchasing inputs (due to their monetary costs), which would undermine productivity in the next period and beyond. In effect, the concern is that shocks can leave households caught in a kind of poverty trap. At the very least, the concern is that a

[1]There has been much research on the relationship between rural poverty and risk, as summarized by Fafchamps and Lund (2003)

negative shock can create lasting damage to households.

The analysis in Paper 2 found relatively little evidence of an impact of idiosyncratic shocks on investment in seed and fertilizer, although there was some evidence that households spent less on inputs following a shock. As discussed in Paper 2, the households described deploying a number of coping strategies to manage the effects of these shocks, particularly relying on savings and receiving support from family and friends. These quantitative results suggest that farmers were able to manage shocks in a way that allowed them to maintain their investments in modern inputs, albeit by purchasing less in some cases.

The objective of this paper is to provide greater qualitative context to the literature that seeks to explain how smallholder farmers decide to invest in modern technologies, such as fertilizer and improved seed. In particular, I seek to better elucidate the risks that farmers face and how these risks impact the farmers' decision to invest in agricultural inputs. The analysis provides greater context to a strand of literature that is primarily based on quantitative data from household surveys, where the richer social and psychological context surrounding agricultural production is sometimes lost.

Using qualitative interview data gathered from smallholder farmers in Uganda, this paper expands on the analysis in Paper 2 by providing a deeper dive into the relationship between shocks and investment in inputs. I focus on the ways in which the portfolios of coping strategies employed by farmers influence their ability to manage shocks and to purchase and use inputs. This paper contributes to the relatively thin literature on the impact of idiosyncratic shocks on agricultural productivity; it also provides further evidence as to the coping strategies that are used by smallholder farmers in responding to shocks.

This qualitative analysis is strongly supportive of the key stories emerging from the quantitative analysis in Paper 2: the farmers interviewed continued to purchase inputs following shocks, albeit in smaller quantities. The main coping strategies that households reported using were "doing nothing" (primarily in response to a drought), selling produce, spending out of off-farm income, and selling livestock. Unlike the survey respondents in Paper 2, the households I interviewed did not indicate that transfers from family and friends served as important coping mechanisms, though many did report receiving support to buy inputs from family and friends. Overall, I suggest that the households display remarkable resilience in the face of shocks, which allows them to continue to invest in their farms.

The paper is organized as follows: Section 4.2 discusses the relevant literature on shocks and coping strategies, while Section 4.3 provides context on the field site and describes the methodology used. The main results are presented in Section 4.4. Section 4.5 concludes.

4.2 Literature

4.2.1 The Full Insurance Model

The literature on coping strategies has a close relationship to literature on informal insurance mechanisms in village economies, and in particular to the literature on so-called "full insurance" models, as discussed in Paper 2. Perhaps the best known work is by Townsend (1994), who shows theoretically that in a world of complete markets, households would be fully protected from idiosyncratic shocks to income; he then develops an empirical framework to test this proposition. The key idea is that household consumption in rural areas can be smoothed in the face of idiosyncratic shocks through various local "risk-bearing institutions," such as support from family networks. Though Townsend finds limited evidence of full insurance in India, his paper and others spawned a number of studies into whether (and how completely) households are able to insure their consumption against shocks. The evidence on full insurance is mixed. For example, Jalan and Ravallion (1999) find that households (and particularly poorer households) in rural China are only partially insured against idiosyncratic income shocks, while Harrower and Hoddinott (2005) find evidence of consumption smoothing following idiosyncratic shocks in Mali. In a widely-cited article, Dercon et al. (2005) use data on a broad set of covariate and idiosyncratic shocks to estimate their impact on per capita consumption in Ethiopia; they find that drought and illness were the only shocks to have a statistically significant negative impact on consumption. Also studying Ethiopia, Porter (2012) finds evidence of consumption smoothing in the face of idiosyncratic shocks. Ajefu (2017) finds little effect of idiosyncratic shocks on household welfare in Nigeria, suggesting that households' coping strategies are effective at smoothing consumption. It would appear that food consumption is better insured than non-food consumption: Skoufias and Quisumbing (2005) look at evidence from five countries and find that food consumption is better insured against idiosyncratic shocks than non-food consumption, and that food consumption is more likely to be supported by informal insurance. My analysis considers the household as a unit, however there has also been research into intra-household allocation of consumption smoothing (Dercon and Krishnan, 2000).

Several studies have specifically looked at consumption smoothing in the face of health shocks. Asfaw and Von Braun (2004) find that when it comes to health shocks in rural Ethiopia, food consumption is insured against illness through own production and risk-sharing mechanisms such as gifts, but non-food consumption is not. De Weerdt and Dercon (2006) test for full insurance against illness in Tanzania. They cannot reject the hypothesis of full insurance for food consumption, while they find evidence of insurance within networks for non-food consumption. Gertler and Gruber (2002) find that households in Indonesia are unable to fully insure consumption against major illness, while Wagstaff (2007) finds that food consumption is negatively correlated with health shocks in Vietnam. Alam and Mahal (2014) reject the hypothesis of full consumption insurance when it comes to major health shocks.

4.2.2 Coping Strategies: Theoretical Foundations

More recently, a literature has emerged that seeks to understand the specific coping strategies that households use in response to shocks. In a seminal paper, Dercon (2002) summarizes the coping strategies available to households facing risks, including income diversification, self-insurance using savings, support from family and neighbors, increased labor supply, savings groups and other traditional credit systems, microfinance, and migration.[2] Many households have the option of relying on what Besley (1995) refers to as non-market institutions, such as credit cooperatives or savings groups, which can help farmers cope with risk and provide access to credit. For instance, in an often-cited paper, Udry (1990) shows evidence of rural credit transactions in villages in northern Nigeria, and describes how these loans can act as insurance against shocks, particularly idiosyncratic shocks.

Looking at data from 16 countries, Heltberg et al. (2015) find that households cope by reducing consumption, working more, borrowing or seeking assistance from formal and informal sources, and relying on savings and asset sales. Similarly, Nikoloski et al. (2017) highlight a number of strategies that are available to households when coping with shocks, including informal transfers, reductions in expenditures, asset sales, using savings, increasing labor supply, and formal safety nets. Looking at data for six countries, they find that many households report doing nothing, and that using savings and borrowing were the most common coping strategies reported.

[2]See also Dercon (2004) as well as Fafchamps (1999) for a thorough treatment of the risk-coping strategies available to the rural poor.

4.2.3 Global Evidence

There is plenty of evidence that smallholder farm households around the world deploy similar coping strategies when faced with shocks. In an early study of Nigeria, Udry (1995) finds that households use savings to cope with shocks, particularly grain sales. Analyzing further data from Nigeria, Urama et al. (2019) find that borrowing, asset sales, and reduced expenditure were the main coping strategies for farm households facing health shocks, while Seyi Olalekan et al. (2011) observe borrowing, asset sales, remittances, changes to consumption patterns, and use of savings as coping strategies. Moller et al. (2019) found borrowing and assistance from others to be the main coping responses to negative shocks in a study of households in Nepal. Analyzing data from South Africa, Paumgarten et al. (2020) find support from family and community support networks and use of savings as the most prevalent coping strategies used by households facing shocks. Berloffa and Modena (2013) use data from Indonesia that shows farmers experiencing sickness and crop loss as the most common shocks, with coping strategies that include taking an extra job, cutting down on household expenses, borrowing, and selling assets. Using data from Ghana, Ansah et al. (2021) analyze the impact of multiple shocks on a household and find that experiencing two or more shocks increases the likelihood that a household will choose productive asset depletion as a coping strategy, as opposed to relying on savings or social networks. For Uganda in particular, Debela et al. (2012) sampled households in Masindi district and found that reduced consumption, support from relatives and friends, and off-farm income were the most common coping strategies following a shock.

There is some evidence that households pursue different coping strategies depending on their level of wealth. For example, Harrower and Hoddinott (2005) find evidence of poor households in Mali relying on credit, gift exchange, and reduced consumption, while non-poor households coped primarily through new income-generating activities. In rural Zimbabwe, Hoddinott (2006) finds that households responded differently to an income shock (drought) depending on their level of assets. Berloffa and Modena (2013) find that asset-poor farms in Indonesia are more likely to use labor supply as a coping mechanism when faced with crop loss. For Uganda, Lawson and Kasirye (2013) supplement national-level data with qualitative evidence that shows that poor households are more likely to reduce consumption than sell assets to cope with a shock.

4.2.4 Coping with Health Shocks

Given their prevalence (and the lack of corresponding insurance coverage in most developing countries), health shocks have been studied separately by researchers. Several studies are frequently cited. In a study of survey data from Pakistan, Heltberg and Lund (2009) find that health shocks are the most frequent and most costly type of shock that households face. De Weerdt and Dercon (2006) find that illness was the most frequently reported shock in Tanzania, with risk-sharing mechanisms (such as gifts) the most important coping strategy. Wagstaff and Lindelow (2014) find that health shocks in Laos cost more than non-health shocks (in terms of direct costs, indirect costs, and asset losses), and that savings, borrowing, and help from others are the main coping strategies. Analyzing data from Bangladesh, Islam and Maitra (2012) find that households are well insured against health shocks, primarily by selling livestock, unless they have access to microcredit. For rural Ethiopia, Yilma et al. (2014) find that households cope with health shocks by using savings, selling assets, and borrowing from informal sources.

The literature specifically on health shocks in Uganda is sparse, with two studies standing out. Isoto et al. (2017) find that uninsured health shocks have a large negative impact on agricultural productivity, though access to credit significantly reduces the impact. Further, Aliga et al. (2023) find that households cope with illness shocks primarily through borrowing and external assistance. These findings echo results from other countries: Cambodia (Nguyen et al., 2020), Ghana (Amponsah, 2016), India Flores et al. (2008), Indonesia (DeLoach and Smith-Lin, 2018), Kenya (Bonfrer and Gustafsson-Wright, 2017), Namibia (Gustafsson-Wright et al., 2011), and Zambia (Hangoma et al., 2018), among others.

4.2.5 Coping with Climate Shocks

Another strand of literature specifically focuses on the impact of climate shocks on smallholder farmers – and the coping strategies they pursue in response. Acosta et al. (2021) provide evidence of the role of livestock ownership as a buffer against the effects of drought on income and consumption. Arslan et al. (2018) explore the importance of livelihood diversification as an adaptation strategy in Zambia, while Asfaw et al. (2018) find positive impacts of crop and livelihood diversification in Niger. Asfaw et al. (2019) analyze data for Malawi, Niger, and Zambia, finding that exposure to rainfall shocks leads to crop or livelihood diversification as coping strategies. Looking at evidence from five African countries, Rahut et al. (2021) find that in addition to changing farming practices, farmers cope with climate risks by using savings, borrowing, seeking alternative employment, and reducing consumption. Further studies have been done on Mozambique (Baez et al., 2018), Nepal (Gautam et al., 2021), Niger (Gao and Mills, 2021), Pakistan (Ashraf and Routray, 2013), and South Africa (Bahta, 2022), among others.

For Uganda, Baranabas et al. (2023) found that smallholders coped with weather shocks primarily by selling productive assets and reducing food consumption. Agamile et al. (2021) find that rainfall shocks in Uganda significantly reduce school attendance, while Antonelli et al. (2022) analyze the optimal levels of both crop diversification and off-farm income for farmers facing climatic shocks in Uganda. Call et al. (2019) find that farmers use a combination of on-farm strategies and off-farm income to cope with climate stresses. Helgeson et al. (2013) surveyed farmers in two districts of Uganda, asking them to consider a scenario in which the community is hit by a natural disaster and they should assume no support from nearby family and friends. By far the most common coping strategy chosen was selling livestock, followed by reducing expenditures. In the Mt. Elgon region, Mubangizi et al. (2019) analyzed households' resilience to rainfall variability, finding that households relied on social capital and asset sales as short-term coping strategies.

Berman et al. (2015) found that the most common flood coping strategies reported were agricultural practices (such as soil and water conservation or delayed planting) economic activities (such as non-farm income activities) and social support; following drought, the most common coping strategies were economic activities, using savings, and social support. They further found that older households were more likely to rely on social support following floods, and that more educated households relied more on savings, likely due to diversified income generating activities. The households' livelihood strategy and level of wealth also influenced their coping strategies, with wealthier and more market-oriented households relying more on economic activities to cope.

4.2.6 Impact on Input Purchases

What about the impact of shocks on input usage, the focus of this paper? The evidence is limited. As mentioned above, Dercon and Christiaensen (2011) show that households are less likely to adopt fertilizer if they risk the possibility of low consumption due to either poor rainfall or poor harvests. There is some evidence of the impact of covariate climate shocks on input adoption, though the direction of this impact seems to vary. Bozzola et al. (2018) find that past drought incidence reduces the area of the farm allocated to hybrid maize seeds in rural Kenya, while Abid et al. (2020) found that farmers in rural Malawi adopted drought- and disease-tolerant crops as coping strategies after climate shocks. For Tanzania, Arslan et al. (2017) find that rainfall variability increases the likelihood of adopting improved seeds, and decreases the adoption of inorganic fertilizer. Another study from Tanzania, Heisse and Morimoto (2023), finds that fertilizer usage is sensitive to climate risks such as rainfall variability and temperature shocks. Bora (2022) finds that fertilizer usage is responsive to rainfall shocks in India. In Malawi, Holden and Quiggin (2017) find evidence that farmers exposed to drought are more likely to adopt drought-tolerant maize varieties, while Nordhagen and Pascual (2013) find that farmers exposed to climate shocks were more likely to purchase seed. Holden and Westberg (2016) find that farmers in Ethiopia are less likely to use fertilizer following rainfall shocks. Also in Ethiopia, Makate et al. (2022) find that exposure to drought and temperature shocks led to increased use of improved seed, a somewhat counterintuitive result, while idiosyncratic shocks had less influence on seed usage. Oyetunde-Usman et al. (2021) find that farmers exposed to production shocks in Nigeria are less likely to purchase improved seeds and inorganic fertilizer. For Uganda, Diiro and Sam (2015) find that farmers who experienced severe weather shocks were less likely to purchase improved seed. Both Makate et al. (2023) (looking at East Africa) and Makate and Makate (2022) (looking at Malawi) find that experiencing a drought prompts farmers to purchase inputs. It is worth noting that these results are quite varied, and may be subject to publication bias (null results may have been excluded from publication). This somewhat confusing quantitative evidence provides further motivation for a qualitative exploration of the relationship between shocks and input purchases.

Weather and climate shocks tend to be strongly covariate within rural communities. Although there may be some heterogeneity in the impacts on different farms and farmers, these are best understood as aggregate shocks rather than idiosyncratic shocks. Thus, there may be few direct lessons from this literature for thinking about the effects of idiosyncratic shocks on input purchases. On this topic, there is far less evidence. One study from Ghana found a negative relationship between ill health and agricultural input usage (Osei-Akoto et al., 2013), while Isoto et al. (2017) analyze data from Uganda and find that access to microcredit can mitigate the impact of health shocks on investment in farm inputs. As mentioned in Paper 2, one of the only studies that considers idiosyncratic risk in the context of input adoption is Gebremariam and Tesfaye (2018), which finds a negative relationship between health shocks and investment in higher-cost innovations such as seed and inorganic fertilizer.

My own work, as reported in Papers 1 and 2, suggests that there is limited impact of idiosyncratic shocks on investment in agricultural inputs. Perhaps the strongest evidence was of an impact on the amount spent on inputs, with this value seeming to decrease after the household experienced an idiosyncratic shock. As I discussed in Paper 2, the limited impact of shocks on input purchasing could be evidence of full insurance operating at the village level, and at the very least speaks to the resilience of farm households after experiencing idiosyncratic shocks. These results suggested further qualitative exploration was needed into the experiences of smallholder farm households, and in the remainder of this paper, I report on the comments and reactions of farming households to questions about the shocks they experienced and open-ended questions about how they coped with those shocks – as well as the impact the shocks had on their input purchasing decisions.

4.3 Context and Methodology

4.3.1 Context

The analysis below is based on fieldwork conducted in Uganda in August and September 2023. The interviews were conducted in communities on the periphery of Mbale municipality, in eastern Uganda. Mbale is among the 20 largest urban centers in Uganda, with 92,863 residents as of the 2014 census (UBOS, 2016). It has a large downtown market center with dozens of input dealers selling seed, fertilizer, and agrochemicals. The interviews took place in neighboring Butebo district. Butebo district is a relatively new district, created in 2017; it was previously a county (Butebo county) within Pallisa district (Uganda Districts Information Handbook, 2021). According to the 2014 census, there were 111,246 residents, primarily of the Iteso and Bagwere people, speaking Ateso and Lugwere (Uganda Districts Information Handbook, 2021). The district is part of the south eastern agro-ecological zone, in the lowland sub-zone, which has "generally fertile and productive soils" (NARO, 2023). Unfortunately neither Butebo district nor Butebo county is directly captured by the Uganda National Panel Survey, the main nationally representative household survey for Uganda (this is the data that was used in Paper 2). As a result, there is no micro data that can be used to further characterize the district. It is not possible to use neighboring districts as a proxy, either: in the 2019-20 UNPS, only two households were sampled for Mbale district and only 20 households for Pallisa district.

However, there are a number of recent news articles that have been written about the district, which provide a bit more context. It is estimated that 88% of households in the district are subsistence farmers (Kolyangha, 2023c), and farmers in the district grow millet, rice, cassava, sorghum, sweet potatoes, groundnuts, beans, soya bean, bananas, cow peas, sesame, maize, and cotton (Uganda Districts Information Handbook, 2021). The road quality in the district is poor, and there are no tarmac roads, which increases the transportation costs for residents (Kolyangha (2023a), Kolyangha (2022)). As of 2022, only five of the seventeen sub-counties in the district had government secondary schools (Kirinya, 2022); there are also seven private secondary schools (Uganda Districts Information Handbook, 2021). The region is prone to flooding and water-logging (Kitunzi and Woniala (2022), Sserugo (2023)), and there has been corruption and mismanagement in the district (Kolyangha, 2023b). On a more positive note, malaria cases reportedly decreased in 2023 thanks to government interventions (Abet and Odaka, 2023).

No information was available about input usage in the district; as discussed above, according to the most recent official statistics from 2019, 25.3% of agricultural households used improved seed in the first agricultural season, and 18.3% used it in the second season. Similarly, for the first season, 9.1% of agricultural households used fertilizer and 22.6% used pesticides, while for the second growing season, 10.1% used fertilizer and 22.7% reported using pesticides (UBOS, 2022). Anecdotally, the area around Mbale is known for comparatively higher input usage. As for shocks, as seen in Paper 2, according to the 2019-20 Uganda National Panel Survey, 12.2% of respondents reported experiencing an idiosyncratic shock during the previous year, while 25.7% reported experiencing a covariate shock during the same period.

The main set of interviews analyzed below took place in two communities in Butebo district. They were located approximately an hour's drive from Mbale, with the majority of the journey taking place on dirt roads. The communities would qualify as rural, though not as remote as many locations in Uganda. This was essential in the selection of these communities: I sought a study area that was rural enough for the main livelihood to be agriculture, as I was interested in interviewing farmers, but not so rural that the communities had no access to agricultural inputs, as I was interested in understanding how shocks impact input purchases. The nearest town center is approximately 3.5 km away, which has a local input dealer; apart from Butebo, the administrative center, this is one of only two trading centers in the district (Uganda Districts Information Handbook, 2021)

The communities were relatively poor by Ugandan standards, though not at the bottom of the distribution. The homesteads were comprised of brick and mud buildings, some with thatched roofs. There were occasional boreholes in the area, and no electricity. The homesteads were interspersed with farming plots and lush, dense vegetation. Agriculture is the main livelihood, though many households reported having some off-farm sources of income. Most households kept livestock of some sort, including cows, goats, chickens, turkeys, and pigs.

Community members reported experiencing a litany of shocks, including crop pests and diseases, illnesses, and deaths. In fact there was unfortunately a shock to the community while we were there: the death and subsequent burial of a child. The community was also coming out of a drought period; the rains arrived while we were there. According to news reports, the district had recently experienced food shortages as well, the result of poor harvests (Kolyangha, 2023c).

4.3.2 Methodology

4.3.2.1 Location

Mbale municipality was selected as a base for fieldwork both because it is a hub for input supply to the surrounding districts and because my research assistant and I were previously familiar with the area. Neighboring Butebo district was selected as the location for the interviews for two reasons. First, on substantive grounds, Butebo seemed to provide the right balance between having agriculture as a primary economic activity yet not being so remote that input use would be too limited, even in the absence of shocks. As a practical matter, Butebo also was a desirable location in which to work because my research assistant had contacts there, ensuring we would have the access necessary to conduct the research.

4.3.2.2 Sampling Strategy

I employed snowball sampling to identify the initial participants. Snowball sampling was appropriate in this instance for several reasons. First, I was not attempting to obtain a statistically representative sample of the area, but rather to sample from a range of households. Second, as my questions had objective answers, I was not concerned that snowball sampling could lead to participants with similar opinions or affinities. Third, we were able to interview participants who experienced a variety of shocks, so the sampling strategy was not limiting when it came to the primary research question.

I relied on my research assistant's local contacts for an initial introduction to the communities. Our primary contact, a local businesswoman and farmer (whom we also interviewed) provided the initial introductions to our interview subjects. We also benefited from the support of the local LC3 or sub-county chairman, who accompanied us on some of our visits and helped to introduce us to the communities.

As it happened, we did not have to rely on the traditional snowball sampling technique for long. A crowd gathered at our interview site, perhaps because of the novelty of our presence, and perhaps because word got around that we were offering modest compensation to our participants (more on this below). We made sure that the group stayed far enough away so as to not be able to hear participants' responses, and impressed on them that they were not to interfere with the interview process. Eventually we handed out consent forms as a way of holding their place in line, and so that the prospective participants could begin to familiarize themselves with the paperwork.

I planned to interview 25-30 households, with the expectation that eventually we would reach "saturation" in the responses, i.e. there would not be much variation in the responses received with each additional participant (Small and Calarco, 2022). We ended up doing more interviews than initially planned, given the level of interest from the community (as well as the exhortations of the sub-county chairman, who communicated privately to my research assistant that we should include as many people as possible, as they know that the chairman brought us to the community and will be voting for him in the next election). The analysis below is based on the results of 32 interviews.

4.3.2.3 Questionnaire

The interviews were semi-structured, based on a pre-drafted questionnaire (included in the Appendix). The first section asked questions about the household head, while the second section focused on basic household characteristics such as the number of members, the number of acres farmed, and whether the household owned any livestock. The third section included questions about the household's usage of agricultural inputs, while the fourth section focused on shocks to the household and the coping strategies that households used in response.

It is worth elaborating on section four of the survey, as this contained the questions most relevant to the overall research question. Households were first asked to elucidate any "bad events" or shocks that had happened to them in the previous year. This question was left open-ended in order to allow the participants to define what they considered shocks. We then went through a list of possible shocks and asked the participant whether the household had experienced any of them. This was roughly the same list of shocks that are included in the Uganda National Panel Survey, in order to provide some level of comparability to the analysis done using that data in Paper 2. The shocks covered in Section 4 were as follows:

Table 4.1: Shocks Included in Survey Questionnaire

Idiosyncratic	Covariate
Reduced off-farm income	Poor rainfall or drought
Illness	Floods, landslides, or erosion
Birth	Pests or crop diseases
Death	Livestock disease
Contributions to social functions (weddings, funerals)	Higher input costs
Theft or violence	Lower output prices

For each shock, the participant was also asked how they coped with its effects. This question was also left open-ended. Once the full list of shocks had been considered, the participant was asked which was the "worst" or the biggest problem, which was purposefully left up to them to define, and then asked which shock had cost them the most money. They were also asked whether they had prepared for any shocks ahead of time. Finally, and most importantly, they were asked how the shocks of the previous year had influenced their decision to purchase inputs.

It is important to note that although the questionnaire was translated for the interviewees, I anticipate that there may have been a challenge translating my understanding of certain concepts to the local context. For example, I sensed that "coping strategy" did not map cleanly onto the local languages, and as such this introduces some subjectivity into the responses. Similarly, as discussed in Section 4.4.7, it is possible that the respondents had a different conception of "support from family and friends" or did not classify support from family and friends as a kind of coping strategy. An economist may view this kind of support in a more transactional sense, whereas if mutual support is deeply embedded in the local social and cultural institutions, it may not be perceived as a specific response to a shock. I am sensitive to the possibility that my respondents and I may have had different understandings of the questions included in the questionnaire.

4.3.2.4 Logistics

In the first community, we conducted interviews at individual homesteads. The majority of interviews took place in the second community, where we were offered seats to conduct the interviews under a tree in front of a house. It appeared to be a common gathering area for the village. Except for the first few interviews, which were made possible through snowball sampling, we selected participants from the crowd of people who had gathered. As mentioned above, we eventually started handing out consent forms as a way for prospective participants to hold their place in line, and we would then select the next participant from the group of individuals with forms. Although we asked questions about the head of the household, we did not insist that the person being interviewed was the household head.

Each time we began by reviewing the consent forms with the participants and then asking the participants to sign them. The consent forms were available in English, Luganda, and Lugishu; the majority of participants requested Luganda. As mentioned, the interviews were semi-structured: we used the questionnaire included in the Appendix to guide the interview, and asked follow-up questions where appropriate. I reviewed the questionnaire with my research assistant prior to going to the field, to ensure that we were on the same page about both the questions and my overall research objectives. My research assistant translated each response for me as the interview progressed, giving me the opportunity to ask him to probe for further information. The interviews were conducted in Lugeri, Lusoga, Luganda, Itesoti, and Lugishu. On average the interviews took 30-40 minutes to complete. We recorded the interviews using both a phone and a digital recorder.

At the conclusion of each interview, we gave the participant an honorarium and a copy of the consent form. Each participant was given UGX 10,000, or approximately GBP 2, as a token for their participation. It was important for me to recognize the participants for their time; smallholder farmers are often asked to complete long interviews under the assumption that they are not busy, and as such many research projects under-value their time. This amount felt appropriate, as it represents approximately the average daily wage for low-skilled workers in urban areas. Indeed, the Uganda Bureau of Statistics estimated that for 2016-17 the median monthly wage in rural areas was UGX 120,000, or approximately GBP 26 (UBOS, 2018). However, I do not believe that it was so generous as to generate undue pressure to participate in the survey. Participants were informed of the compensation as part of the recruitment process. Also, as was explained in the consent form, participants who chose to withdraw before the survey is completed would still receive the compensation.

4.3.2.5 Positionality

It is important to note that I am cognizant of the inherent power imbalance between myself, a "mzungu" or foreigner, and my interview subjects. Indeed, as mentioned above, our presence seemed to be something of a novelty in the village, which I believe contributed to us attracting a crowd of onlookers. We attempted to make the participants as comfortable as possible, but of course it is possible that they were nervous to speak to us. It is also possible that they responded with what they thought I wanted to hear, a risk that was unfortunately unavoidable. I considered the possibility of sending my research assistant to conduct the interviews alone, but felt that it was important to be present to be able to ask follow-up questions.

It is also worth noting that I came to these interviews having completed the quantitative analysis for Paper 2, which showed little impact of shocks on input purchases except for some potential impact on spending. It is possible that I was primed to hear certain responses as a result of having done this analysis, and this may have colored my follow-up questions. However, we did follow the questionnaire when completing the interviews, and the questions were mainly objective, meaning that my views and interpretations are less likely to impact on the results. I attempted to be as impartial as possible when analyzing the transcripts.

Finally, as mentioned, there was a death in the community during our time there. We canceled our visit one day as the community was attending the burial, and I discussed with my research assistant when it would be appropriate for us to return. I made a small monetary contribution to the family of the deceased, which is considered the appropriate gesture in their culture.

4.3.2.6 Ethics

The research was approved by the Oxford Department for International Development's Departmental Research Ethics Committee (ref: SSH/ODID DREC: C1A_22_085), the Mildmay Uganda Research Ethics Committee (ref: MUREC-2022-169) and the Uganda National Council for Science and Technology (ref: SS1724ES). My research assistant signed a confidentiality agreement.

I wish to flag two potential ethical issues. First, although it was clear in the consent form that participation was voluntary, it is possible that the incentive payment influenced people to participate who might otherwise have abstained. Given the subject matter of the interviews was not controversial, it is my belief that there was relatively little potential harm involved. Second, on the subject of COVID-19, we believed there to be relatively little risk of COVID-19 transmission, as cases in Uganda were under control. We took precautions, such as conducting interviews outside as much as possible, and when I felt unwell during fieldwork I took a test to rule out COVID-19.

4.3.2.7 Analysis

As mentioned above, the interviews were recorded. My research assistant used these recordings to produce transcriptions of the interviews, which faithfully represented the responses of the participants. The transcriptions were anonymized in order to protect the participants' identity. My analysis was based on these transcriptions, rather than field notes, in order to hew as closely as possible to what was actually said by the participants.

I then went through a process of coding the transcriptions, producing a spreadsheet that logged each participant's responses to the questions that were asked. This allowed me to look for patterns in the responses, which formed the basis of the analysis that is presented below.

Two caveats on the data: first, Doss et al. (2018) found that husbands and wives surveyed reported different numbers of shocks, suggesting that by interviewing only one household member we may not be getting the full picture. Second, there is potential for measurement error with self-reported illness data, as illness can mean different things to different households (Asfaw and Von Braun (2004), Gertler and Gruber (2002)). These limitations were borne in mind when analyzing the responses.

4.4 Results

4.4.1 Household Demographics

Table 4.2 provides a basic breakdown of the demographic and wealth characteristics that were captured in the interviews. Note that the respondents were asked about the age, education level, and farming experience of the household head; some respondents were not the head of the household. This meant that in many cases the number of years of farming experience was a rough estimate. Also, in one case, the household head did not farm, but the respondent did, so the years of experience were hers; in another case, the respondent was uncertain of the age

Table 4.2: Descriptive statistics

	Minimum	Maximum	Average
Age[a]	28	88	49.7
Education level[ab]	None	Diploma/Nurse	Primary 6/7
Number of years farming[ab]	3	70	20+
Number of household members	2	20	7.2
Number of adults	2	8	3.1
Acres farmed	<1	6	2
	Yes	No	
Membership in savings group[c]	46.9%	53.1%	
Own/access to mobile phone[c]	87.5%	12.5%	
Own livestock[c]	93.8%	6.3%	
Off-farm income[c]	84.4%	15.6%	

[a]These apply to the household head.

[b]These values are medians.

[c]These questions applied to the household as a whole.

Source: Author's calculations using interview data.

of the household head and provided hers instead. For the quotes that are cited below, I have provided the name of the respondent and the age of the household head.[3]

About half of the household heads were middle-aged, and their median level of education was 6-7 years of primary school. More than half had been farming for 20 years or more. There were 3.1 adults per household on average, comparable with the figures seen in Paper 2. They cultivated an average of 2 acres per household, and 72% cultivated 2 acres or fewer. This is slightly higher than the national figures from 2019, which showed that smallholder farmers cultivated an average of 1.1 acres, with the majority farming less than 2 acres and very few (0.1%) farming 5 acres or more (UBOS, 2022).[4] Though it is less than the average number of acres reported in the data used in Paper 2, which was roughly 3.9. In terms of the measures of wealth, nearly 90% owned or had access to a mobile phone (also an indicator of access to information), more than 90% owned livestock, and more than 80% had some source of off-farm income. Membership in a savings group was almost a 50-50 split, a potential source of credit for inputs (though this does not seem to have been the case, as discussed further below).

[3]Except in one instance where the respondent provided only their initials.

[4]These estimates were produced using an FAO methodology, whereby the number of small-scale producers was calculated using the bottom 40% of the cumulative distribution of operated land, number of animals (TLU), and total value of farm production.

4.4.2 Overview of Shocks

Shocks were very common in the communities I visited. In terms of production shocks, almost every household reported crop pests or diseases, livestock disease, and increased input costs. As previously mentioned, the area had experienced a drought, which every household reported. Idiosyncratic shocks were very common as well – almost every respondent reported illness of some kind and having to spend money on social expenditures such as weddings and funerals. This means that almost all the households I interviewed had experienced multiple shocks in the previous year. As one respondent described,

> Drought was rampant because it dried up most of the crops plus pests and diseases also attacked and affected some crops which had remained. As for livestock, diseases attacked mainly chicken where I ended up losing many and yet chicken does not have realistic treatment. The family as a whole got sick but I lost my husband's aunt with whom we were staying with. I also lost my mother, who was brought here for treatment, but when she got frailer, I took her back but later died. (Barbra, 40)

By and large, our questionnaire covered the shocks that households experienced – only a few mentioned other problems that fell outside of the categories we used.

Another respondent provided an example of the litany of shocks that households experienced:

> Q: First – which bad events did your household experience in the past year?
> Respondent: Drought, when it set in the crops dried and sometimes when the bad rains set in [like hail storm] they also destroyed crops. There was a problem of pests and diseases for example there was a pest that attacked maize, which could cut the stalk and the maize falls down, and also a disease which used to turn the leaves to yellow.
> Q: What about bad events at home?
> Respondent: In my household several times my kids and I get sick, and we go to the government health center for treatment. However, most times they prescribe drugs that we have to buy from drug shops and I end up selling some of my produce to finance that. I lost my grandmother although I was not staying with her, contributed

a bag of cement and UGX 50,000. I sold my produce to finance that too. (Christine, 47)

We asked respondents both which shock was the biggest problem for them and which was the most expensive. Interestingly, the answers to these questions differed significantly. Drought and illness were most commonly reported as the biggest problem that the households faced, but illness was far more commonly cited as the most expensive problem. This could be because the impact of the drought was more difficult to quantify than the money that was outlaid for treatment expenses. There were no obvious demographic patterns to the responses. When asked if they planned for any bad events to happen, almost all said no, although a few mentioned buying livestock as a kind of insurance mechanism against future expenditures, and three said they had planted cassava in expectation of a drought, as it fares better.

It was also possible to roughly calculate the most common coping strategies, based on the strategies that were reported – 260 in total across the various shocks. Recall from Paper 2 that the most common coping strategies were unconditional support from family and friends, "doing nothing," and relying on savings. Based on the respondents' answers, the most common coping strategy reported in my interviews was doing nothing (18%), though as discussed later this was heavily driven by the response to the drought that the community was experiencing. The second most common coping strategy was to sell produce (14%), followed by off-farm income (13%) and selling livestock (11%).[5] There is some mismatch between the categories used in Paper 2 and the open-ended responses provided by these respondents, so it is difficult to compare the results. For example, one coping strategy option in the data from the UNPS (used in Paper 2) was to take on more non-farm employment; this was certainly the case for some of the respondents here, who reported relying on off-farm income, but some were merely using the income they already had, not increasing their efforts. Selling produce was not an option in the UNPS, but could theoretically be classed as "using savings," if accumulated produce is treated as an asset. There were far more reports of livestock sales here than in Paper 2, where the figure was under 5%.

Overall, besides doing nothing, the other three top coping strategies (selling produce, off-farm income, and selling livestock) point to households using their accumulated assets and

[5]Interestingly, when asked whether the prices for their crops were lower than usual, the respondents that had participated in the market were almost evenly split on whether or not they were lower. This seems curious, as one would expect they were all experiencing the same local market conditions, but it is possible they were using different crops as reference points.

income to cope with shocks, rather than relying on family and friends – which appeared to be the most prevalent strategy in the UNPS results from Paper 2. Indeed, only 5% of the reported coping strategies were reliance on friends and family. Given the community experienced a covariate shock (the drought), it is possible that the households were simply unable to support each other when all had been negatively affected. It is also possible that there are different community norms around reciprocity and mutual support. Either way, these results suggest that the households had the resources to cope with most shocks themselves, as will be explored further in Section 4.5.

There were no obvious patterns in the demographic or wealth characteristics of respondents when it came to coping strategies, even for those who reported sources of off-farm income that are theoretically more remunerative (some of them still reported selling livestock, for example). Some reported a consistent coping strategy across the shocks, such as selling produce, though the majority said that they employed a portfolio of coping strategies. In some cases the appropriate coping strategy may have depended on the type of shock, but perhaps in other cases the coping strategy depended on the order in which the shocks were experienced – borrowing or relying on others' support, for example, when one's own resources are depleted.

4.4.3 Health Shocks

Almost all of the respondents reported illness in the household in the previous year. As discussed in Paper 2, illness shocks can have a negative effect on agricultural productivity. For example, Asenso-Okyere et al. (2011) describe three potential impacts of illness: the person who is ill has less time available to work, more time is spent by other household members on caregiving, and the households incurs costs to treat the illness, which could include transportation costs, the cost of medical services, and the time lost to seeking treatment. These three impacts combine to reduce the amount of time that is available for farm activities and reduce the level of liquid assets that might otherwise be used to invest in the farm, both of which can have a negative impact on agricultural productivity. As described by one respondent, "Yes, when in the village you can get a problem of treatment of the children who might deplete the money that would have been for inputs" (Fred, 70). Or as another responded, "I fell sick and did not get time to weed hence less yields" (Nasabu, 47).

In Uganda, most health expenditures are paid out of pocket, as few are insured (as discussed by Ssewanyana and Kasirye (2020)), and there is limited public provision of health services, though there are government-funded health clinics. In fact, there is a government hospital near the community that I visited, and more than a third of respondents reported visiting this facility for treatment. This helped to limit the impact of the illness shocks, as treatment at the government hospital is free. However, drugs and other consumables are not free, and several households reported having to spend money on these items. The community was fortunate to have free treatment available nearby, as treatment costs can sometimes have debilitating effects: several studies have shown how out-of-pocket health expenditures can lead to poverty, including Van Damme et al. (2004), McIntyre et al. (2006), Flores et al. (2008), Oudmane et al. (2019), and Ebaidalla and Ali (2019).

In a review of the literature on the economic impacts of health shocks in low- and middle-income countries, Alam and Mahal (2014) find that households cope with out of pocket health expenditures using income, savings, borrowing, and asset sales. I found a similar pattern in my interviews. The respondents who reported an illness shock used several coping strategies: savings, borrowing, support from family and friends, off-farm income, selling produce, and selling livestock. Selling produce or livestock and using funds earned through off-farm employment were the most common coping strategies. Three of the respondents said that their husbands paid for the treatment, and while it is possible that this money had been borrowed, these households did report seemingly better paying sources of off-farm income: a nurse with a drug shop, a mechanic, and a teacher. This speaks to the importance of off-farm income in buttressing households against shocks, as discussed further below. Indeed, six other respondents also mentioned off-farm income as one of their coping strategies for a health shock. Also, three of the four respondents that reported help from family and friends were among the oldest in the sample, and perhaps as a result had larger kin networks to support them, though two of them also reported that they were still working off-farm.

Despite these coping strategies, households that experienced illness still reported buying fewer inputs. One respondent stated "Yes, it affected me because I put a lot of money in treatment and bought less inputs" (Robert, 37), while another had purchased the same amount as the previous year but clarified that: "Yes I stated that but because of illnesses, you end up borrowing money, yet I would have bought more inputs" (Christine, 47). This may be because illness was most commonly cited as the most expensive shock the households faced.

Five households reported another kind of health shock: a birth. As discussed in Paper 2, pregnancy and birth can be a double shock, both requiring expenditures on health services and potentially reducing the available pool of labor.[6] Two of the households relied on family for support, one relied on family and friends and off-farm income, one sold livestock, and one mentioned attending the public hospital. Four said they purchased fewer inputs as a result of all of the shocks they experienced.

Finally, only a handful of deaths in the household were reported. As discussed in Paper 2, a death can have a significant monetary impact on a household, both in lost labor (depending on the age of the deceased) and funeral costs. Though family, friends, and community members are expected to contribute, as discussed below, a funeral can still be an expensive proposition for a household. As one respondent explained, "... [I]n the village there is an arrangement for every household to contribute in case of death but you also sell some of your property" (Fred, 70). Fortunately, one of the respondents that experienced a death was a member of a burial group, a mutual aid society where members typically contribute each month and receive a payment from the group when they experience a death (see Twesigye et al. (2019) for more). Another respondent received support from a burial group upon the death of an aunt, which I classified as a social expenditure as the aunt was not a member of the household. As the respondent described, "Within the community we have a group for women and it's called a burial group. It collects money and gives the person who has lost someone to cater for contributions" (Grace, 48). Unfortunately, one of the other households had to sell an acre of land to cope with the deaths it experienced, which can have a devastating impact on the household's productive capacity if this land had been used for farming, especially when most of these households are farming so little land to begin with.

4.4.4 Social Expenditures

We asked households whether they incurred any social expenditures, specifically asking about weddings and funerals, which are the most common. Recall from Paper 2 that the reported annual spending on social expenditures in 2019-20 was on average more than UGX 135,000 (GBP 28) per household per year among households that spent. This is high in comparison to the estimated UGX 120,000 median monthly wage in rural areas, approximately GBP 26 (UBOS, 2018). Traditionally, Ugandans are expected to contribute to the cost of weddings

[6] As I also discuss in Paper 2, I consider a birth a health shock, despite the fact that it is anticipated and therefore gives the household time to plan. Nevertheless, depending on the circumstances of the household, and the timing of the pregnancy vis-a-vis the agricultural seasons, the household may struggle to marshal the necessary resources in time.

and funerals within their social circle and community. These contributions are essential to the households that are hosting the wedding or funeral, just as De Weerdt and Dercon (2006) find that risk-sharing mechanisms such as gifts are the most important coping strategy in response to deaths in the household.

Depending on the tribe, weddings and funerals can be very large functions and therefore very expensive for the community. These expenses are not planned, which is why they represent a shock to the household, and they are seen as a social requirement, meaning they must be funded somehow. Both monetary and in-kind gifts are considered appropriate; gifts reported were as low as UGX 5,000 (GBP 1). For example, one respondent said “Yes I contributed a sack of cement and a bed sheet which is a norm in our culture” (Grace, 48) while another contributed a sack of cement and UGX 50,000 (GBP 10).

Social expenditures were an incredibly common shock, experienced by almost all of the households we interviewed. They were also second most commonly reported as the most expensive shock, after illness. Selling livestock and produce to finance social expenditures were the primary coping methods reported by the respondents; there were no obvious patterns to the coping mechanisms based on the characteristics of respondents. One respondent reported “No wedding events but for funerals we have attended and contributed. We sell some our produce to finance transport and other burial requirements like condolence” (Edinansi, 67). Another explained:

> Q: Did you lose anyone this past year?
>
> Respondent: Not in the family but the extended family who we buried.
>
> Q: Did you have to contribute for burial?
>
> Respondent: Very obvious, every clan member had to contribute a portion of what was tabled for each to pay.
>
> Q: How did you cope with that using your hard earned money?
>
> Respondent: Yes, you have to sell some of your produce or livestock like chicken to contribute to the cause. (Festo, 40)

4.4.5 Off-Farm Income

One pattern that showed in the interviews was the prevalence of off-farm income of some kind. Almost all respondents reported off-farm employment in some form. This tracks with evidence from the literature: using the UNPS data used in Paper 2, Nagler and Naudé (2017) find that 42% of rural Ugandan households operate non-farm enterprises of some sort. Furthermore, income diversification as a livelihood strategy is common in rural Africa, as discussed by Barrett et al. (2001). Working as a farm laborer was most common, while trading (such as buying and selling produce) was next most common. A few reported formal employment, such as teaching.

Relying on off-farm income is a common coping strategy in the literature. In one of the earlier studies on the impact of idiosyncratic shocks, Kochar (1995) finds that farm households in India respond to crop shocks by increasing wage income. In an analysis of Indonesia, Cameron and Worswick (2003) find that households reallocate labor from farming to off-farm labor activities following a crop loss. For Malawi, Coulibaly et al. (2015) found that farmers responded to crop failure primarily by pursuing off-farm income diversification. Chuang (2019) finds that Indian households respond to rainfall shocks by seeking off-farm income, while Cunguara et al. (2011) find that households in Mozambique respond to drought by engaging in off-farm income generating activities. Seeking off-farm income was the most prevalent coping strategy for the Ethiopian farmers facing weather shocks in the data analyzed by Gao and Mills (2018).

Interestingly, using off-farm income as a coping strategy was not reported very frequently by my respondents. Selling produce or livestock, for example, were far more common. It is possible, however, that the presence of off-farm income is underwriting these other coping strategies. Households may not be able to purchase livestock as a savings mechanism without this off-farm income, and may not be able to afford to sell produce without other income to finance food purchases. Though 12 of the respondents did report that their off-farm income had decreased in the prior year, so for them it may not have been available as a coping strategy; there were no common characteristics among these respondents, including their source of income. I would posit that in fact the participation in off-farm income generating activities is an essential preventative mechanism for these households, even if they did not report using the income directly to cope with shocks.

4.4.6 Doing Nothing

Recall that the most commonly reported coping strategy reported by respondents was "doing nothing." The analysis in Paper 2 found that this was the second most common coping strategy, both for households that purchased inputs and households that did not. There is evidence in the literature that this phenomenon occurs in other countries as well. Gao and Mills (2021) find in Niger, for example, that households that were exposed to a shock reported doing nothing as their most common coping strategy, followed by use of savings, asset sales, and informal social safety nets. For Malawi, Coulibaly et al. (2015) found that farmers responded to crop failure primarily by pursuing off-farm income diversification, though “doing nothing” was the third most common coping strategy. Similarly, Nikoloski et al. (2017), looking at data for six countries, find that many households report doing nothing.

The respondents that I interviewed rarely reported having “done nothing” as their coping strategy, with one major exception: drought. In the case of drought, the vast majority of households reported that there was nothing they could do to cope; a handful reported having the manpower and resources to be able to water their crops, and these seemed to have more remunerative off-farm activities. As one respondent said, “Coping with drought there was nothing I could do because I could not put on laborers to water the gardens” (Christine, 28). Another said watering was not even possible: “There is nothing that we could do because even watering with a watering can was impossible because there was no source of water” (George, 45). One said “I could not do anything about the drought and just prayed to God to help that the rains come” (Edith, 29), while another summed up the attitude of many of the respondents: “We had nothing to do but only to wait for the rains to set in and we plant afresh” (Ester, 49).

The fact that “doing nothing” was rarely cited as a coping strategy outside of the context of drought speaks to the strength of the coping mechanisms that these households had available to them – and to the ineffectiveness of informal mechanisms when facing an aggregate, community-level shock such as a drought. As discussed, most had a source of outside income to help underwrite their liquidity, and they were able to rely on selling produce and livestock as key coping mechanisms. They also benefited from the proximity of a government health facility that reduced the cost of treatment. Overall, as will be discussed further in Section 4.5, the community seems relatively resilient to the idiosyncratic shocks that it faced.

4.4.7 Social Support

Another interesting deviation from the findings in Paper 2 concerned the number of times respondents reported relying on family and friends for support following a shock. Recall that unconditional help from relatives and friends was the most commonly cited coping mechanism in the UNPS data, strong evidence of the importance of social networks in recovering from the impact of a shock. There is also much evidence in the literature that suggests that households rely on their family and friends following a shock. Looking at data from the Philippines, Fafchamps and Lund (2003) find that gifts and informal loans are common, mostly used for immediate consumption purposes. They further find that risk sharing takes place within small groups of family and friends, rather than at the village level. Wossen et al. (2016) show that households in Ethiopia with better social capital are able to smooth consumption in the face of shocks. Carter and Maluccio (2003) find that in South African communities with higher levels of social capital, households are better able to cope with idiosyncratic shocks. Using evidence from Ethiopia, Wuepper et al. (2018) find that households with greater social capital are more specialized, implying that households with access to support from family and friends do not see the need to diversify their income portfolios as a risk mitigation strategy. Grootaert (2002) finds that households with higher levels of social capital in Burkina Faso have higher per capita consumption expenditures and better access to credit. For a summary of the research on risk sharing between households, see Fafchamps (2011).

However, the households that I interviewed only cited support from family and friends on a few occasions, particularly for coping with illness, births, and social expenditures. This is despite the fact that most respondents indicated that they had family or friends they could rely on for support. When it comes to covariate shocks that impact the entire community, such as the drought, it would make sense to see less support from social networks. But for idiosyncratic shocks, we could expect to see more exchanges between households, particularly given the results from Paper 2. It is possible that there is not a strong culture of giving within this community; it is also possible that, given the sheer number of shocks these households reported facing, none had the extra resources to be able to offer support to other community members. Of course support from family and friends can also come from outside the immediate community, where the incidence of shocks may be different; however, this was not found in the interviews I conducted. Another possibility is that the respondents did not conceptualize monetary or in-kind gifts from family and friends as "support" – perhaps the practice is so normalized that it is not considered as a specific response to a particular event. Or the term calls to mind monetary support, and respondents did not consider in-kind support when describing their coping strategies.

4.4.8 Credit Access

Given the liquidity constraints that smallholder households face, access to credit is seen as a key enabler of investment in agricultural inputs. There is a literature that focuses on access to credit as a binding constraint to technology adoption – see for example Boucher et al. (2008), Guirkinger and Boucher (2008), Giné and Yang (2009), Matsumoto and Yamano (2011), and Verteramo Chiu et al. (2014). In a review of the existing literature, Magruder (2018) focuses on access to credit, access to insurance, and information as constraints to technology adoption. He finds that all three constraints are binding for at least some population of farmers. Mulvaney and Kelsey (2020) interviewed 30 Ugandan farmers and found a lack of cash/credit was a major barrier to investment, while Van Campenhout et al. (2016) found that access to credit, assets, and livestock were significant predictors of fertilizer usage among Ugandan rice and potato farmers. Adjognon et al. (2017) studied four countries, including Uganda, and found that input credit usage tends to be very low, with inputs usually self-financed from off-farm income or crop sales. Interestingly, farmers do not always avail themselves even when they have access to credit: Bridle et al. (2019) found in a review of nine randomized evaluations that a majority of farmers did not take out loans when offered credit.

Slightly under half of households I interviewed reported membership in a savings group. These are common institutions in Uganda, whereby members of a community or interest group join together and pool savings to create a pot of money that can then be lent out to members or disbursed at the end of the year. Despite having access to credit through membership in the savings group, several respondents reported that the interest rates were too high for them to use this credit to finance input purchases. This is a common problem with agricultural microfinance in Uganda – farmers struggle to find lending terms that accommodate the risk profile, ideal repayment period, and interest rates that would facilitate investment in agricultural production. As one respondent reported, "I don't take myself to have access to credit because the savings group where I belong, gives credit but by the time the season ends, the interest has accumulated to an extent that you may sell your produce to pay back and end up with nothing" (Christine, 28). Another cited a similar issue: "I don't have access to credit even in the savings group, because their interest is so high which can make you fail to pay" (Edith, 29). Another does not borrow from the savings group because "You can put money in farming and end up getting a loss" (Esther, 34). These problems exist outside of the savings groups as well – one respondent described the interest rates they would face should they try to access credit: "The interests are too high for example for every UGX 100,000, you pay UGX 50,000 as interest [50%], if you borrow and use for agriculture and the season goes bad, you end up failing to pay" (Nasabu, 47). Some community members may have been able to borrow informally from each other, although this was not discussed.

Overall, credit access seems to be high within the communities I visited. Interestingly, when asked whether they trusted their local agrodealer, thirteen respondents volunteered that one of the reasons they trust him is that he gives them credit. When asked about credit access in general, two-thirds of respondents said they have access to credit, including the credit offered by the agrodealer. Fourteen respondents said they purchased inputs on credit in the past year, thirteen of whom had reported that the local input dealer gives them credit (though I did not ask the source of the credit in every case). One described the arrangement with the agrodealer: "Yes I did purchase on credit inputs, planted, and harvested and the agro dealer bought the produce. Therefore, I paid his debt and he gave me the balance" (DW, 60). Of the remaining respondents, eight had access to credit but did not borrow (with one citing the high interest rate charged by the savings group), while the rest said they had no access to credit. There were no obvious demographic or wealth patterns among those with/without access to credit. Understandably, members of savings groups were more likely to report access to credit.

4.4.9 Livestock Sales

It is worth dwelling for a moment on the frequency with which the households reported selling livestock as a coping mechanism – the fourth most common response, at 11%. The respondents that reported selling livestock did not have any obvious common characteristics, except of course for the fact that they all owned livestock (though not all households with livestock reported this coping mechanism). Livestock in this context functions as a savings mechanism in addition to a productive asset. The livestock are sold when need arises: as one respondent explained, "We also buy chicken and goats which we sell later to pay for bills like school fees" (Nasabu, 47). The respondents valued their livestock: 28 respondents reported having experienced livestock disease, and all but one paid to treat the animal, with several saying they sold produce in order to do so.[7] Unfortunately, livestock are also a common target for thieves: of the 15 respondents that reported a theft, 11 said they had lost livestock.

As mentioned above, when asked if they had planned for or expected any of the shocks that occurred, six respondents said they used livestock as insurance against unexpected expenses. One explained: "Yes, one strategy was buying the cow to provide milk for the children and it also acts as security in case need arises, we sell the calf" (Julius, 38). As another described,

[7]One respondent reported that all of their chickens died but it was unclear whether they had done anything to treat them.

"Usually you expect some problems that is why I buy goats so that I can sell to solve my problems" (Grace, 48). Yet there are risks that come with selling productive assets, which undermines the future income growth potential of the household.

Ansah et al. (2021) differentiate between asset smoothing (coping mechanisms that aim to preserve productive assets, such as diversifying income or decreasing consumption) and consumption smoothing (where assets are depleted to maintain consumption, such as through selling livestock, using savings, or engaging in off-farm work). Based on a stochastic model of rural households, Zimmerman and Carter (2003) find that the poorer households in their model use changes in consumption to buffer assets in the face of shocks, choosing an asset smoothing strategy, while wealthier households pursue consumption smoothing. By relying on livestock sales, the households in this sample appear to have chosen consumption smoothing. Thus although the households appear to have coped relatively well with the impact of the shocks, this may be at the expense of their longer-term productivity.

4.4.10 Input Purchases

This final section of results addresses the primary research question: did the experience of shocks influence households' purchasing decision when it came time to invest in inputs for their farm? The respondents were asked this explicitly at the end of the interview, after we had discussed both their input usage in the previous year and the shocks the household had experienced. Recall from Paper 2 that there was limited evidence that the experience of a shock impacted whether or not a household purchased inputs, but that there was some evidence that the amount spent on inputs decreased.

Every household reported having purchased inputs of some sort in the previous year, even if they only purchased local (not improved) seed.[8] Twenty-five respondents reported having purchased either local or improved seed, twenty reported having purchased pesticides, and fifteen purchased fertilizer. When asked why they purchased the inputs that they did, the respondents provided a variety of answers: they purchased what they could afford, the inputs were purchased to produce better yields, they were needed to treat pests, etc. Pests and crop diseases were rampant, reported by 30 of the respondents; most purchased pesticides, and some reported selling livestock or produce in order to do so. Eight did nothing, and four specified

[8]Though a few respondents later stated that they did not buy inputs as a result of the shocks they experienced – so for at least three households there was a discrepancy between their responses at different points in the interview.

that it was because they had no money; they had no clear common characteristics. Several respondents stated that they prefer local seeds to improved seeds, citing that local seeds grow faster or yield better. One respondent mentioned avoiding improved seeds for fear of purchasing counterfeits. When asked if they felt confident in their knowledge of how to use inputs, 68.8% said they were; among those who lacked confidence, there was no clear pattern when it came to education level or number of years farming.

Almost every respondent reported that he or she had purchased fewer inputs as a result of the totality of the shocks the household had experienced.[9] This tracks with the results from Paper 2, and suggests that the shocks had some impact on the households' cash flow in such a way that they were unable to invest in their desired amount of inputs. Here are a few of their explanations:

- "Yes, especially the death of my son cost me a lot and led me buy less inputs." (Nasabu, 47)
- "They influenced my purchasing power in that I bought less." (Esther, 30)
- "Yes it affected me on what I purchased because I had to go for less and I had to sell some of my home kept seeds to solve some of my problems." (Ayubu, 30)
- "All the problems have a cost implication causing one to go and borrow, therefore sometimes I may be forced not to buy or to buy in less quantities." (Susan, 39)
- "The problems have cost me a lot because I wanted to buy tomatoes and hope to harvest in December but the lack of funds is the major setback." (Fred, 70)
- "The need arose especially during the drought period where I used to spend a lot of money on food preventing me from inputs that's why I bought one kilo of maize." (Zebidayo, 53)
- "Yes, it affected me because I put a lot of money in treatment and bought less inputs." (Robert, 37)

Similarly, though all reported input purchases, when asked what would have prevented them from buying inputs, 29 respondents mentioned a lack of money. This is further evidence that

[9] A few said the shocks did not influence their input purchasing decision; once again, they were among those with seemingly more remunerative off-farm income sources, though others with similar sources reported that they purchased less.

input purchases are sensitive to the household's level of liquidity at the time of planting, which is often impacted by a shock.

Those who reported buying less included almost every household that reported purchasing inputs on credit in the previous year. So although access to credit was an enabler for these households, the shocks they experienced seem to have led them to reduce their debt load by purchasing less. The respondents also reported high price sensitivity when it came to changes in input prices. Almost all said that input costs were higher than usual in the previous year. When asked how they coped with the higher prices, thirteen respondents said they bought less – a common response that was unprompted, as the question was open-ended. There were no demographic patterns behind these responses. One respondent said that buying inputs was the biggest problem for them in the previous year – perhaps a reflection of the increased input costs. This shock in particular seems to have influenced how much the households spent on inputs, though the effect was limited to the intensive margin, as all still purchased inputs.

Interestingly, though family and friends were not commonly cited as a coping strategy – certainly not as commonly as was found in Paper 2 – nineteen respondents reported that they were able to get help in buying inputs from family and friends, and a number of them reported having received that help in the previous year. For example, "Yes, my brother usually once in a while helps when I don't have money," according to one respondent (Christine, 28), and "Yes, I have especially my mother in Mbale whenever I request for something she assists me," according to another (Esther, 34). It is unclear why this support was not reported as a coping strategy elsewhere in the interviews; it is possible that the respondents didn't perceive the support in those terms, particularly if it wasn't in response to a specific shock. Yet although so many respondents reported support from family and friends in buying inputs, they still reported buying less than they desired, suggesting that the support was not enough to cover the cash flow deficit caused by the shocks.

Overall, it would appear that the households' input purchases were very sensitive to the households' liquidity when it came time to purchase inputs – liquidity that in many cases was influenced by the shocks they experienced. Indeed, when asked what would have prevented them from buying inputs, almost every respondent reported that a lack of money would be the main barrier. As one explained, "Sometimes it can be sickness, like in children and money is finished on medical and you cannot buy the inputs" (Edinansi, 67). Another also cited untimely expenses as a barrier to input purchases: "School fees takes a lot of money plus sickness/illnesses. It can be a wrong timing and you find yourself failing to buy inputs" (Nasabu, 47). These results suggest that there is indeed a linkage between shocks and input purchases, and that in the case of these communities the shocks they experienced led to them purchasing fewer inputs.

4.5 Conclusion

What can we conclude from this analysis? The respondents reported a myriad of shocks, from drought and pests to illness and social expenditures. Yet the vast majority also reported having purchased inputs, suggesting that the impact of these shocks was muted. Indeed, the majority also reported having purchased less, especially in the face of increased input prices, yet they were still able to invest in production in the previous year. Clearly the shocks had an impact of some sort, seemingly dampening the households' spending power, but they were not so severe as to preclude input purchases entirely.

How should we interpret this phenomenon? One possibility is that the shocks themselves are not as severe as I had initially hypothesized. This could explain the households' ability to maintain some level of input expenditure even after experiencing compounded shocks. Yet the literature reviewed here and in Paper 2 suggests that shocks such as the ones seen here can have profound effects on smallholder farm households, both on their labor productivity and on their resource envelope. It seems unlikely that the shocks had minimal effect, particularly since in most cases the households reported having to resort to a coping strategy to recover.

I would like to posit that something else is at work here, namely that the households in this sample have demonstrated remarkable resilience. Recall the main coping strategies that the households reported using: doing nothing (primarily in response to the drought), selling produce, off-farm income, and selling livestock. Unlike the results from Paper 2, the households did not rely on family and friends as a primary coping mechanism, though many did report receiving support to buy inputs from family and friends. Instead, they relied on their own resources to cope with the shocks, which demonstrates a high level of resilience.

How do we define resilience? Resilience is a buzzword in international development discourse at the moment, with no consensus definition. The US Agency for International Development (USAID) has a Center for Resilience, which it defines as "the ability of people, households, communities, countries and systems to mitigate, adapt to and recover from shocks and stresses in a manner that reduces chronic vulnerability and facilitates inclusive growth" USAID (2023).

The UK government defines resilience as "the ability of countries, communities and households to manage change by maintaining or transforming living standards in the face of shocks or stresses without compromising their long term prospects" (Sturgess and Sparrey, 2016). Béné et al. (2014) highlight three critical dimensions of resilience: absorptive capacity (the ability to resist the impact of a shock or change), adaptive capacity (the ability to make incremental adjustments, such as diversifying livelihoods), and transformative capacity (the ability to make fundamental shifts to modes of production, for example). The authors consider these three capacities as ordered, linked to different intensities of shock or change (moving from absorptive to adaptive and then to transformative). There is much debate over how to define and then measure the concept of household resilience, as discussed by Béné et al. (2016), Ansah et al. (2019), Barrett et al. (2021), Constas et al. (2022) and Upton et al. (2022), and some discussion as to its limitations, as in Béné et al. (2014).

There is limited evidence as to the drivers of resilience in Uganda. In an analysis of resilience in Uganda, d'Errico and Di Giuseppe (2018) find that female headed-households, large households, and households involved in crop activities are likely to be less resilient, while better-educated households and those that have self-managed enterprises are likely to be more resilient. Using data from Tanzania and Uganda, d'Errico et al. (2018) find that a household's adaptive capacity is the most important factor in determining its resilience, and that level of education and the proportion of income earners in the household are the drivers of adaptive capacity.

If we take resilience to broadly mean a household is able to withstand the impact of a shock or stress in a way that allows it to maintain its standard of living, it would appear that the households in the sample exhibited high levels of resilience. Though we do not have information about the household's consumption levels, we do know that the households continued to invest in inputs, which suggests enough of a surplus was available beyond immediate consumption needs. This could demonstrate that the households are aware of the potential "poverty trap" that could arise if they fail to purchase inputs, remaining stuck in a cycle of low investment and low returns (see Barrett et al. (2016) for a review). It is unclear, however, whether the households will have the adaptive capacity to manage and absorb major changes to their risk environment, such as may occur due to conflict or climate change, particularly given the overwhelmingly negative impact of the drought on the community. The community appears to be in a resilience "equilibrium" for now, but may not remain so in future – evidence of current resilience does not mean these communities should not be strengthened by government and donor programs in order to better withstand the shocks that may be coming their way. Overall, the results suggest that for households of this type, the impact of shocks on input purchases is less severe than one might hypothesize, and that policies to promote input investment should focus on other barriers to adoption.

4.6 Appendix

OXFORD DEPARTMENT OF INTERNATIONAL DEVELOPMENT
Queen Elizabeth House
3 Mansfield Road, Oxford OX1 3TB
Tel: +44 (0)1865 (2)81800
www.qeh.ox.ac.uk

Principal Investigator: Courtney Blair, DPhil Candidate
Email: courtney.blair@sant.ox.ac.uk
Local Researcher: Wante Jackson Isiko
wanteisiko@gmail.com, +256 701 879505

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This interview guide corresponds to Research Protocol v4 dated 3/23/2023.

Study Title: Understanding Ugandan Smallholder Farmers' Perspectives on Risk in the Context of Input Adoption

Phase 1: Smallholder Farmer Household Interview

Interview Guide

Section 1:

First we will ask some questions about the head of your household:

1. What is his or her age?
2. What is his or her highest level of education?
3. How long has he or she been farming?

Section 2:

Now we will ask some questions about your household:

1. How many household members are there?
2. How many acres does your household regularly farm?
3. Does anyone in your household belong to a savings group?
4. Does anyone in your household own or have access to a mobile phone?
5. Does your household own any livestock?
6. Does your household have income from something besides farming? What is the source of the income?

Section 3:

These questions will be about your use of agricultural inputs:

1. Is there an agrodealer nearby, or somewhere you can purchase agricultural inputs?
    a. If yes:
        i. How far away?
2. Do you trust this person?
3. Did you purchase agricultural inputs in the last year? This includes improved seed, fertilizer, pesticides, herbicides, and other chemicals.
    a. If yes:
        i. What did you purchase for the first season?
        ii. What did you purchase for the second season?
        iii. Why did you decide to purchase these inputs?
        iv. What would have prevented you from buying inputs?
    b. If no:
        i. Why didn't you purchase agricultural inputs?
4. Are you concerned that using improved seed or fertilizer would create more risk for your harvest?
5. Certain inputs such as seed and fertilizer can be purchased in very small quantities. Have you considered buying a small quantity, such as would cost 2,000 or 5,000 shillings, to test the product on your farm?
    a. If no:
        i. Why not?
6. Do you feel confident in your knowledge of how to use improved seed? What about fertilizer?
7. How did you learn about how to use improved seed? What about fertilizer?
8. If you had questions about agricultural inputs, who would you ask for help?
9. Do you have access to credit?
    a. If yes:
        i. Could you have purchased inputs on credit?
            1. If yes:
                a. Did you purchase inputs on credit this past year?
            2. If no:
                a. Why not?
10. What do you know about the problem with counterfeit inputs?
11. How did you find out about the problem with counterfeit inputs?
12. What do you do to avoid counterfeit inputs?

Section 4:

Now we will ask about some of the events that your household may have faced in the past year:

1. Which of these did you experience in the last year:
    a. Was there poor rainfall or drought?
    b. What about floods, landslides, or erosion?
    c. Did you experience any pests or crop diseases?
    d. Did you experience any livestock disease?
    e. Were the costs of agricultural inputs higher than usual?

f. Were the prices for your crops lower than usual?
g. Were there any other problems with your farm? What were they?
h. Did your income from outside your farm decrease?
i. Did anyone in your household experience illness?
j. Has there been a death in your household?
k. Have you contributed money or other resources to help pay for a wedding?
l. Have you contributed money or other resources to help pay for a funeral?
m. Did you experience theft or violence?
n. Did you experience any other problems that we have not mentioned?

2. Which of these was the biggest problem for you?
3. Which cost you the most money?
4. Did you expect any of these things to happen, even if they didn't occur?
    a. If yes:
        i. What did you expect would happen?
5. Are there other events that you expect could happen to you? What are they? Which is the most serious / would cause the biggest problem?
6. How did these events influence your decision to purchase agricultural inputs?

OXFORD DEPARTMENT OF INTERNATIONAL DEVELOPMENT
Queen Elizabeth House
3 Mansfield Road, Oxford OX1 3TB
Tel: +44 (0)1865 (2)81800
www.qeh.ox.ac.uk

Principal Investigator: Courtney Blair, DPhil Candidate
Email: courtney.blair@sant.ox.ac.uk
Local Researcher: Wante Jackson Isiko
wanteisiko@gmail.com, +256 701 879505

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Study Title: Understanding Ugandan Smallholder Farmers' Perspectives on Risk in the Context of Input Adoption

Phase 2: Agrodealer Interview

Interview Guide

Section 1:

First we will ask some questions about your business:

1. How long has this business been operating?
2. Why did you decide to enter into this type of business?
3. What is the most popular product that you sell?
4. Do you have regular clients that return every season or every time they purchase inputs? What percentage of your clients would you say are regular?
5. Do you conduct outreach to gain new clients? What do you do?
6. How do you get new information about the products you sell and how to use them?

Section 2:

Now we will ask some questions about your relationship with your customers:

1. Do you provide information to your clients? What type of information?
2. Do you provide product recommendations? How do you decide which products to recommend?
3. Do your clients rely on you to recommend products, or do they know what they want already?
4. Do you provide different information or recommendations to new vs. established clients?
5. Do you provide credit to your clients?
    a. If yes:
        i. How do you decide which customers to offer credit to?
6. Do you ever encourage farmers to sample small amounts of the products, so they can test them on their farms?

7. Do your clients know about how to use inputs properly? Do you provide them with this information?
8. Do you think that most farmers in your area understand the benefits of using inputs?
    a. If no:
        i. Why not?
9. Why don't more farmers purchase inputs?

Section 3:

Now we would like to ask some questions about your experience with counterfeit inputs:

1. Are you aware of the problem with counterfeit inputs?
    a. If yes:
        i. How did you come to know about it?
2. How do you get new information about which products are counterfeit?
3. Where do you think the counterfeit products are coming from?
4. What steps do you take to avoid purchasing counterfeit products?
5. Do you feel confident in your ability to identify counterfeit products?
6. What do you look for to know if a product is counterfeit?
7. Do you provide information to farmers about counterfeit products?
    a. If yes:
        i. What information do you provide?

Chapter 5

Conclusion

5.1 Thesis Summary

This thesis has commented on two types of risks that farmers face: counterfeit products and idiosyncratic shocks. The *prima facie* hypothesis of my research was that these risks would act as a barrier to technology adoption. I explored this hypothesis using existing and novel datasets, making use of both qualitative and quantitative methods.

Paper 1 focuses on the risk of counterfeit products, an acknowledged problem in Uganda that is starting to garner attention from international researchers. Using a dataset that I was instrumental in collecting and constructing, we analyzed whether farmers' knowledge of the presence of counterfeit products influenced their decision to purchase inputs. We found that awareness of counterfeits is positively and significantly related to farmers' use of agricultural chemicals, suggesting that the presence of counterfeits does not serve as a binding constraint on adoption. This implies that farmers are engaging in risk management strategies to avoid counterfeit products, whether by relying on their own ability to identify them or patronizing trusted agrodealers.

My second paper shifted the focus to idiosyncratic shocks, those shocks such as illness and death that impact a single household (as opposed to poor weather or pests, which can affect an entire community). Using nationally representative household survey data, I looked specifically at whether the realization of a shock impacted the household's decision to purchase inputs. I found almost no evidence of a statistical relationship between shocks and input purchases, and limited evidence suggesting that experiencing a shock influenced the amount spent on inputs. Instead I found that households had a portfolio of coping strategies, relying on help from relatives/friends and their own savings in particular, which seemed to allow them to absorb the impact of the shock.

My final paper extends the exploration of idiosyncratic shocks through qualitative interview data collected during fieldwork in Uganda. Similar to Paper 2, I find that most households purchase inputs, although most also reported that they purchased fewer inputs as a result of the shocks they experienced in the previous year (which included covariate shocks). The respondents reported similar coping strategies, namely selling produce, off-farm income, and selling livestock, which again seemed to allow the households to absorb the impact of the shocks they experienced.

5.2 Final reflections

What are the main takeaways from this research? First of all, though we already have ample evidence, it is clear that smallholder farmers face a variety of risks. Though not as prevalent as covariate shocks such as drought, idiosyncratic shocks nevertheless play a non-trivial role in farmers' lives, and have the potential to destabilize households. They also have the potential to impact farmers' ability to invest in their farms through the purchase of agricultural inputs. Yet the one consistent result across my three papers is that farmers are still managing to purchase inputs despite these risks.

How is that possible? These papers provide further evidence that farmers have strategies to manage the risks that they face. When it comes to counterfeit products, this includes buying from trusted agrodealers and abandoning products that perform poorly. As for idiosyncratic shocks, farmers appear to manage risk through a variety of coping strategies, including relying on the community for support and buffering income shocks through their own savings. The households in my studies display a relatively high level of resilience, even if it falls short of full insurance.

Tellingly, one of the farmers I spoke to that did not purchase inputs cited risk as the main reason they do not purchase inputs. They don't trust their local agrodealer, and know that they run the risk of purchasing poor quality products from them: "First of all, some sell expired items, secondly, here they use wrong weighing scales and they want to make a lot of profits on items and they are not reliable." And when asked why they don't purchase inputs, they responded:

> Respondent: Some are fake, when you plant, they don't germinate very well, sec-

> ondly, they are very expensive for example you find a kilogram of beans at a high amount than when you get from yours. They buy at a low amount like UGX 2,500 and when you go to their store they sell at amount higher like UGX 8,000 or UGX 10,000 and that why I keep my seeds. Q: Any other reasons? Respondent: Other reasons is, you may find expired seeds because they take long and also they apply some chemicals for example me when I store my seeds am able to get some and use for food now when you go and find they have added some chemicals you can't consume it.

Besides the understandable price sensitivity, this farmer is wary of purchasing counterfeit or poor quality products that will not germinate or yield properly. Of all the reasons he or she could have cited, from lack of knowledge to lack of access to needing credit, the risk of buying subpar products was top of mind. This farmer's situation also emphasizes the need for trustworthy, reliable agrodealers, who are on the front lines of combating counterfeit products and providing reassurance to farmers – this farmer may have had a different perspective on purchasing improved seed if he or she had access to such an agrodealer.

From a policy perspective, there are several lessons to be learned. First, when it comes to counterfeit products, it is essential to cultivate relationships between farmers and agrodealers, and to ensure that agrodealers are well-educated on strategies to identify and avoid counterfeit products. There have been previous interventions to this effect in Uganda, and I can only recommend that they continue. Knowledge of counterfeits was widespread in the areas surveyed in Paper 1, but as mentioned this could be the result of previous development efforts, and so greater sensitization is also likely needed to reach other farmers in the country. As for the risk of idiosyncratic shocks, it would appear that smallholder farmers are relatively well-insured against them, though interventions could encourage informal institutions such as savings and burial groups. Overall, though, it would appear that different barriers need to be addressed, such as access to credit or even physical access to quality products.

As for future research, though there have been several promising studies on the counterfeits issue in Uganda, more investigation is still needed to understand the source and scope of the problem – pinpointing where in the supply chain these products are cropping up and how widespread they are. I would also recommend more research be done into how farmers come to know about the counterfeit issue, the best ways of reaching them with information about the problem, and how to promote trusting relationships between farmers and agrodealers. Given mine is one of the few studies to investigate the role of idiosyncratic shocks in patterns of input adoption, I would also recommend further studies into the relationship between idiosyncratic shocks and input purchase, to build the evidence base further. And since there was some limited evidence that the shocks reduced input purchases on the intensive margin, it would be interesting to see more research on informal insurance transactions, as clearly the coping mechanisms did not fully cover the impact of the shocks.

Perhaps my main personal takeaway from this research is that too often the narratives of aid projects and even academic articles go too far in undermining the agency of smallholder farmers and their ability to anticipate and cope with the risk that is ever-present in their lives. They can be resourceful and resilient. They employ risk-management strategies both as individual households and as communities. They understand the value of continuing to invest in their farms when it's within their ability to do so. We must provide them with the support and resources they need, and generate research-backed evidence we can act upon, to ensure that as many farmers as possible are able to make the investment in agricultural inputs.

Bibliography

Abay, K. A., G. Blalock, G. Berhane. 2017. Locus of control and technology adoption in developing country agriculture: Evidence from Ethiopia. *Journal of Economic Behavior & Organization* **143** 98–115. ISSN 0167-2681. DOI 10.1016/j.jebo.2017.09.012. https://ezproxy-prd.bodleian.ox.ac.uk:2056/science/article/pii/S0167268117302536. Publisher: North-Holland.

Abedullah, S. Pandey. 2004. Risk and Fertilizer Use in the Rainfed Rice Ecosystem of Tarlac, Philippines. *Journal of Agricultural and Applied Economics* **36**(1) 241–250.

Abet, T., A. K. Odaka. 2023. 60 districts move out of malaria epidemic. *Monitor* https://www.monitor.co.ug/uganda/news/national/60-districts-move-out-of-malaria-epidemic-4308394.

Abid, M., A. Ali, D. B. Rahut, M. Raza, M. Mehdi. 2020. Ex-ante and ex-post coping strategies for climatic shocks and adaptation determinants in rural Malawi. *Climate Risk Management* **27** 100200. ISSN 22120963. DOI 10.1016/j.crm.2019.100200. https://linkinghub.elsevier.com/retrieve/pii/S2212096319302116.

Acosta, A., F. Nicolli, P. Karfakis. 2021. Coping with climate shocks: The complex role of livestock portfolios. *World Development* **146** 105546. ISSN 0305-750X. DOI 10.1016/j.worlddev.2021.105546. https://www.sciencedirect.com/science/article/pii/S0305750X21001613.

Adjognon, S. G., L. S. O. Liverpool-Tasie, T. A. Reardon. 2017. Agricultural input credit in Sub-Saharan Africa: Telling myth from facts. *Food Policy* **67** 93–105. ISSN 03069192. DOI 10.1016/j.foodpol.2016.09.014. https://linkinghub.elsevier.com/retrieve/pii/S0306919216303815.

Adong, A. 2014. Impact of households' membership of farmer groups on the adoption of agricultural technologies in Uganda: Evidence from the Uganda Census of Agriculture 2008/09. *Agrekon* **53**(2) 108–136. ISSN 0303-1853, 2078-0400. DOI 10.1080/03031853.2014.915485. http://www.tandfonline.com/doi/abs/10.1080/03031853.2014.915485.

Adong, A., J. Tinker, D. Levine, S. Mbowa, T. Odokonyero. 2020. Encouraging fertilizer adoption through risk free sales offer: A randomized control trial in Uganda. *World Development Perspectives* **19** 100230. ISSN 24522929. DOI 10.1016/j.wdp.2020.100230. https://linkinghub.elsevier.com/retrieve/pii/S2452292920300527.

Agamile, P., R. Dimova, J. Golan. 2021. Crop Choice, Drought and Gender: New Insights from Smallholders' Response to Weather Shocks in Rural Uganda. *Journal of Agricultural Economics* **72**(3) 829–856. ISSN 1477-9552. DOI 10.1111/1477-9552.12427. https://onlinelibrary.wiley.com/doi/abs/10.1111/1477-9552.12427. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/1477-9552.12427.

Agamile, P., D. Lawson. 2021. Rainfall shocks and children's school attendance: evidence from Uganda. *Oxford Development Studies* **49**(3) 291–309. ISSN 1360-0818, 1469-9966. DOI 10.1080/13600818.2021.1895979. https://www.tandfonline.com/doi/full/10.1080/13600818.2021.1895979.

Agulanna, F. T., A. E. Ikpi, V. O. Okoruwa, V. O. Akinyosoye. 2013. A Synergetic Linkage between Agricultural Productivity, Nutrition and Health. *African Journal of Biomedical Research* **16**(1) 1–9. ISSN 1119-5096. DOI 10.4314/ajbr.v16i1. https://www.ajol.info/index.php/ajbr/article/view/108945. Number: 1.

Ajambo, R., G. Elepu, B. Bashaasha, P. Okori. 2017. Farmers' preferences for maize attributes in eastern and Western Uganda. *African Crop Science Journal* **25**(2) 177–187. ISSN 2072-6589. DOI 10.4314/acsj.v25i2.4. https://www.ajol.info/index.php/acsj/article/view/156973. Number: 2.

Ajani, O. I. Y., W. M. Ashagidigbi. 2008. Effect of malaria on rural households' farm income in oyo state, nigeria. *African Journal of Biomedical Research* **11**(3). ISSN 1119-5096. DOI 10.4314/ajbr.v11i3.50723. https://www.ajol.info/index.php/ajbr/article/view/50723. Number: 3.

Ajefu, J. B. 2017. Income shocks, informal insurance mechanisms, and household consumption expenditure. *International Journal of Social Economics* **44**(12) 1818–1832. ISSN 03068293. DOI https://doi.org/10.1108/IJSE-04-2015-0094. https://www.proquest.com/docview/1962248960/abstract/73F52BEC33124B4DPQ/1. Num Pages: 15 Place: Bradford, United Kingdom Publisher: Emerald Group Publishing Limited.

Akerlof, G. A. 1970. The Market for "Lemons": Quality Uncertainty and the Market Mechanism. *The Quarterly Journal of Economics* **84**(3) 488–500. ISSN 0033-5533. DOI 10.2307/1879431. https://www.jstor.org/stable/1879431. Publisher: Oxford University Press.

Alam, K., A. Mahal. 2014. Economic impacts of health shocks on households in low and middle income countries: a review of the literature. *Globalization and Health* **10**(1) 21. ISSN 1744-8603. DOI 10.1186/1744-8603-10-21. https://doi.org/10.1186/1744-8603-10-21.

Alene, A. D., V. Manyong, G. Omanya, H. Mignouna, M. Bokanga, G. Odhiambo. 2008. Smallholder market participation under transactions costs: Maize supply and fertilizer demand in Kenya. *Food Policy* **33**(4) 318–328. ISSN 03069192. DOI 10.1016/j.foodpol.2007.12.001. https://linkinghub.elsevier.com/retrieve/pii/S0306919207000681.

Ali, R. 2010. Impact of Rural Road Improvement on High Yield Variety Technology Adoption: Evidence from Bangladesh. Working Papers 95255, University of Maryland, Department of Agricultural and Resource Economics. DOI 10.22004/ag.econ.95255.

Ali, W., A. Abdulai, A. K. Mishra. 2020. Recent Advances in the Analyses of Demand for Agricultural Insurance in Developing and Emerging Countries. *Annual Review of Resource Economics* **12**(1) 411–430. ISSN 1941-1340, 1941-1359. DOI 10.1146/annurev-resource-110119-025306. https://www.annualreviews.org/doi/10.1146/annurev-resource-110119-025306.

Aliga, A., F. Matovu, F. Wasswa. 2023. How do the poor cope with health shocks? Experiences from a cross-sectional study in Uganda. *Australasian Medical Journal* **16**(4) 611–624. DOI 10.21767/AMJ.2022.3935. https://www.proquest.com/openview/82991bcd5f5644c8f4149ed3f73054e8/1?pq-origsite=gscholar&cbl=54991.

Amare, M., N. D. Jensen, B. Shiferaw, J. D. Cissé. 2018. Rainfall shocks and agricultural productivity: Implication for rural household consumption. *Agricultural Systems* **166** 79–89.

ISSN 0308521X. DOI 10.1016/j.agsy.2018.07.014. https://linkinghub.elsevier.com/retrieve/pii/S0308521X18302440.

Amare, M., B. Shiferaw. 2017. Nonfarm employment, agricultural intensification, and productivity change: empirical findings from Uganda. *Agricultural Economics* **48**(S1) 59–72. ISSN 01695150. DOI 10.1111/agec.12386. https://onlinelibrary.wiley.com/doi/10.1111/agec.12386.

Amare, M., B. Shiferaw, H. Takeshima, G. Mavrotas. 2021. Variability in agricultural productivity and rural household consumption inequality: Evidence from Nigeria and Uganda. *Agricultural Economics* **52**(1) 19–36. ISSN 1574-0862. DOI 10.1111/agec.12604. https://ezproxy-prd.bodleian.ox.ac.uk:2152/doi/10.1111/agec.12604. Publisher: John Wiley & Sons, Ltd.

Amponsah, S. 2016. The Incidence of Health Shocks, Formal Health Insurance, and Informal Coping Mechanisms. *Perspectives on Global Development and Technology* **15**(6) 665–695. ISSN 1569-1500, 1569-1497. DOI 10.1163/15691497-12341412. https://brill.com/view/journals/pgdt/15/6/article-p665_4.xml.

Amurwon, J., F. Hajdu, J. Seeley. 2015. The relevance of timing of illness and death events in the household life cycle for coping outcomes in rural Uganda in the era of HIV. *International Journal for Equity in Health* **14**(1) 105. ISSN 1475-9276. DOI 10.1186/s12939-015-0253-0. http://www.equityhealthj.com/content/14/1/105.

Anderson, S. 2007. The Economics of Dowry and Brideprice. *Journal of Economic Perspectives* **21**(4) 151–174. ISSN 0895-3309. DOI 10.1257/jep.21.4.151. https://pubs.aeaweb.org/doi/10.1257/jep.21.4.151.

Andrews, F. M., R. Crandall, R. M. Andrews. 1976. The Validity of Measures of Self-Reported Well-Being. *Social Indicators Research* **3**(1) 1–19. ISSN 0303-8300. https://www.jstor.org.ezproxy-prd.bodleian.ox.ac.uk/stable/27521775. Publisher: Springer.

Ansah, I. G. K., C. Gardebroek, R. Ihle. 2019. Resilience and household food security: a review of concepts, methodological approaches and empirical evidence. *Food Security* **11**(6) 1187–1203. ISSN 1876-4525. DOI 10.1007/s12571-019-00968-1. https://doi.org/10.1007/s12571-019-00968-1.

Ansah, I. G. K., C. Gardebroek, R. Ihle. 2021. Shock interactions, coping strategy choices and household food security. *Climate and Development* **13**(5) 414–426. ISSN 1756-5529. DOI 10.1080/17565529.2020.1785832. https://ezproxy-prd.bodleian.ox.ac.uk:2398/doi/full/10.1080/17565529.2020.1785832. Publisher: Taylor & Francis.

Antle, J. M., P. L. Pingali. 1994. Pesticides, Productivity, and Farmer Health: A Philippine Case Study on JSTOR. *American Journal of Agricultural Economics* **76**(3) 418–430. https://ezproxy-prd.bodleian.ox.ac.uk:2116/stable/1243654.

Antonelli, C., M. Coromaldi, G. Pallante. 2022. Crop and income diversification for rural adaptation: Insights from Ugandan panel data. *Ecological Economics* **195** 107390. ISSN 09218009. DOI 10.1016/j.ecolecon.2022.107390. https://linkinghub.elsevier.com/retrieve/pii/S0921800922000520.

Appleton, S., A. Balihuta. 1996. Education and agricultural productivity: Evidence from Uganda. *Journal of International Development* **8**(3) 415–444. ISSN 09541748, 10991328. DOI 10.1002/(SICI)1099-1328(199605)8:3⟨415::AID-JID396⟩3.0.CO;2-9. https://onlinelibrary.wiley.com/doi/10.1002/(SICI)1099-1328(199605)8:3<415::AID-JID396>3.0.CO;2-9.

Ariga, J., E. Mabaya, M. Waithaka, M. Wanzala-Mlobela. 2019. Can improved agricultural technologies spur a green revolution in Africa? A multicountry analysis of seed and fertilizer delivery systems. *Agricultural Economics* **50**(S1) 63–74. ISSN 1574-0862. DOI 10.1111/agec.12533. https://onlinelibrary.wiley.com/doi/abs/10.1111/agec.12533. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/agec.12533.

Arslan, A., F. Belotti, L. Lipper. 2017. Smallholder productivity and weather shocks: Adoption and impact of widely promoted agricultural practices in Tanzania. *Food Policy* **69** 68–81. ISSN 03069192. DOI 10.1016/j.foodpol.2017.03.005. https://linkinghub.elsevier.com/retrieve/pii/S0306919217301872.

Arslan, A., R. Cavatassi, F. Alfani, N. Mccarthy, L. Lipper, M. Kokwe. 2018. Diversification Under Climate Variability as Part of a CSA Strategy in Rural Zambia. *The Journal of Development Studies* **54**(3) 457–480. ISSN 0022-0388, 1743-9140. DOI 10.1080/00220388.2017.1293813. https://www.tandfonline.com/doi/full/10.1080/00220388.2017.1293813.

Asenso-Okyere, K., F. A. Asante, J. Tarekegn, K. Andam. 2009. The Linkages Between Agriculture and Malaria: Issues for Policy, Research, and Capacity Strengthening. IFPRI Discussion Paper 00861, International Food Policy Research Institute, Washington, DC.

Asenso-Okyere, K., C. Chiang, P. Thangata, K. Andam. 2011. Interactions between health and farm-labor productivity. Food Policy Report, International Food Policy Research Institute, Washington, D.C. OCLC: ocn708356426.

Asfaw, A., J. Von Braun. 2004. Is Consumption Insured against Illness? Evidence on Vulnerability of Households to Health Shocks in Rural Ethiopia. *Economic Development and Cultural Change* **53**(1) 115–129. ISSN 0013-0079. DOI 10.1086/423255. `https://www.jstor.org/stable/10.1086/423255`. Publisher: The University of Chicago Press.

Asfaw, S., A. P. Mortari, A. Arslan, P. Karfakis, L. Lipper. 2015. Welfare Impacts of Climate Shocks: Evidence from Uganda. In *Agriculture in an Interconnected World*. Milan, Italy. DOI 10.22004/ag.econ.230217.

Asfaw, S., G. Pallante, A. Palma. 2018. Diversification Strategies and Adaptation Deficit: Evidence from Rural Communities in Niger. *World Development* **101** 219–234. ISSN 0305750X. DOI 10.1016/j.worlddev.2017.09.004. `https://linkinghub.elsevier.com/retrieve/pii/S0305750X16301863`.

Asfaw, S., A. Scognamillo, G. D. Caprera, N. Sitko, A. Ignaciuk. 2019. Heterogeneous impact of livelihood diversification on household welfare: Cross-country evidence from Sub-Saharan Africa. *World Development* **117** 278–295. ISSN 0305750X. DOI 10.1016/j.worlddev.2019.01.017. `https://linkinghub.elsevier.com/retrieve/pii/S0305750X19300233`.

Ashour, M., L. Billings, D. O. Gilligan, N. Karachiwalla. 2015. An Evaluation of the Impact of E-verification on Counterfeit Agricultural Inputs and Technology Adoption in Uganda. Baseline Report, International Food Policy Research Institute. `https://www.ifpri.org/publication/evaluation-impact-e-verification-counterfeit-agricultural-inputs-and-technology-adoption`.

Ashour, M., D. O. Gilligan, J. B. Hoel, N. I. Karachiwalla. 2019. Do Beliefs About Herbicide Quality Correspond with Actual Quality in Local Markets? Evidence from Uganda. *The Journal of Development Studies* **55**(6) 1285–1306. ISSN 0022-0388, 1743-9140. DOI 10.108

0/00220388.2018.1464143. https://www.tandfonline.com/doi/full/10.1080/00220388.2018.1464143.

Ashraf, M., J. K. Routray. 2013. Perception and understanding of drought and coping strategies of farming households in north-west Balochistan. *International Journal of Disaster Risk Reduction* **5** 49–60. ISSN 22124209. DOI 10.1016/j.ijdrr.2013.05.002. https://linkinghub.elsevier.com/retrieve/pii/S2212420913000344.

Asiimwe, J. B., P. Mpuga. 2007. Implications of Rainfall Shocks for Household Income and Consumption in Uganda. AERC Research Paper 168, African Economic Research Consortium, Nairobi. https://www.africaportal.org/publications/implications-of-rainfall-shocks-for-household-income-and-consumption-in-uganda/. Publisher: African Economic Research Consortium (AERC).

Asravor, R. K. 2019. Farmers' risk preference and the adoption of risk management strategies in Northern Ghana. *Journal of Environmental Planning and Management* **62**(5) 881–900. ISSN 0964-0568. DOI 10.1080/09640568.2018.1452724. https://ezproxy-prd.bodleian.ox.ac.uk:2398/doi/full/10.1080/09640568.2018.1452724. Publisher: Routledge.

Attanasio, O., S. J. Davis. 1996. Relative Wage Movements and the Distribution of Consumption. *Journal of Political Economy* **104**(6) 1227–1262. ISSN 0022-3808. https://www.jstor.org/stable/2138938. Publisher: University of Chicago Press.

Audibert, M., J. Etard. 2003. Productive Benefits after Investment in Health in Mali. *Economic Development and Cultural Change* **51**(3) 769–782. ISSN 0013-0079, 1539-2988. DOI 10.1086/367982. http://www.journals.uchicago.edu/doi/10.1086/367982.

Auriol, E., S. G. M. Schilizzi. 2015. Quality signaling through certification in developing countries. *Journal of Development Economics* **116** 105–121. ISSN 0304-3878. DOI 10.1016/j.jdeveco.2015.03.007. https://www.sciencedirect.com/science/article/pii/S0304387815000437.

Awotide, B. A., T. Abdoulaye, A. Alene, V. M. Manyong. 2015. Impact of Access to Credit on Agricultural Productivity: Evidence from Smallholder Cassava Farmers in Nigeria. 34. Milan, Italy.

Babcock, B. A. 2015. Using Cumulative Prospect Theory to Explain Anomalous Crop Insurance Coverage Choice. *American Journal of Agricultural Economics* **97**(5) 1371–1384. ISSN 0002-9092, 1467-8276. DOI 10.1093/ajae/aav032. https://onlinelibrary.wiley.com/doi/abs/10.1093/ajae/aav032.

Badiane, O., J. Ulimwengu. 2013. Malaria incidence and agricultural efficiency in Uganda. *Agricultural Economics* **44**(1) 15–23. ISSN 01695150. DOI 10.1111/j.1574-0862.2012.00626.x. https://onlinelibrary.wiley.com/doi/10.1111/j.1574-0862.2012.00626.x.

Baez, J. E., G. Caruso, C. Niu. 2018. Extreme Weather and Poverty Risk: Evidence from Multiple Shocks in Mozambique. Technical Report 11, World Bank Group. https://doi.org/10.1007/s41885-019-00049-9.

Bagamba, F., P. R. Ntakyo, G. Otim, D. J. Spielman, B. Van Campenhout. 2023. Policy and performance in Uganda's seed sector: Opportunities and challenges. *Development Policy Review* **41**(3) e12665. ISSN 1467-7679. DOI 10.1111/dpr.12665. https://onlinelibrary.wiley.com/doi/abs/10.1111/dpr.12665. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/dpr.12665.

Bahta, Y. T. 2022. Nexus between Coping Strategies and Households' Agricultural Drought Resilience to Food Insecurity in South Africa. *Land* **11**(6) 893. ISSN 2073-445X. DOI 10.3390/land11060893. https://www.mdpi.com/2073-445X/11/6/893. Number: 6 Publisher: Multidisciplinary Digital Publishing Institute.

Baksh, M., C. G. Neumann, M. Paolisso, R. M. Trostle, A. Jansen. 1994. The influence of reproductive status on rural Kenyan women's time use. *Social Science & Medicine* **39**(3) 345–354. ISSN 02779536. DOI 10.1016/0277-9536(94)90130-9. https://linkinghub.elsevier.com/retrieve/pii/0277953694901309.

Bandiera, O., I. Rasul. 2006. Social Networks and Technology Adoption in Northern Mozambique. *The Economic Journal* **116**(514) 869–902. ISSN 0013-0133, 1468-0297. DOI 10.1111/j.1468-0297.2006.01115.x. https://academic.oup.com/ej/article/116/514/869/5087879.

Baranabas, O., O. David, S. Edward, K. Rabecca, M. M. Geoffrey. 2023. Assessing the Smallholder Farmers' Coping Strategies to the Effects of Climate Change: Evidence in Rural Districts of Northern Uganda. *International Journal of Agriculture and Animal Produc-*

tion(IJAAP) ISSN 2799-0907 **3**(03) 11–24. ISSN 2799-0907. DOI 10.55529/ijaap.33.11.24. http://hmjournals.com/journal/index.php/IJAAP/article/view/1879. Number: 03.

Barrett, C., T. Reardon, P. Webb. 2001. Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. *Food Policy* **26**(4) 315–331. ISSN 03069192. DOI 10.1016/S0306-9192(01)00014-8. https://linkinghub.elsevier.com/retrieve/pii/S0306919201000148.

Barrett, C. B., T. Garg, L. McBride. 2016. Well-Being Dynamics and Poverty Traps. *Annual Review of Resource Economics* **8** 303–327. ISSN 1941-1340. https://www.jstor.org/stable/26773368. Publisher: Annual Reviews.

Barrett, C. B., K. Ghezzi-Kopel, J. Hoddinott, N. Homami, E. Tennant, J. Upton, T. Wu. 2021. A scoping review of the development resilience literature: Theory, methods and evidence. *World Development* **146** 105612. ISSN 0305750X. DOI 10.1016/j.worlddev.2021.105612. https://linkinghub.elsevier.com/retrieve/pii/S0305750X21002278.

Barriga, A., N. Fiala. 2020. The supply chain for seed in Uganda: Where does it go wrong? *World Development* **130** 104928. ISSN 0305750X. DOI 10.1016/j.worlddev.2020.104928. https://linkinghub.elsevier.com/retrieve/pii/S0305750X20300541.

Bayite-Kasule, S. 2009. Inorganic fertilizer in Uganda: Knowledge gaps, profitability, subsidy, and implications of a national policy. Technical Report Brief No. 8, International Food Policy Research Institute.

Beaman, L., A. BenYishay, J. Magruder, A. M. Mobarak. 2018. Can Network Theory-based Targeting Increase Technology Adoption? NBER Working Paper 24912, National Bureau of Economic Research.

Beaman, L., D. Karlan, B. Thuysbaert, C. Udry. 2014. Selection into Credit Markets: Evidence from Agriculture in Mali. NBER Working Paper 20387, National Bureau of Economic Research, Cambridge, MA. DOI 10.3386/w20387. http://www.nber.org/papers/w20387.pdf.

Behrman, J. R., A. D. Foster, M. R. Rosenzweig. 1997. The dynamics of agricultural production and the calorie-income relationship: Evidence from Pakistan. *Journal of Econometrics* **77** 187–207.

Benson, T., P. Lubega, S. Bayite-Kasule, T. Mogues, J. Nyachwo. 2012. The Supply of Inorganic Fertilizers to Smallholder Farmers in Uganda: Evidence for Fertilizer Policy Development. IFPRI Discussion Paper 01228, International Food Policy Research Institute.

Berha, A. N., Y. K. Mogess, M. A. Wassie. 2021. Revisiting nutrition–labor productivity link: new empirical evidence from farm households in Ethiopia. *Agriculture & Food Security* **10**(1) 61. ISSN 2048-7010. DOI 10.1186/s40066-021-00312-x. https://agricultureandfoodsecurity.biomedcentral.com/articles/10.1186/s40066-021-00312-x.

Berloffa, G., F. Modena. 2013. Income shocks, coping strategies, and consumption smoothing: An application to Indonesian data. *Journal of Asian Economics* **24** 158–171. ISSN 10490078. DOI 10.1016/j.asieco.2012.11.004. https://linkinghub.elsevier.com/retrieve/pii/S1049007812001108.

Berman, R. J., C. H. Quinn, J. Paavola. 2015. Identifying drivers of household coping strategies to multiple climatic hazards in Western Uganda: implications for adapting to future climate change. *Climate and Development* **7**(1) 71–84. ISSN 1756-5529, 1756-5537. DOI 10.1080/17565529.2014.902355. http://www.tandfonline.com/doi/abs/10.1080/17565529.2014.902355.

Besley, T. 1995. Nonmarket Institutions for Credit and Risk Sharing in Low-Income Countries. *Journal of Economic Perspectives* **9**(3) 115–127. ISSN 0895-3309. DOI 10.1257/jep.9.3.115. https://pubs.aeaweb.org/doi/10.1257/jep.9.3.115.

Binswanger, H. P. 1980. Attitudes toward Risk: Experimental Measurement in Rural India. *American Journal of Agricultural Economics* **62**(3) 395–407. ISSN 0002-9092. DOI 10.2307/1240194. https://www.jstor.org/stable/1240194. Publisher: [Agricultural & Applied Economics Association, Oxford University Press].

Bizimungu, E., N. S. Kabunga. 2018. A latent class analysis of improved agro-technology use behavior in Uganda: Implications for optimal targeting. IFPRI Discussion Paper 01704, International Food Policy Research Institute, Washington, DC. DOI 10.2499/1024320661. https://ebrary.ifpri.org/digital/collection/p15738coll2/id/132258. Edition: 0.

Blair, C., E. Gralla, J. Goentzel. 2018. Postmortem on Recent Experiments with E-verification in Uganda's Seed Sector. Technical report, USAID/Uganda Feed the Future Market System

Monitoring Activity. https://dspace.mit.edu/handle/1721.1/142789. Accepted: 2022-05-27T13:57:40Z.

Blattman, C., J. C. Jamison, T. Koroknay-Palicz, K. Rodrigues, M. Sheridan. 2015. Measuring the Measurement Error: A Method to Qualitatively Validate Survey Data. https://www-nber-org.ezproxy-prd.bodleian.ox.ac.uk/system/files/working_papers/w21447/w21447.pdf.

Bocquého, G., F. Jacquet, A. Reynaud. 2014. Expected utility or prospect theory maximisers? Assessing farmers' risk behaviour from field-experiment data. *European Review of Agricultural Economics* **41**(1) 135–172. ISSN 1464-3618, 0165-1587. DOI 10.1093/erae/jbt006. https://academic.oup.com/erae/article-lookup/doi/10.1093/erae/jbt006.

Bohr, N., T. Deisemann, D. Gollin, F. Kosmowski, T. J. Lybbert. 2024. The seeds of misallocation: Fertilizer use and maize varietal misidentification in Ethiopia. *Journal of Development Economics* **171** 103349. ISSN 0304-3878. DOI 10.1016/j.jdeveco.2024.103349. https://www.sciencedirect.com/science/article/pii/S0304387824000981.

Bold, T., K. C. Kaizzi, J. Svensson, D. Yanagizawa-Drott. 2017. Lemon Technologies and Adoption: Measurement, Theory and Evidence from Agricultural Markets in Uganda. *The Quarterly Journal of Economics* **132**(3) 1055–1100. ISSN 0033-5533, 1531-4650. DOI 10.1093/qje/qjx009. https://academic.oup.com/qje/article/132/3/1055/3064350.

Bonfrer, I., E. Gustafsson-Wright. 2017. Health shocks, coping strategies and foregone healthcare among agricultural households in Kenya. *Global Public Health* **12**(11) 1369–1390. DOI 10.1080/17441692.2015.1130847. https://www.tandfonline.com/doi/epdf/10.1080/17441692.2015.1130847?needAccess=true. ISSN: 1744-1692.

Bonilla-Cedrez, C., J. Chamberlin, R. J. Hijmans. 2021. Fertilizer and grain prices constrain food production in sub-Saharan Africa. *Nature Food* **2**(10) 766–772. ISSN 2662-1355. DOI 10.1038/s43016-021-00370-1. https://www.nature.com/articles/s43016-021-00370-1.

Bora, K. 2022. Rainfall shocks and fertilizer use: a district level study of India. *Environment and Development Economics* **27**(6) 556–577. ISSN 1355-770X, 1469-4395. DOI 10.1017/S1355770X21000413. https://www.cambridge.org/core/journals/environment-and-development-economics/article/rainfall-shocks-and-fertilizer-use-a-district-level

-study-of-india/8F3026D669EE3A1CCF01980C5D993577. Publisher: Cambridge University Press.

Boucher, S. R., M. R. Carter, C. Guirkinger. 2008. Risk Rationing and Wealth Effects in Credit Markets: Theory and Implications for Agricultural Development. *American Journal of Agricultural Economics* **90**(2) 409–423. ISSN 0002-9092, 1467-8276. DOI 10.1111/j.1467-8276.2007.01116.x. https://onlinelibrary.wiley.com/doi/10.1111/j.1467-8276.2007.01116.x.

Bozzola, M., M. Smale, S. Di Falco. 2018. Climate, shocks, weather and maize intensification decisions in rural Kenya. In C. S. Berck, P. Berck, S. D. Falco, eds., *Agricultural Adaptation to Climate Change in Africa: Food Security in a Changing Environment*. Routledge. ISBN 978-1-351-36951-0. Google-Books-ID: BGVQDwAAQBAJ.

Brenner, P. S., J. DeLamater. 2016. Lies, Damned Lies, and Survey Self-Reports? Identity as a Cause of Measurement Bias. *Social Psychology Quarterly* **79**(4) 333–354. ISSN 0190-2725. https://www.jstor.org.ezproxy-prd.bodleian.ox.ac.uk/stable/44078252. Publisher: [Sage Publications, Inc., American Sociological Association].

Brick, K., M. Visser. 2015. Risk preferences, technology adoption and insurance uptake: A framed experiment. *Journal of Economic Behavior & Organization* **118** 383–396. ISSN 01672681. DOI 10.1016/j.jebo.2015.02.010. https://linkinghub.elsevier.com/retrieve/pii/S0167268115000451.

Bridle, L., J. Magruder, C. McIntosh, T. Suri. 2019. Experimental Insights on the Constraints to Agricultural Technology Adoption. Working Paper, Agricultural Technology Adoption Initiative (ATAI).

Brune, L., X. Giné, J. Goldberg, D. Yang. 2011. Commitments to Save: A Field Experiment in Rural Malawi. Policy Research Working Paper 5748, World Bank. https://elibrary.worldbank.org/doi/abs/10.1596/1813-9450-5748.

Bruxvoort, K., C. Festo, M. Cairns, A. Kalolella, F. Mayaya, S. P. Kachur, D. Schellenberg, C. Goodman. 2015. Measuring Patient Adherence to Malaria Treatment: A Comparison of Results from Self-Report and a Customised Electronic Monitoring Device. *PLOS ONE* **10**(7) e0134275. ISSN 1932-6203. DOI 10.1371/journal.pone.0134275. https://dx.plos.org/10.1371/journal.pone.0134275.

Bumb, B., D. I. Gregory. 2006. Factors affecting supply of fertilizer in Sub-Saharan Africa. Agriculture and Rural Development Discussion Paper 24, World Bank. https://www.semanticscholar.org/paper/Factors-affecting-supply-for-fertilizer-in-Africa-Bumb-Gregory/4d3b4bb1bafcb999d22f874c0d774785f90d770d.

Burgard, S. A., P. V. Chen. 2014. Challenges of health measurement in studies of health disparities. *Social Science & Medicine* **106** 143–150. ISSN 0277-9536. DOI 10.1016/j.socscimed.2014.01.045. https://www.sciencedirect.com/science/article/pii/S0277953614000720.

Burke, W. J., T. S. Jayne, J. R. Black. 2017. Factors explaining the low and variable profitability of fertilizer application to maize in Zambia. *Agricultural Economics* 12.

Butler, J. S., R. V. Burkhauser, J. M. Mitchell, T. P. Pincus. 1987. Measurement Error in Self-Reported Health Variables. *The Review of Economics and Statistics* **69**(4) 644–650. ISSN 0034-6535. DOI 10.2307/1935959. https://www.jstor.org.ezproxy-prd.bodleian.ox.ac.uk/stable/1935959. Publisher: The MIT Press.

Béné, C., R. M. Al-Hassan, O. Amarasinghe, P. Fong, J. Ocran, E. Onumah, R. Ratuniata, T. V. Tuyen, J. A. McGregor, D. J. Mills. 2016. Is resilience socially constructed? Empirical evidence from Fiji, Ghana, Sri Lanka, and Vietnam. *Global Environmental Change* **38** 153–170. ISSN 09593780. DOI 10.1016/j.gloenvcha.2016.03.005. https://linkinghub.elsevier.com/retrieve/pii/S0959378016300267.

Béné, C., A. Newsham, M. Davies, M. Ulrichs, R. Godfrey-Wood. 2014. Review Article: Resilience, Poverty and Development. *Journal of International Development* **26**(5) 598–623. ISSN 1099-1328. DOI 10.1002/jid.2992. https://onlinelibrary.wiley.com/doi/abs/10.1002/jid.2992. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/jid.2992.

Cai, J., A. D. Janvry, E. Sadoulet. 2015. Social Networks and the Decision to Insure. *American Economic Journal: Applied Economics* **7**(2) 81–108. ISSN 1945-7782, 1945-7790. DOI 10.1257/app.20130442. https://pubs.aeaweb.org/doi/10.1257/app.20130442.

Call, M., C. Gray, P. Jagger. 2019. Smallholder responses to climate anomalies in rural Uganda. *World Development* **115** 132–144. ISSN 0305750X. DOI 10.1016/j.worlddev.2018.11.009. https://linkinghub.elsevier.com/retrieve/pii/S0305750X18304133.

Cameron, L. A., C. Worswick. 2003. The Labor Market as a Smoothing Device: Labor Supply Responses to Crop Loss. *Review of Development Economics* **7**(2) 327–341. ISSN 13636669. DOI 10.1111/1467-9361.00194. https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,uid&db=bsu&AN=9491937&site=ehost-live&authtype=ip,uid. Publisher: Wiley-Blackwell.

Carter, M., A. de Janvry, E. Sadoulet, A. Sarris. 2017. Index Insurance for Developing Country Agriculture: A Reassessment. *Annual Review of Resource Economics* **9**(1) 421–438. ISSN 1941-1340. DOI 10.1146/annurev-resource-100516-053352. https://ezproxy-prd.bodleian.ox.ac.uk:3118/doi/10.1146/annurev-resource-100516-053352. Publisher: Annual Reviews.

Carter, M., R. Laajaj, D. Yang. 2014. Subsidies and the Persistence of Technology Adoption: Field Experimental Evidence from Mozambique. NBER Working Paper 20465, National Bureau of Economic Research, Cambridge, MA. DOI 10.3386/w20465. http://www.nber.org/papers/w20465.pdf.

Carter, M., R. Laajaj, D. Yang. 2021. Subsidies and the African Green Revolution: Direct Effects and Social Network Spillovers of Randomized Input Subsidies in Mozambique. *American Economic Journal: Applied Economics* **13**(2) 206–229. ISSN 1945-7782, 1945-7790. DOI 10.1257/app.20190396. https://pubs.aeaweb.org/doi/10.1257/app.20190396.

Carter, M. R. 2016. What farmers want: the “gustibus multiplier” and other behavioral insights on agricultural development. *Agricultural Economics* **47**(S1) 85–96. ISSN 01695150. DOI 10.1111/agec.12312. https://onlinelibrary.wiley.com/doi/10.1111/agec.12312.

Carter, M. R., L. Cheng, A. Sarris. 2016. Where and how index insurance can boost the adoption of improved agricultural technologies. *Journal of Development Economics* **118** 59–71. ISSN 03043878. DOI 10.1016/j.jdeveco.2015.08.008. https://linkinghub.elsevier.com/retrieve/pii/S0304387815000991.

Carter, M. R., R. Laajaj, D. Yang. 2013. The Impact of Voucher Coupons on the Uptake of Fertilizer and Improved Seeds: Evidence from a Randomized Trial in Mozambique. *American Journal of Agricultural Economics* **95**(5) 1345–1351. ISSN 0002-9092, 1467-8276. DOI 10.1093/ajae/aat040. https://onlinelibrary.wiley.com/doi/abs/10.1093/ajae/aat040.

Carter, M. R., P. D. Little, T. Mogues, W. Negatu. 2007. Poverty Traps and Natural Disasters in Ethiopia and Honduras. *World Development* **35**(5) 835–856. ISSN 0305-750X. DOI 10.1016/j.worlddev.2006.09.010. https://www.sciencedirect.com/science/article/pii/S0305750X07000149.

Carter, M. R., T. J. Lybbert. 2012. Consumption versus asset smoothing: testing the implications of poverty trap theory in Burkina Faso. *Journal of Development Economics* **99**(2) 255–264. ISSN 03043878. DOI 10.1016/j.jdeveco.2012.02.003. https://linkinghub.elsevier.com/retrieve/pii/S0304387812000077.

Carter, M. R., J. A. Maluccio. 2003. Social Capital and Coping with Economic Shocks: An Analysis of Stunting of South African Children. *World Development* **31**(7) 1147–1163. ISSN 0305750X. DOI 10.1016/S0305-750X(03)00062-7. https://linkinghub.elsevier.com/retrieve/pii/S0305750X03000627.

CGTN. 2019. Marriage Traditions in Uganda: Lavish ways of paying bride price come under debate. *CGTN* https://news.cgtn.com/news/334d444f774d4464776c6d636a4e6e62684a4856/index.html.

Chapoto, A., T. Jayne. 2008. Impact of AIDS-Related Mortality on Farm Household Welfare in Zambia. *Economic Development and Cultural Change* **56**(2) 327–374. ISSN 0013-0079, 1539-2988. DOI 10.1086/522894. http://www.journals.uchicago.edu/doi/10.1086/522894.

Chavas, J., C. Nauges. 2020. Uncertainty, Learning, and Technology Adoption in Agriculture. *Applied Economic Perspectives and Policy* **42**(1) 42–53. ISSN 2040-5790, 2040-5804. DOI 10.1002/aepp.13003. https://onlinelibrary.wiley.com/doi/10.1002/aepp.13003.

Christiaensen, L., L. Demery, eds. 2017. *Agriculture in Africa: Telling Myths from Facts*. The World Bank. ISBN 978-1-4648-1134-0 978-1-4648-1137-1. DOI 10.1596/978-1-4648-1134-0. http://elibrary.worldbank.org/doi/book/10.1596/978-1-4648-1134-0.

Chuang, Y. 2019. Climate variability, rainfall shocks, and farmers' income diversification in India. *Economics Letters* **174** 55–61. ISSN 01651765. DOI 10.1016/j.econlet.2018.10.015. https://linkinghub.elsevier.com/retrieve/pii/S0165176518304270.

Clarke, D. J. 2016. A Theory of Rational Demand for Index Insurance. *American Economic*

Journal: Microeconomics **8**(1) 283–306. ISSN 1945-7669, 1945-7685. DOI 10.1257/mic.2014 0103. https://pubs.aeaweb.org/doi/10.1257/mic.20140103.

Clot, S., C. Y. Stanton, M. Willinger. 2017. Are impatient farmers more risk-averse? Evidence from a lab-in-the-field experiment in rural Uganda. *Applied Economics* **49**(2) 156–169. ISSN 0003-6846. DOI 10.1080/00036846.2016.1192277. https://ezproxy-prd.bodleian.ox.ac.uk:2398/doi/full/10.1080/00036846.2016.1192277. Publisher: Routledge.

Cochrane, J. H. 1991. A Simple Test of Consumption Insurance. *Journal of Political Economy* **99**(5) 957–976. ISSN 0022-3808. https://www.jstor.org/stable/2937654. Publisher: University of Chicago Press.

Cole, M. A., E. Neumayer. 2006. The impact of poor health on total factor productivity. *The Journal of Development Studies* **42**(6) 918–938. ISSN 0022-0388, 1743-9140. DOI 10.1080/00220380600774681. https://www.tandfonline.com/doi/full/10.1080/0022038060077 4681.

Cole, S., X. Giné, J. Vickery. 2017. How Does Risk Management Influence Production Decisions? Evidence from a Field Experiment. *The Review of Financial Studies* **30**(6) 1935–1970. ISSN 0893-9454, 1465-7368. DOI 10.1093/rfs/hhw080. https://academic.oup.com/rfs/article/30/6/1935/2433387.

Conley, T., C. Udry. 2001. Social Learning Through Networks: The Adoption of New Agricultural Technologies in Ghana. *American Journal of Agricultural Economics* **83**(3) 668–673. ISSN 0002-9092, 1467-8276. DOI 10.1111/0002-9092.00188. https://onlinelibrary.wiley.com/doi/abs/10.1111/0002-9092.00188.

Conley, T. G., C. R. Udry. 2010. Learning about a New Technology: Pineapple in Ghana. *American Economic Review* **100**(1) 35–69. ISSN 0002-8282. DOI 10.1257/aer.100.1.35. https://pubs.aeaweb.org/doi/10.1257/aer.100.1.35.

Constas, M. A., M. d'Errico, R. Pietrelli. 2022. Toward Core Indicators for Resilience Analysis: A framework to promote harmonized metrics and empirical coherence. *Global Food Security* **35** 100655. ISSN 22119124. DOI 10.1016/j.gfs.2022.100655. https://linkinghub.elsevier.com/retrieve/pii/S2211912422000451.

Contzen, N., S. De Pasquale, H.-J. Mosler. 2015. Over-Reporting in Handwashing Self-Reports: Potential Explanatory Factors and Alternative Measurements. *PLoS ONE* **10**(8) e0136445. ISSN 1932-6203. DOI 10.1371/journal.pone.0136445. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4547747/.

Coulibaly, J. Y., G. A. Gbetibouo, G. Kundhlande, G. W. Sileshi, T. L. Beedy. 2015. Responding to Crop Failure: Understanding Farmers' Coping Strategies in Southern Malawi. *Sustainability* **7**(2) 1620–1636. ISSN 2071-1050. DOI 10.3390/su7021620. https://www.mdpi.com/2071-1050/7/2/1620. Number: 2 Publisher: Multidisciplinary Digital Publishing Institute.

Cox, D., M. Fafchamps. 2007. Chapter 58 Extended Family and Kinship Networks: Economic Insights and Evolutionary Directions. In T. P. Schultz, J. A. Strauss, eds., *Handbook of Development Economics*, volume 4, 3711–3784. Elsevier. DOI 10.1016/S1573-4471(07)04058-2. https://www.sciencedirect.com/science/article/pii/S1573447107040582.

Croppenstedt, A., M. Demeke, M. M. Meschi. 2003. Technology Adoption in the Presence of Constraints: the Case of Fertilizer Demand in Ethiopia. *Review of Development Economics* **7**(1) 58–70. ISSN 1467-9361. DOI 10.1111/1467-9361.00175. https://ezproxy-prd.bodleian.ox.ac.uk:2152/doi/10.1111/1467-9361.00175. Publisher: John Wiley & Sons, Ltd.

Croppenstedt, A., C. Muller. 2000. The Impact of Farmers' Health and Nutritional Status on Their Productivity and Efficiency: Evidence from Ethiopia. *Economic Development and Cultural Change* **48**(3) 475–502. ISSN 0013-0079, 1539-2988. DOI 10.1086/452607. https://www.journals.uchicago.edu/doi/10.1086/452607.

Cunguara, B., A. Langyintuo, I. Darnhofer. 2011. The role of nonfarm income in coping with the effects of drought in southern Mozambique. *Agricultural Economics* **42**(6) 701–713. ISSN 1574-0862. DOI 10.1111/j.1574-0862.2011.00542.x. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1574-0862.2011.00542.x. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1574-0862.2011.00542.x.

Darby, M. R., E. Karni. 1973. Free Competition and the Optimal Amount of Fraud. *The Journal of Law & Economics* **16**(1) 67–88. ISSN 0022-2186. https://www.jstor.org/stable/724826. Publisher: [University of Chicago Press, Booth School of Business, University of Chicago, University of Chicago Law School].

de Brauw, A., P. Eozenou. 2014. Measuring risk attitudes among Mozambican farmers. *Journal of Development Economics* **111** 61–74. ISSN 03043878. DOI 10.1016/j.jdeveco.2014.08.002. https://linkinghub.elsevier.com/retrieve/pii/S0304387814000959.

de Janvry, A., E. Sadoulet. 2002. World Poverty and the Role of Agricultural Technology: Direct and Indirect Effects. *Journal of Development Studies* **38**(4) 1–26. ISSN 0022-0388, 1743-9140. DOI 10.1080/00220380412331322401. http://www.tandfonline.com/doi/abs/10.1080/00220380412331322401.

de Janvry, A., E. Sadoulet. 2020. Using agriculture for development: Supply- and demand-side approaches. *World Development* **133** 105003. ISSN 0305-750X. DOI 10.1016/j.worlddev.2020.105003. https://www.sciencedirect.com/science/article/pii/S0305750X20301297.

De Weerdt, J., S. Dercon. 2006. Risk-sharing networks and insurance against illness. *Journal of Development Economics* **81**(2) 337–356. ISSN 0304-3878. DOI 10.1016/j.jdeveco.2005.06.009. https://www.sciencedirect.com/science/article/pii/S0304387806000666.

De Weerdt, J., M. Fafchamps. 2011. Social Identity and the Formation of Health Insurance Networks. *The Journal of Development Studies* **47**(8) 1152–1177. ISSN 0022-0388. DOI 10.1080/00220388.2010.527952. https://doi.org/10.1080/00220388.2010.527952. Publisher: Routledge _eprint: https://doi.org/10.1080/00220388.2010.527952.

Debela, B., G. Shively, A. Angelsen, M. Wik. 2012. Economic Shocks, Diversification, and Forest Use in Uganda. *Land Economics* **88**(1) 139–154. ISSN 0023-7639, 1543-8325. DOI 10.3368/le.88.1.139. http://le.uwpress.org/cgi/doi/10.3368/le.88.1.139.

Deinigner, K., J. Okidi. 2001. Rural Households: Incomes, Productivity, and Nonfarm Enterprises. In P. Collier, R. Reinikka, eds., *Uganda's Recovery: The Role of Farms, Firms, and Government*, 123–175. World Bank Publications. ISBN 978-0-8213-4664-8. Google-Books-ID: KV1eOH9Jfj0C.

DeLoach, S. B., M. Smith-Lin. 2018. The Role of Savings and Credit in Coping with Idiosyncratic Household Shocks. *The Journal of Development Studies* **54**(9) 1513–1533. ISSN 0022-0388, 1743-9140. DOI 10.1080/00220388.2017.1380795. https://www.tandfonline.com/doi/full/10.1080/00220388.2017.1380795.

Dercon, S. 2002. Income Risk, Coping Strategies, and Safety Nets. *The World Bank Research Observer* **17**(2) 141–166.

Dercon, S. 2004. Growth and shocks: evidence from rural Ethiopia. *Journal of Development Economics* **74**(2) 309–329. ISSN 03043878. DOI 10.1016/j.jdeveco.2004.01.001. https://linkinghub.elsevier.com/retrieve/pii/S0304387804000173.

Dercon, S., L. Christiaensen. 2011. Consumption risk, technology adoption and poverty traps: Evidence from Ethiopia. *Journal of Development Economics* **96**(2) 159–173. ISSN 03043878. DOI 10.1016/j.jdeveco.2010.08.003. https://linkinghub.elsevier.com/retrieve/pii/S0304387810000878.

Dercon, S., J. Hoddinott, T. Woldehanna. 2005. Shocks and Consumption in 15 Ethiopian Villages, 1999–2004. *Journal of African Economies* **14**(4) 559–585. ISSN 0963-8024. DOI 10.1093/jae/eji022. https://doi.org/10.1093/jae/eji022.

Dercon, S., P. Krishnan. 2000. In Sickness and in Health: Risk Sharing within Households in Rural Ethiopia. *Journal of Political Economy* **108**(4) 688–727. ISSN 0022-3808. DOI 10.1086/316098. https://www.jstor.org/stable/10.1086/316098. Publisher: The University of Chicago Press.

d'Errico, M., S. Di Giuseppe. 2018. Resilience mobility in Uganda: A dynamic analysis. *World Development* **104** 78–96. ISSN 0305750X. DOI 10.1016/j.worlddev.2017.11.020. https://linkinghub.elsevier.com/retrieve/pii/S0305750X17303820.

Dibba, L., M. Zeller, A. Diagne, T. Nielsen. 2015. How Accessibility to Seeds Affects the Potential Adoption of an Improved Rice Variety: The Case of The New Rice for Africa (NERICA) in The Gambia. *Quarterly Journal of International Agriculture* (1) 33–58. DOI 10.22004/ag.econ.206295. Num Pages: 26.

Diiro, G. M., M. Kassie, B. W. Muriithi, C. M. Mutero. 2022. Gender Heterogeneous Effects of Malaria Risk on Agriculture Productivity: Empirical Evidence from Rural Ethiopia. *The Journal of Developing Areas* **56**(1) 73–91. ISSN 1548-2278. DOI 10.1353/jda.2022.0011. https://muse.jhu.edu/article/835744. Publisher: Tennessee State University College of Business.

Diiro, G. M., A. P. Ker, A. G. Sam. 2015. The role of gender in fertiliser adoption in Uganda. *African Journal of Agricultural and Resource Economics* **10**(2) 117–130. DOI 10.22004/ag.econ.208922. Num Pages: 14.

Diiro, G. M., A. G. Sam. 2015. Agricultural Technology Adoption and Nonfarm Earnings in Uganda: A Semiparametric Analysis. *The Journal of Developing Areas* **49**(2) 145–162. ISSN 1548-2278. DOI 10.1353/jda.2015.0013. `http://muse.jhu.edu/content/crossref/journals/journal_of_developing_areas/v049/49.2.diiro.html`.

Domínguez, C., J. Donovan, C. S. Srinivasan, G. Zanello, M. Peña. 2022. In-store seed purchasing decisions, implications for scaling hybrid maize seed sales through agro-dealers. DOI 10.21203/rs.3.rs-2346961/v1. `https://www.researchsquare.com/article/rs-2346961/v1`. ISSN: 2693-5015.

Dontsop Nguezet, P. M., A. Diagne, O. V. Okoruwa, V. Ojehomon, V. Manyong. 2013. Estimating the Actual and Potential Adoption Rates and Determinants of NERICA Rice Varieties in Nigeria. *Journal of Crop Improvement* **27**(5) 561–585. ISSN 1542-7528. DOI 10.1080/15427528.2013.811709. `https://doi.org/10.1080/15427528.2013.811709`. Publisher: Taylor & Francis _eprint: https://doi.org/10.1080/15427528.2013.811709.

Dorward, A., I. Mwale, R. Tuseo. 2022. Labor Market and Wage Impacts of HIV/AIDS in Rural Malawi. *Review of Agricultural Economics* **28**(3) 429–439.

Doss, C., A. D. Oduro, C. D. Deere, H. Swaminathan, W. Baah-Boateng, S. J. Y. 2018. Assets and shocks: a gendered analysis of Ecuador, Ghana and Karnataka, India. *Canadian Journal of Development Studies / Revue canadienne d'études du développement* **39**(1) 1–18. ISSN 0225-5189, 2158-9100. DOI 10.1080/02255189.2017.1316244. `https://www.tandfonline.com/doi/full/10.1080/02255189.2017.1316244`.

Duflo, E., M. Kremer, J. Robinson. 2008. How High Are Rates of Return to Fertilizer? Evidence from Field Experiments in Kenya. *American Economic Review* **98**(2) 482–488. ISSN 0002-8282. DOI 10.1257/aer.98.2.482. `https://pubs.aeaweb.org/doi/10.1257/aer.98.2.482`.

Duflo, E., M. Kremer, J. Robinson. 2011. Nudging Farmers to Use Fertilizer: Theory and Experimental Evidence from Kenya. *American Economic Review* **101**(6) 2350–2390. ISSN 0002-8282. DOI 10.1257/aer.101.6.2350. `https://pubs.aeaweb.org/doi/10.1257/aer.101.6.2350`.

d'Errico, M., D. Romano, R. Pietrelli. 2018. Household resilience to food insecurity: evidence from Tanzania and Uganda. *Food Security* **10**(4) 1033–1054. ISSN 1876-4525. DOI 10.1007/s12571-018-0820-5. https://doi.org/10.1007/s12571-018-0820-5.

Ebaidalla, E. M., M. E. M. Ali. 2019. Determinants and impact of household's out-of-pocket healthcare expenditure in Sudan: evidence from urban and rural population*. *Middle East Development Journal* **11**(2) 181–198. ISSN 1793-8120. DOI 10.1080/17938120.2019.1668163. https://doi.org/10.1080/17938120.2019.1668163. Publisher: Routledge _eprint: https://doi.org/10.1080/17938120.2019.1668163.

Emerick, K., A. de Janvry, E. Sadoulet, M. H. Dar. 2016. Technological Innovations, Downside Risk, and the Modernization of Agriculture. *American Economic Review* **106**(6) 1537–1561. ISSN 0002-8282. DOI 10.1257/aer.20150474. https://pubs.aeaweb.org/doi/10.1257/aer.20150474.

Emerick, K., A. de Janvry, E. Sadoulet, M. H. Dar. 2017. Enhancing the diffusion of information about agricultural technology.

Fafchamps, M. 1999. Rural Poverty, Risk and Development. Technical report, Food and Agriculture Organization of the United Nations. DOI 10.4337/9781781950685. https://www.elgaronline.com/view/1843764369.xml.

Fafchamps, M. 2011. Chapter 24 - Risk Sharing Between Households. In J. Benhabib, A. Bisin, M. O. Jackson, eds., *Handbook of Social Economics*, volume 1, 1255–1279. North-Holland. DOI 10.1016/B978-0-444-53707-2.00007-4. https://www.sciencedirect.com/science/article/pii/B9780444537072000074.

Fafchamps, M., S. Lund. 2003. Risk-sharing networks in rural Philippines. *Journal of Development Economics* **71**(2) 261–287. ISSN 0304-3878. DOI 10.1016/S0304-3878(03)00029-4. https://www.sciencedirect.com/science/article/pii/S0304387803000294.

Fafchamps, M., F. Shilpi. 2003. The spatial division of labour in Nepal. *Journal of Development Studies* **39**(6) 23–66. ISSN 0022-0388, 1743-9140. DOI 10.1080/00220380312331293577. http://www.tandfonline.com/doi/abs/10.1080/00220380312331293577.

Fairbairn, A., H. Michelson, B. Ellison, A. Maertens, V. Manyong. 2017. Unobservable Quality, Information and Mineral Fertilizer Demand. Draft Working Paper, University of Illinois.

Falco, C., V. Rotondi, D. Kong, V. Spelta. 2021. Investment, insurance and weather shocks: Evidence from Cambodia. *Ecological Economics* **188** 107115. ISSN 09218009. DOI 10.1016/j.ecolecon.2021.107115. https://linkinghub.elsevier.com/retrieve/pii/S0921800921001737.

FAO. 2022. FAOSTAT. https://www.fao.org/faostat/en/#data.

Feder, G., R. E. Just, D. Zilberman. 1985. Adoption of Agricultural Innovations in Developing Countries: A Survey. *Economic Development and Cultural Change* **33**(2) 255–298. ISSN 0013-0079, 1539-2988. DOI 10.1086/451461. https://www.journals.uchicago.edu/doi/10.1086/451461.

Fishman, R., S. C. Smith, V. Bobić, M. Sulaiman. 2017. How Sustainable are Benefits from Extension for Smallholder Farmers? Evidence from a Randomized Phase-Out of the BRAC Program in Uganda. IZA Discussion Paper 10641, IZA Institute of Labor Economics. https://www.ssrn.com/abstract=2940631.

Flores, G., J. Krishnakumar, O. O'Donnell, E. van Doorslaer. 2008. Coping with health-care costs: implications for the measurement of catastrophic expenditures and poverty. *Health Economics* **17**(12) 1393–1412. ISSN 1099-1050. DOI 10.1002/hec.1338. https://onlinelibrary.wiley.com/doi/abs/10.1002/hec.1338. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/hec.1338.

Foster, A. D., M. R. Rosenzweig. 1995. Learning by Doing and Learning from Others: Human Capital and Technical Change in Agriculture. *Journal of Political Economy* **103**(6) 1176–1209. ISSN 0022-3808, 1537-534X. DOI 10.1086/601447. https://www.journals.uchicago.edu/doi/10.1086/601447.

Foster, A. D., M. R. Rosenzweig. 2010. Microeconomics of Technology Adoption. *Annual Review of Economics* **2**(1) 395–424. ISSN 1941-1383, 1941-1391. DOI 10.1146/annurev.economics.102308.124433. https://www.annualreviews.org/doi/10.1146/annurev.economics.102308.124433.

Fox, M. P., S. Rosen, W. B. MacLeod, M. Wasunna, M. Bii, G. Foglia, J. L. Simon. 2004. The impact of HIV/AIDS on labour productivity in Kenya. *Tropical Medicine and International Health* **9**(3) 318–324. ISSN 1360-2276, 1365-3156. DOI 10.1111/j.1365-3156.2004.01207.x. https://onlinelibrary.wiley.com/doi/10.1111/j.1365-3156.2004.01207.x.

Freeman, K., H. Qin. 2020. The Role of Information and Interaction Processes in the Adoption of Agriculture Inputs in Uganda. *Agronomy* **10**(2) 202. ISSN 2073-4395. DOI 10.3390/agronomy10020202. https://www.mdpi.com/2073-4395/10/2/202.

Gallup, J. L., J. D. Sachs. 2001. The economic burden of malaria. *The American Journal of Tropical Medicine and Hygiene* **64**(1_suppl) 85–96. DOI 10.4269/ajtmh.2001.64.85. https://www.ajtmh.org/view/journals/tpmd/64/1_suppl/article-p85.xml. Publisher: American Society of Tropical Medicine and Hygiene Section: The American Journal of Tropical Medicine and Hygiene.

Gao, J., B. F. Mills. 2018. Weather Shocks, Coping Strategies, and Consumption Dynamics in Rural Ethiopia. *World Development* **101** 268–283. ISSN 0305-750X. DOI 10.1016/j.worlddev.2017.09.002. https://www.sciencedirect.com/science/article/pii/S0305750X17302978.

Gao, J., B. F. Mills. 2021. Influence of weather shocks and coping strategies on food consumption: Evidence from rural Niger. *African Journal of Agricultural and Resource Economics* **16**(3) 193–215. ISSN 1993-3738. DOI 10.22004/ag.econ.333948.

Gautam, N. P., N. K. Raut, B. B. K. Chhetri, N. Raut, M. H. U. Rashid, X. Ma, P. Wu. 2021. Determinants of Poverty, Self-Reported Shocks, and Coping Strategies: Evidence from Rural Nepal. *Sustainability* **13**(4) 1790. ISSN 2071-1050. DOI 10.3390/su13041790. https://www.mdpi.com/2071-1050/13/4/1790. Number: 4 Publisher: Multidisciplinary Digital Publishing Institute.

Gebremariam, G., W. Tesfaye. 2018. The heterogeneous effect of shocks on agricultural innovations adoption: Microeconometric evidence from rural Ethiopia. *Food Policy* **74** 154–161. ISSN 03069192. DOI 10.1016/j.foodpol.2017.12.010. https://linkinghub.elsevier.com/retrieve/pii/S0306919217310679.

Genoni, M. E. 2012. Health Shocks and Consumption Smoothing: Evidence from Indonesia. *Economic Development and Cultural Change* **60**(3) 475–506. ISSN 0013-0079. DOI 10.1086/664019. https://www.jstor.org/stable/10.1086/664019. Publisher: The University of Chicago Press.

Gertler, P. 2006. Is Social Capital the Capital of the Poor? The Role of Family and Community in Helping Insure Living Standards against Health Shocks. *CESifo Economic Studies* **52**(3)

455–499. ISSN 1610-241X, 1612-7501. DOI 10.1093/cesifo/ifl012. https://academic.oup.com/cesifo/article-lookup/doi/10.1093/cesifo/ifl012.

Gertler, P., J. Gruber. 2002. Insuring Consumption against Illness. *The American Economic Review* **92**(1) 51–70. ISSN 0002-8282. https://www.jstor.org/stable/3083321. Publisher: American Economic Association.

Gharib, M. H., L. H. Palm-Forster, T. J. Lybbert, K. D. Messer. 2021. Fear of fraud and willingness to pay for hybrid maize seed in Kenya. *Food Policy* **102** 102040. ISSN 0306-9192. DOI 10.1016/j.foodpol.2021.102040. https://www.sciencedirect.com/science/article/pii/S030691922100018X.

Gilgen, D. D., C. G. N. C. G. N. Mascie-Taylor, L. L. Rosetta. 2001. Intestinal helminth infections, anaemia and labour productivity of female tea pluckers in Bangladesh. *Tropical Medicine & International Health* **6**(6) 449–457. ISSN 1365-3156. DOI 10.1046/j.1365-3156.2001.00729.x. https://onlinelibrary.wiley.com/doi/abs/10.1046/j.1365-3156.2001.00729.x. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1046/j.1365-3156.2001.00729.x.

Gillespie, S. 1989. Potential impact of AIDS on farming systems. *Land Use Policy* **6**(4) 301–312. ISSN 02648377. DOI 10.1016/0264-8377(89)90022-7. https://linkinghub.elsevier.com/retrieve/pii/0264837789900227.

Gilligan, D. O., N. Karachiwalla, G. Thai. 2019. An Evaluation of the Impact of E-verification on Counterfeit Agricultural Inputs and Technology Adoption in Uganda. Endline Report, International Food Policy Research Institute.

Giné, X., D. Yang. 2009. Insurance, credit, and technology adoption: Field experimental evidencefrom Malawi. *Journal of Development Economics* **89**(1) 1–11. ISSN 03043878. DOI 10.1016/j.jdeveco.2008.09.007. https://linkinghub.elsevier.com/retrieve/pii/S0304387808000898.

Gkiza, I. G., S. A. Nastis. 2017. Health and Women's Role in Agricultural Production Efficiency. *Applied Economic Perspectives and Policy* **39**(3) 428–440. ISSN 2040-5790, 2040-5804. DOI 10.1093/aepp/ppw025. https://onlinelibrary.wiley.com/doi/abs/10.1093/aepp/ppw025.

Gollin, D., S. Parente, R. Rogerson. 2002. The Role of Agriculture in Development. *American Economic Review* **92**(2) 160–164.

Griliches, Z. 1957. Hybrid Corn: An Exploration in the Economics of Technological Change. *Econometrica* **25**(4) 501–522. https://ezproxy-prd.bodleian.ox.ac.uk:2116/stable/1905380.

Grimard, F. 1997. Household consumption smoothing through ethnic ties: evidence from Cote d'Ivoire. *Journal of Development Economics* **53**(2) 391–422. ISSN 03043878. DOI 10.1016/S0304-3878(97)00016-3. https://linkinghub.elsevier.com/retrieve/pii/S0304387897000163.

Grootaert, C. 2002. Social Capital, Household Welfare and Poverty in Burkina Faso. *Journal of African Economics* **11**(1) 4–38. ISSN 14643723. DOI 10.1093/jae/11.1.4. https://academic.oup.com/jae/article-lookup/doi/10.1093/jae/11.1.4.

Guirkinger, C., S. R. Boucher. 2008. Credit constraints and productivity in Peruvian agriculture. *Agricultural Economics* **39**(3) 295–308. ISSN 0169-5150. DOI 10.1111/j.1574-0862.2008.00334.x. https://ezproxy-prd.bodleian.ox.ac.uk:2152/doi/full/10.1111/j.1574-0862.2008.00334.x. Publisher: John Wiley & Sons, Ltd.

Gustafsson-Wright, E., W. Janssens, J. Van Der Gaag. 2011. The inequitable impact of health shocks on the uninsured in Namibia. *Health Policy and Planning* **26**(2) 142–156. ISSN 0268-1080, 1460-2237. DOI 10.1093/heapol/czq029. https://academic.oup.com/heapol/article-lookup/doi/10.1093/heapol/czq029.

Haggblade, S., A. Diarra, W. Jiang, A. Assima, N. Keita, A. Traore, M. Traore. 2021. Fraudulent pesticides in West Africa: a quality assessment of glyphosate products in Mali. *International Journal of Pest Management* **67**(1) 32–45. ISSN 0967-0874, 1366-5863. DOI 10.1080/09670874.2019.1668076. https://www.tandfonline.com/doi/full/10.1080/09670874.2019.1668076.

Ham, J. C., K. Jacobs. 2000. Testing for Full Insurance Using Exogenous Information. *Journal of Business & Economic Statistics* **18**(4) 387–397. ISSN 0735-0015. DOI 10.2307/1392221. https://www.jstor.org/stable/1392221. Publisher: [American Statistical Association, Taylor & Francis, Ltd.].

Hangoma, P., A. Aakvik, B. Robberstad. 2018. Health Shocks and Household Welfare in Zambia: An Assessment of Changing Risk. *Journal of International Development* **30**(5) 790–817. ISSN 09541748. DOI 10.1002/jid.3337. https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,uid&db=bsu&AN=130671050&site=ehost-live&authtype=ip,uid. Publisher: John Wiley & Sons, Inc.

Harrison, G. W., S. J. Humphrey, A. Verschoor. 2010. Choice under Uncertainty: Evidence from Ethiopia, India and Uganda. *The Economic Journal* **120**(543) 80–104. ISSN 0013-0133, 1468-0297. DOI 10.1111/j.1468-0297.2009.02303.x. https://academic.oup.com/ej/article/120/543/80-104/5089605.

Harrower, S., J. Hoddinott. 2005. Consumption Smoothing in the Zone Lacustre, Mali. *Journal of African Economies* **14**(4) 489–519. ISSN 1464-3723, 0963-8024. DOI 10.1093/jae/eji007. http://academic.oup.com/jae/article/14/4/489/752059/Consumption-Smoothing-in-the-Zone-Lacustre-Mali.

Hasibuan, A. M., D. Gregg, R. Stringer. 2021. The role of certification, risk and time preferences in promoting adoption of climate-resilient citrus varieties in Indonesia. *Climatic Change* **164**(3) 1–21. ISSN 1573-1480. DOI 10.1007/s10584-021-03015-1. https://link-springer-com.ezproxy-prd.bodleian.ox.ac.uk/article/10.1007/s10584-021-03015-1. Company: Springer Distributor: Springer Institution: Springer Label: Springer Number: 3 Publisher: Springer Netherlands.

Hayashi, F., J. Altonji, L. Kotlikoff. 1996. Risk-Sharing between and within Families. *Econometrica* **64**(2) 261–294. ISSN 0012-9682. DOI 10.2307/2171783. https://www.jstor.org/stable/2171783. Publisher: [Wiley, Econometric Society].

Headey, D., O. Ecker. 2013. Rethinking the measurement of food security: from first principles to best practice. *Food Security* **5**(3) 327–343. ISSN 1876-4525. DOI 10.1007/s12571-013-0253-0. https://doi.org/10.1007/s12571-013-0253-0.

Heisse, C., R. Morimoto. 2023. Climate vulnerability and fertilizer use – panel evidence from Tanzanian maize farmers. *Climate and Development* **0**(0) 1–13. ISSN 1756-5529. DOI 10.1080/17565529.2023.2206373. https://doi.org/10.1080/17565529.2023.2206373. Publisher: Taylor & Francis _eprint: https://doi.org/10.1080/17565529.2023.2206373.

Helgeson, J. F., S. Dietz, S. Hochrainer-Stigler. 2013. Vulnerability to Weather Disasters: the Choice of Coping Strategies in Rural Uganda. *Ecology and Society* **18**(2). ISSN 1708-3087. https://www.jstor.org/stable/26269323. Publisher: Resilience Alliance Inc.

Heltberg, R., N. Lund. 2009. Shocks, Coping, and Outcomes for Pakistan's Poor: Health Risks Predominate. *The Journal of Development Studies* **45**(6) 889–910. ISSN 0022-0388, 1743-9140. DOI 10.1080/00220380902802214. https://www.tandfonline.com/doi/full/10.1080/00220380902802214.

Heltberg, R., A. M. Oviedo, F. Talukdar. 2015. What do Household Surveys Really Tell Us about Risk, Shocks, and Risk Management in the Developing World? *The Journal of Development Studies* **51**(3) 209–225. ISSN 0022-0388. DOI 10.1080/00220388.2014.959934. https://doi.org/10.1080/00220388.2014.959934. Publisher: Routledge _eprint: https://doi.org/10.1080/00220388.2014.959934.

Hoddinott, J. 2006. Shocks and their consequences across and within households in Rural Zimbabwe. *Journal of Development Studies* **42**(2) 301–321. ISSN 0022-0388, 1743-9140. DOI 10.1080/00220380500405501. http://www.tandfonline.com/doi/abs/10.1080/00220380500405501.

Hoel, J. B., H. Michelson, B. Norton, V. Manyong. 2024. Misattribution prevents learning. *American Journal of Agricultural Economics* **106**(5) 1571–1594. ISSN 1467-8276. DOI 10.1111/ajae.12466. https://onlinelibrary.wiley.com/doi/abs/10.1111/ajae.12466. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/ajae.12466.

Holden, S. T., J. Quiggin. 2017. Climate risk and state-contingent technology adoption: shocks, drought tolerance and preferences. *European Review of Agricultural Economics* **44**(2) 285–308. ISSN 0165-1587. DOI 10.1093/erae/jbw016. https://doi.org/10.1093/erae/jbw016.

Holden, S. T., N. B. Westberg. 2016. Exploring technology use under climate risk and shocks through an experimental lens. *African Journal of Agricultural and Resource Economics* **11**(1) 47–62. DOI 10.22004/ag.econ.233848. Num Pages: 16.

Horner, N. K., R. E. Patterson, M. L. Neuhouser, J. W. Lampe, S. A. Beresford, R. L. Prentice. 2002. Participant characteristics associated with errors in self-reported energy intake from the Women's Health Initiative food-frequency questionnaire123. *The American Journal of*

Clinical Nutrition **76**(4) 766–773. ISSN 0002-9165. DOI 10.1093/ajcn/76.4.766. https://www.sciencedirect.com/science/article/pii/S0002916523059695.

Hotelling, H. 1929. Stability in Competition. *The Economic Journal* **39**(153) 41–57. ISSN 0013-0133. DOI 10.2307/2224214. https://www.jstor.org/stable/2224214. Publisher: [Royal Economic Society, Wiley].

Hsu, E., A. W. Wambugu. 2023. Can Informed Buyers Improve Goods Quality? Experimental Evidence from Crop Seeds. G2LMLIC Working Paper 74, IZA Institute of Labor Economics. https://g2lm-lic.iza.org/publications/wp/can-informed-buyers-improve-goods-quality-experimental-evidence-from-crop-seeds/.

Huffman, W. E. 2020. Human Capital and Adoption of Innovations: Policy Implications. *Applied Economic Perspectives and Policy* **42**(1) 92–99. ISSN 2040-5790, 2040-5804. DOI 10.1002/aepp.13010. https://onlinelibrary.wiley.com/doi/10.1002/aepp.13010.

Humphrey, S. J. 2004. Decision-making Under Risk among Small Farmers in East Uganda. *Journal of African Economics* **13**(1) 44–101. ISSN 1464-3723. DOI 10.1093/jae/13.1.44. https://academic.oup.com/jae/article-lookup/doi/10.1093/jae/13.1.44.

IFPRI. 2008. Linkages between Land Management, Land Degradation, and Poverty in Sub-Saharan Africa The Case of Uganda. Technical report, International Food Policy Research Institute, Washington, DC. DOI 10.2499/9780896291683RR159. https://ebrary.ifpri.org/digital/collection/p15738coll2/id/25447. Edition: 0.

Ihli, H. J., B. Chiputwa, O. Musshoff. 2016. Do Changing Probabilities or Payoffs in Lottery-Choice Experiments Affect Risk Preference Outcomes? Evidence from Rural Uganda. *Journal of Agricultural and Resource Economics* **41**(2) 324–345.

Islam, A., P. Maitra. 2012. Health shocks and consumption smoothing in rural households: Does microcredit have a role to play? *Journal of Development Economics* **97**(2) 232–243. ISSN 03043878. DOI 10.1016/j.jdeveco.2011.05.003. https://linkinghub.elsevier.com/retrieve/pii/S0304387811000484.

Isoto, R. E., A. G. Sam, D. S. Kraybill. 2017. Uninsured Health Shocks and Agricultural Productivity among Rural Households: The Mitigating Role of Micro-credit. *The Journal of Development Studies* **53**(12) 2050–2066. ISSN 0022-0388, 1743-9140. DOI 10.1080/00220388

.2016.1262027. https://www.tandfonline.com/doi/full/10.1080/00220388.2016.1262027.

Jack, B. K. 2013. Market inefficiencies and the adoption of agricultural technologies in developing countries. Technical report, UC Berkeley. https://escholarship.org/uc/item/6m25r19c.

Jacoby, H. G. 2000. Access to Markets and the Benefits of Rural Roads. *The Economic Journal* **110**(465) 713–737. ISSN 0013-0133, 1468-0297. DOI 10.1111/1468-0297.00562. https://academic.oup.com/ej/article/110/465/713-737/5140059.

Jalan, J., M. Ravallion. 1999. Are the poor less well insured? Evidence on vulnerability to income risk in rural China. *Journal of Development Economics* **58**(1) 61–81. ISSN 0304-3878. DOI 10.1016/S0304-3878(98)00103-5. https://www.sciencedirect.com/science/article/pii/S0304387898001035.

Jayne, T. S., L. Fox, K. Fuglie, A. Adelaja. 2021. Agricultural Productivity Growth, Resilience, and Economic Transformation in Sub-Saharan Africa - Implications for USAID. Technical report, USAID.

Jordan, A., M. Guerzoni. 2021. “Cursed is the ground because of you”:: The impact of culture, religion, and ethnicity on the adoption of fertilisers in rural Ethiopia. *Journal of Evolutionary Economics* **31**(3) 853–890. ISSN 0936-9937, 1432-1386. DOI 10.1007/s00191-021-00731-w. https://link.springer.com/10.1007/s00191-021-00731-w.

Joughin, J. 2014. The Political Economy of Seed Reform in Uganda: Promoting a Regional Seed Trade Market. Africa Trade Practice Working Paper Series 3, The World Bank. https://openknowledge.worldbank.org/bitstream/handle/10986/17604/839040NWP0Afri0no30382116B00PUBLIC0.pdf?sequence=1&isAllowed=y.

Kabunga, N. S., T. Dubois, M. Qaim. 2012. Heterogeneous information exposure and technology adoption: the case of tissue culture bananas in Kenya. *Agricultural Economics* **43**(5) 473–486. ISSN 01695150. DOI 10.1111/j.1574-0862.2012.00597.x. https://onlinelibrary.wiley.com/doi/10.1111/j.1574-0862.2012.00597.x.

Kaizzi, K. C., J. Byalebeka, O. Semalulu, I. Alou, W. Zimwanguyizza, A. Nansamba, P. Musinguzi, P. Ebanyat, T. Hyuha, C. S. Wortmann. 2012. Maize Response to Fertilizer and Nitrogen

Use Efficiency in Uganda. *Agronomy Journal* **104**(1) 73–82. ISSN 1435-0645. DOI 10.2134/agronj2011.0181. https://onlinelibrary.wiley.com/doi/abs/10.2134/agronj2011.0181. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.2134/agronj2011.0181.

Kalokwera, P. 2022. Bylaw on Acholi bride price eases traditional marriages. *Monitor* https://www.monitor.co.ug/uganda/news/national/bylaw-on-acholi-bride-price-eases-traditional-marriages-3895254.

Karlan, D., E. Kutsoati, M. McMillan, C. Udry. 2011. Crop Price Indemnified Loans for Farmers: A Pilot Experiment in Rural Ghana. *Journal of Risk and Insurance* **78**(1) 37–55. ISSN 00224367. DOI 10.1111/j.1539-6975.2010.01406.x. https://onlinelibrary.wiley.com/doi/10.1111/j.1539-6975.2010.01406.x.

Karlan, D., R. Osei, I. Osei-Akoto, C. Udry. 2014. Agricultural Decisions After Relaxing Credit and Risk Constraints. *The Quarterly journal of economics* **129**(2) 597–652. ISSN 0033-5533. DOI 10.1093/qje/qju002. Place: CARY Publisher: Oxford University Press.

Kasirye, I. 2013. Constraints to Agricultural Technology Adoption in Uganda: Evidence from the 2005/06-2009/10 Uganda National Panel Survey. Research Series 151979, Economic Policy Research Centre (EPRC). https://ideas.repec.org/p/ags/eprcrs/151979.html. Publication Title: Research Series.

Kassem, H. S., B. A. Alotaibi. 2020. Do farmers perceive risks of fraudulent pesticides? Evidence from Saudi Arabia. *PLOS ONE* **15**(9) e0239298. ISSN 1932-6203. DOI 10.1371/journal.pone.0239298. https://dx.plos.org/10.1371/journal.pone.0239298.

Kassie, M., B. Shiferaw, G. Muricho. 2011. Agricultural Technology, Crop Income, and Poverty Alleviation in Uganda. *World Development* **39**(10) 1784–1795. ISSN 0305750X. DOI 10.1016/j.worlddev.2011.04.023. https://linkinghub.elsevier.com/retrieve/pii/S0305750X11000933.

Katungi, E., S. Edmeades, M. Smale. 2008. Gender, social capital and information exchange in rural Uganda. *Journal of International Development* **20**(1) 35–52. ISSN 0954-1748. DOI 10.1002/jid.1426. https://ezproxy-prd.bodleian.ox.ac.uk:2152/doi/abs/10.1002/jid.1426. Publisher: John Wiley & Sons, Ltd.

Kazianga, H., C. Udry. 2006. Consumption smoothing? Livestock, insurance and drought in rural Burkina Faso. *Journal of Development Economics* **79**(2) 413–446. ISSN 03043878. DOI 10.1016/j.jdeveco.2006.01.011. https://linkinghub.elsevier.com/retrieve/pii/S030438780600006X.

Khor, L. Y., S. Ufer, T. Nielsen, M. Zeller. 2018. Impact of risk aversion on fertiliser use: evidence from Vietnam. *Oxford Development Studies* **46**(4) 483–496. ISSN 1360-0818. DOI 10.1080/13600818.2018.1445212. https://ezproxy-prd.bodleian.ox.ac.uk:2398/doi/full/10.1080/13600818.2018.1445212. Publisher: Routledge.

Kiiza, B., G. Pederson. 2012. ICT-based market information and adoption of agricultural seed technologies: Insights from Uganda. *Telecommunications Policy* **36**(4) 253–259. ISSN 03085961. DOI 10.1016/j.telpol.2012.01.001. https://linkinghub.elsevier.com/retrieve/pii/S0308596112000110.

Kijima, Y., T. Matsumoto, T. Yamano. 2006. Nonfarm employment, agricultural shocks, and poverty dynamics: evidence from rural Uganda. *Agricultural Economics* **35**(s3) 459–467. ISSN 0169-5150, 1574-0862. DOI 10.1111/j.1574-0862.2006.00191.x. https://onlinelibrary.wiley.com/doi/10.1111/j.1574-0862.2006.00191.x.

Kirinya, A. 2022. Only 5 out of 17 Sub Counties in Butebo District Have Secondary Schools :: Uganda Radionetwork. *URN* https://ugandaradionetwork.net/story/only-5-out-of-17-sub-counties-in-butebo-district-have-secondary-schools-.

Kitunzi, Y., M. Woniala. 2022. Death toll in floods rises to 23, hundreds homeless. *Monitor* https://www.monitor.co.ug/uganda/news/national/death-toll-in-floods-rises-to-23-hundreds-homeless-3899848.

Knight, J., S. Weir, T. Woldehanna. 2003. The role of education in facilitating risk-taking and innovation in agriculture. *Journal of Development Studies* **39**(6) 1–22. ISSN 0022-0388, 1743-9140. DOI 10.1080/00220380312331293567. http://www.tandfonline.com/doi/abs/10.1080/00220380312331293567.

Kochar, A. 1995. Explaining Household Vulnerability to Idiosyncratic Income Shocks. *The American Economic Review* **85**(2) 159–164. ISSN 0002-8282. https://www.jstor.org/stable/2117911. Publisher: American Economic Association.

Kolyangha, M. 2022. Butebo leaders blame poverty on poor road network. *Monitor* https://www.monitor.co.ug/uganda/news/national/butebo-leaders-blame-poverty-on-poor-road-network-3680938.

Kolyangha, M. 2023a. Butebo projects stall after top officials allegedly swindle Shs3b. *Monitor* https://www.monitor.co.ug/uganda/news/national/butebo-projects-stall-after-top-officials-allegedly-swindle-shs3b-4139026.

Kolyangha, M. 2023b. Butebo residents blame high poverty levels on poor roads. *Monitor* https://www.monitor.co.ug/uganda/news/national/butebo-residents-blame-high-poverty-levels-on-poor-roads-4339312.

Kolyangha, M. 2023c. Food shortage hits Butebo. *Monitor* https://www.monitor.co.ug/uganda/news/national/food-shortage-hits-butebo--4251880.

Komarek, A. M., A. De Pinto, V. H. Smith. 2020. A review of types of risks in agriculture: What we know and what we need to know. *Agricultural Systems* **178** 102738. ISSN 0308521X. DOI 10.1016/j.agsy.2019.102738. https://linkinghub.elsevier.com/retrieve/pii/S0308521X18312034.

Krezanoski, P. J., D. R. Bangsberg, A. C. Tsai. 2018. Quantifying bias in measuring insecticide-treated bednet use: meta-analysis of self-reported vs objectively measured adherence. *Journal of Global Health* **8**(1). DOI 10.7189/jogh.08.010411. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5878861/. Publisher: International Society for Global Health.

Krishna, A., D. Lumonya, M. Markiewicz, F. Mugumya, A. Kafuko, J. Wegoye. 2006. Escaping poverty and becoming poor in 36 villages of Central and Western Uganda. *Journal of Development Studies* **42**(2) 346–370. ISSN 0022-0388, 1743-9140. DOI 10.1080/00220380500405634. http://www.tandfonline.com/doi/abs/10.1080/00220380500405634.

Laajaj, R., K. Macours, C. Masso, M. Thuita, B. Vanlauwe. 2020. Reconciling yield gains in agronomic trials with returns under African smallholder conditions. *Scientific Reports* **10** 14286. ISSN 2045-2322. DOI 10.1038/s41598-020-71155-y. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7459313/.

Lamb, R. L. 2003. Fertilizer Use, Risk, and Off-Farm Labor Markets in the Semi-Arid Tropics of India. *American Journal of Agricultural Economics* **85**(2) 359–371. ISSN 0002-9092, 1467-

8276. DOI 10.1111/1467-8276.00125. https://onlinelibrary.wiley.com/doi/10.1111/1467-8276.00125.

Larson, D. F., S. Savastano, S. Murray, A. Palacios-López. 2015. Are Women Less Productive Farmers? How Markets and Risk Affect Fertilizer Use, Productivity, and Measured Gender Effects in Uganda. Policy Research Working Paper 7241, The World Bank. DOI 10.1596/1813-9450-7241. http://elibrary.worldbank.org/doi/book/10.1596/1813-9450-7241.

Lawson, D., I. Kasirye. 2013. How the Extreme Poor Cope with Crises: Understanding the Role of Assets and Consumption. *Journal of International Development* **25**(8) 1129–1143. ISSN 1099-1328. DOI 10.1002/jid.2968. https://onlinelibrary.wiley.com/doi/abs/10.1002/jid.2968. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/jid.2968.

Le Cotty, T., E. Maître d'Hôtel, R. Soubeyran, J. Subervie. 2018. Linking Risk Aversion, Time Preference and Fertiliser Use in Burkina Faso. *The Journal of Development Studies* **54**(11) 1991–2006. ISSN 0022-0388. DOI 10.1080/00220388.2017.1344645. https://ezproxy-prd.bodleian.ox.ac.uk:2398/doi/full/10.1080/00220388.2017.1344645. Publisher: Routledge.

Ligon, E. 1998. Risk Sharing and Information in Village Economies. *The Review of Economic Studies* **65**(4) 847–864. ISSN 0034-6527. https://www.jstor.org/stable/2566915. Publisher: [Oxford University Press, Review of Economic Studies, Ltd.].

Ligon, E., J. P. Thomas, T. Worrall. 2002. Informal Insurance Arrangements with Limited Commitment: Theory and Evidence from Village Economies. *The Review of Economic Studies* **69**(1) 209–244. ISSN 0034-6527. https://www.jstor.org/stable/2695959. Publisher: [Oxford University Press, Review of Economic Studies, Ltd.].

Lim, S. S. 2017. Consumption Vulnerability to Prolonged Illness. *Journal of International Development* **29**(3) 351–369. ISSN 1099-1328. DOI 10.1002/jid.3119. https://onlinelibrary.wiley.com/doi/abs/10.1002/jid.3119. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/jid.3119.

Lindrio, P. 2019. As Brides Get Older, Bride Prices Go Down. *Global Press Journal* https://globalpressjournal.com/africa/uganda/brides-get-older-bride-prices-go/.

Liu, E. M. 2013. Time to Change What to Sow: Risk Preferences and Technology Adoption Decisions of Cotton Farmers in China. *The Review of Economics and Statistics* **95**(4) 1386–1403. ISSN 0034-6535, 1530-9142. DOI 10.1162/REST_a_00295. https://direct.mit.edu/rest/article/95/4/1386/58283/Time-to-Change-What-to-Sow-Risk-Preferences-and.

Liverpool-Tasie, L. S. O., B. T. Omonona, A. Sanou, W. O. Ogunleye. 2017. Is increasing inorganic fertilizer use for maize production in SSA a profitable proposition? Evidence from Nigeria. *Food Policy* **67** 41–51. ISSN 0306-9192. DOI 10.1016/j.foodpol.2016.09.011. https://ezproxy-prd.bodleian.ox.ac.uk:2056/science/article/pii/S0306919216303785. Publisher: Pergamon.

Liverpool-Tasie, L. S. O., A. Winter-Nelson. 2012. Social Learning and Farm Technology in Ethiopia: Impacts by Technology, Network Type, and Poverty Status. *Journal of Development Studies* **48**(10) 1505–1521. ISSN 0022-0388, 1743-9140. DOI 10.1080/00220388.2012.693167. http://www.tandfonline.com/doi/abs/10.1080/00220388.2012.693167.

Lubega, M., C. S. Nakamya, E. Namugumya, J. Najjemba. 2022. The effect of COVID-19 public health guidelines on the funeral traditions and burial rituals among the Baganda, a tribe in Central Uganda. *PAMJ - One Health* **7**(7). ISSN 2707-2800. DOI 10.11604/pamj-oh.2022.7.7.31048. https://www.one-health.panafrican-med-journal.com/content/article/7/7/full. Number: 7.

MAAIF. 2016. The Seeds and Plant Regulations, 2016. https://www.agriculture.go.ug/wp-content/uploads/2023/01/Seeds-and-Plant-Regulations-2017.pdf.

MAAIF. 2017. Performance Review Report Financial Year 2015 to 2016. Technical report, Ministry of Agriculture, Animal Industry and Fisheries, Uganda. https://www.agriculture.go.ug/wp-content/uploads/2019/09/MAAIF-Performance-Report-2015-2016.pdf.

MAAIF. 2018. National Seed Policy. Technical report, Ministry of Agriculture, Animal Industry and Fisheries, Uganda. https://www.agriculture.go.ug/wp-content/uploads/2019/05/Ministry-of-Agriculture-Animal-Industry-and-Fisheries-National-Seed-Policy.pdf.

Mabaya, E., R. Ssebuliba, M. Kyotalimye, M. Waithaka, M. Mugoya, B. Damba, M. Camara, K. Tihanyi. 2023. Uganda Country Report 2022. Technical report, The African Seed Access Index.

Mace, B. J. 1991. Full Insurance in the Presence of Aggregate Uncertainty. *Journal of Political Economy* **99**(5) 928–956. ISSN 0022-3808. https://www.jstor.org/stable/2937653. Publisher: University of Chicago Press.

Magnan, N., D. J. Spielman, T. J. Lybbert, K. Gulati. 2015. Leveling with friends: Social networks and Indian farmers' demand for a technology with heterogeneous benefits. *Journal of Development Economics* **116** 223–251. ISSN 03043878. DOI 10.1016/j.jdeveco.2015.05.003. https://linkinghub.elsevier.com/retrieve/pii/S0304387815000619.

Magruder, J. R. 2018. An Assessment of Experimental Evidence on Agricultural Technology Adoption in Developing Countries. *Annual Review of Resource Economics* **10**(1) 299–316. ISSN 1941-1340, 1941-1359. DOI 10.1146/annurev-resource-100517-023202. https://www.annualreviews.org/doi/10.1146/annurev-resource-100517-023202.

Makate, C., A. Angelsen, S. T. Holden, O. T. Westengen. 2022. Crops in crises: Shocks shape smallholders' diversification in rural Ethiopia. *World Development* **159** 106054. ISSN 0305750X. DOI 10.1016/j.worlddev.2022.106054. https://linkinghub.elsevier.com/retrieve/pii/S0305750X22002443.

Makate, C., A. Angelsen, S. T. Holden, O. T. Westengen. 2023. Rainfall shocks and inequality have heterogeneous effects on farmers' seed purchase decisions in East Africa. *Climate Risk Management* .

Makate, C., M. Makate. 2022. Do Rainfall Shocks Prompt Commercial Input Purchases Amongst Smallholder Farmers in Diverse Regions and Environments in Malawi? *Sustainability* **14**(22) 14904. ISSN 2071-1050. DOI 10.3390/su142214904. https://www.mdpi.com/2071-1050/14/22/14904. Number: 22 Publisher: Multidisciplinary Digital Publishing Institute.

Maredia, M. K., B. Bartle. 2023. Excess demand amid quality misperceptions: the case for low-cost seed quality signalling strategies. *European Review of Agricultural Economics* **50**(2) 360–394. ISSN 0165-1587. DOI 10.1093/erae/jbac019. https://doi.org/10.1093/erae/jbac019.

Marra, M., D. J. Pannell, A. A. Ghadim. 2003. The economics of risk, uncertainty and learning in the adoption of new agricultural technologies: where are we on the learning curve? *Agricultural Systems* **75**(2-3) 215–234. ISSN 0308-521X. DOI 10.1016/S0308-521X(02)00066-5.

https://ezproxy-prd.bodleian.ox.ac.uk:2056/science/article/pii/S0308521X02000665. Publisher: Elsevier.

Martin, B. L., E. Abbott. 2011. Mobile Phones and Rural Livelihoods: Diffusion, Uses, and Perceived Impacts Among Farmers in Rural Uganda. *Information Technologies & International Development* **7**(4) 17–34. ISSN 15447529. https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,uid&db=bth&AN=71618637&site=ehost-live&authtype=ip,uid. Publisher: University of Southern California, USC Annenberg Press.

Mastenbroek, A., B. Ntare. 2016. Uganda Early Generation Seed Study: unlocking pathways for sustainable provision of EGS for food crops in Uganda. Technical Report Report CDI-16-030, Wageningen University & Research Centre for Development Innovation, Wageningen.

Mastenbroek, A., I. Sirutyte, R. Sparrow. 2021. Information Barriers to Adoption of Agricultural Technologies: Willingness to Pay for Certified Seed of an Open Pollinated Maize Variety in Northern Uganda. *Journal of Agricultural Economics* **72**(1) 180–201. ISSN 1477-9552. DOI 10.1111/1477-9552.12395. https://onlinelibrary.wiley.com/doi/abs/10.1111/1477-9552.12395. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/1477-9552.12395.

Matsumoto, T., T. Yamano. 2011. The Impacts of Fertilizer Credit on Crop Production and Income in Ethiopia. In T. Yamano, K. Otsuka, F. Place, eds., *Emerging Development of Agriculture in East Africa: Markets, Soil, and Innovations*, 59–72. Springer Netherlands, Dordrecht. ISBN 978-94-007-1201-0. DOI 10.1007/978-94-007-1201-0_4. https://doi.org/10.1007/978-94-007-1201-0_4.

Matsumoto, T., T. Yamano, D. Sserunkuuma. 2010. Technology Adoption in Agriculture: Evidence from Experimental Intervention in Maize Production in Uganda. DOI 10.1007/978-94-007-5760-8_12. http://link.springer.com/10.1007/978-94-007-5760-8_12.

Matsumoto, T., T. Yamano, D. Sserunkuuma. 2013. Technology Adoption and Dissemination in Agriculture: Evidence from Sequential Intervention in Maize Production in Uganda. GRIPS Discussion Paper 13-14, National Graduate Institute for Policy Studies, Tokyo.

Mbugua, M., J. Nzuma, E. Muange, C. Kunyanga. 2020. Social networks and household food consumption smoothing in the presence of idiosyncratic shocks: insights from rural Kenya. *Development in Practice* **30**(3) 383–393. ISSN 0961-4524, 1364-9213. DOI 10.1080/09614524

.2020.1715344. https://www.tandfonline.com/doi/full/10.1080/09614524.2020.1715344.

McArthur, J. W., G. C. McCord. 2017. Fertilizing growth: Agricultural inputs and their effects in economic development. *Journal of Development Economics* **127** 133–152. ISSN 0304-3878. DOI 10.1016/j.jdeveco.2017.02.007. https://ezproxy-prd.bodleian.ox.ac.uk:2056/science/article/pii/S0304387817300172. Publisher: North-Holland.

McIntyre, D., M. Thiede, G. Dahlgren, M. Whitehead. 2006. What are the economic consequences for households of illness and of paying for health care in low- and middle-income country contexts? *Social Science & Medicine* **62**(4) 858–865. ISSN 0277-9536. DOI 10.1016/j.socscimed.2005.07.001. https://www.sciencedirect.com/science/article/pii/S0277953605003631.

Mekonnen, D. A., N. Gerber, J. A. Matz. 2018. Gendered Social Networks, Agricultural Innovations, and Farm Productivity in Ethiopia. *World Development* **105** 321–335. ISSN 0305-750X. DOI 10.1016/j.worlddev.2017.04.020. https://ezproxy-prd.bodleian.ox.ac.uk:2056/science/article/pii/S0305750X17301316. Publisher: Pergamon.

Michelson, H., A. Fairbairn, B. Ellison, A. Maertens, V. Manyong. 2021. Misperceived quality: Fertilizer in Tanzania. *Journal of Development Economics* **148** 102579. ISSN 0304-3878. DOI 10.1016/j.jdeveco.2020.102579. https://www.sciencedirect.com/science/article/pii/S0304387820301541.

Michelson, H., S. Gourlay, T. Lybbert, P. Wollburg. 2023. Review: Purchased agricultural input quality and small farms. *Food Policy* **116** 102424. ISSN 0306-9192. DOI 10.1016/j.foodpol.2023.102424. https://www.sciencedirect.com/science/article/pii/S0306919223000222.

Michelson, H., S. Gourlay, P. Wollburg. 2022. Non-Labor Input Quality and Small Farms in Sub-Saharan Africa: A Review. Policy Research Working Paper 10092, The World Bank. DOI 10.1596/1813-9450-10092. https://hdl.handle.net/10986/37570.

Michelson, H., C. Magomba, A. Maertens. 2024. Restoring Trust: Evidence from the Fertiliser Market in Tanzania.

Michler, J. D., E. Tjernström, S. Verkaart, K. Mausch. 2019. Money Matters: The Role of Yields and Profits in Agricultural Technology Adoption. *American Journal of*

Agricultural Economics **101**(3) 710–731. ISSN 1467-8276. DOI 10.1093/ajae/aay050. https://onlinelibrary.wiley.com/doi/abs/10.1093/ajae/aay050. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1093/ajae/aay050.

Miehe, C., R. Sparrow, D. J. Spielman, B. Van Campenhout. 2023. The (perceived) quality of agricultural technology and its adoption: Experimental evidence from Uganda. IFPRI Discussion Paper 2198, IFPRI. https://hdl.handle.net/10568/132361. Publisher: International Food Policy Research Institute.

Minten, B., C. B. Barrett. 2008. Agricultural Technology, Productivity, and Poverty in Madagascar. *World Development* **36**(5) 797–822. ISSN 0305750X. DOI 10.1016/j.worlddev.2007.05.004. https://linkinghub.elsevier.com/retrieve/pii/S0305750X08000107.

Minten, B., B. Koru, D. Stifel. 2013. The last mile(s) in modern input distribution: Pricing, profitability, and adoption. *Agricultural Economics* **44**(6) 629–646. ISSN 1574-0862. DOI 10.1111/agec.12078. https://ezproxy-prd.bodleian.ox.ac.uk:2152/doi/10.1111/agec.12078. Publisher: John Wiley & Sons, Ltd.

Mishra, K., A. G. Sam, G. M. Diiro, M. J. Miranda. 2020. Gender and the dynamics of technology adoption: Empirical evidence from a household-level panel data. *Agricultural Economics* **51**(6) 857–870. ISSN 0169-5150, 1574-0862. DOI 10.1111/agec.12596. https://onlinelibrary.wiley.com/doi/10.1111/agec.12596.

Mitra, S., M. Palmer, D. Mont, N. Groce. 2016. Can Households Cope with Health Shocks in Vietnam? *Health Economics* **25**(7) 888–907. ISSN 1099-1050. DOI 10.1002/hec.3196. https://onlinelibrary.wiley.com/doi/abs/10.1002/hec.3196. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/hec.3196.

Mobarak, A. M., M. R. Rosenzweig. 2013. Informal Risk Sharing, Index Insurance, and Risk Taking in Developing Countries. *American Economic Review* **103**(3) 375–380. ISSN 0002-8282. DOI 10.1257/aer.103.3.375. https://pubs.aeaweb.org/doi/10.1257/aer.103.3.375.

MoH. 2016. Malaria Bulletin. Technical Report Issue 1 Volume 1, Uganda Ministry of Health. https://www.health.go.ug/cause/malaria-bulletin-2016/.

Moller, L. R., C. Smith-Hall, H. Meilby, S. Rayamajhi, L. B. Herslund, H. O. Larsen, O. J. Nielsen, A. Byg. 2019. Empirically based analysis of households coping with unexpected shocks in the central Himalayas. *Climate and Development* **11**(7) 597–606. ISSN 1756-5529, 1756-5537. DOI 10.1080/17565529.2018.1518812. https://www.tandfonline.com/doi/full/10.1080/17565529.2018.1518812.

Monitor. 2021a. Rising cost of grief. *Monitor* https://www.monitor.co.ug/uganda/magazines/life/rising-cost-of-grief-1722154.

Monitor. 2021b. 'Scientific' burials save Lango families from wasting money. *Monitor* https://www.monitor.co.ug/uganda/news/national/-scientific-burials-save-lango-families-from-wasting-money-3501312.

Monitor Deloitte. 2014. Counterfeiting in African Agriculture Inputs – Challenges & Solutions. Draft Technical Report. https://www.agrilinks.org/sites/default/files/resource/files/BMGF_Addressing%20Counterfeit%20Ag%20%20Inputs_Research%20Read-out%20%282%29%20%281%29.pdf.

Morduch, J. 1999. Between the State and the Market: Can Informal Insurance Patch the Safety Net? *The World Bank Research Observer* **14**(2) 187–207. ISSN 0257-3032. https://www.jstor.org/stable/3986364. Publisher: Oxford University Press.

Morris, M., V. A. Kelly, R. J. Kopicki, D. Byerlee. 2007. *Fertilizer Use in African Agriculture: Lessons Learned and Good Practice Guidelines*. The World Bank. ISBN 978-0-8213-6880-0 978-0-8213-6881-7. DOI 10.1596/978-0-8213-6880-0. http://elibrary.worldbank.org/doi/book/10.1596/978-0-8213-6880-0.

Moser, C. M., C. B. Barrett. 2006. The complex dynamics of smallholder technology adoption: the case of SRI in Madagascar. *Agricultural Economics* **35**(3) 373–388. ISSN 0169-5150, 1574-0862. DOI 10.1111/j.1574-0862.2006.00169.x. https://onlinelibrary.wiley.com/doi/10.1111/j.1574-0862.2006.00169.x.

Mosley, P., A. Verschoor. 2005. Risk Attitudes and the 'Vicious Circle of Poverty'. *The European Journal of Development Research* **17**(1) 59–88. ISSN 0957-8811, 1743-9728. DOI 10.1080/09578810500066548. http://link.springer.com/10.1080/09578810500066548.

Mubangizi, N., F. B. Kyazze, P. I. Mukwaya. 2019. Determinants of Strategies that Enhance Farmers' Resilience to Rainfall Variability in Mt. Elgon Region, Eastern Uganda. In Y. Bamutaze, S. Kyamanywa, B. R. Singh, G. Nabanoga, R. Lal, eds., *Agriculture and Ecosystem Resilience in Sub Saharan Africa: Livelihood Pathways Under Changing Climate*, Climate Change Management, 509–539. Springer International Publishing, Cham. ISBN 978-3-030-12974-3. DOI 10.1007/978-3-030-12974-3_23. https://doi.org/10.1007/978-3-030-12974-3_23.

Mukasa, A. N. 2018. Technology adoption and risk exposure among smallholder farmers: Panel data evidence from Tanzania and Uganda. *World Development* **105** 299–309. ISSN 0305750X. DOI 10.1016/j.worlddev.2017.12.006. https://linkinghub.elsevier.com/retrieve/pii/S0305750X17303996.

Mulvaney, C., K. Kelsey. 2020. A phenomenological inquiry to understand Ugandan farmers' perceived barriers to fertilizer use. *Advancements in Agricultural Development* **1**(1) 63–74. ISSN 2690-5078. DOI 10.37433/aad.v1i1.7. https://agdevresearch.org/index.php/aad/article/view/7. Number: 1.

Mwakalobo, A. B. S. 2007. Implications of HIV/AIDS for Rural Livelihoods in Tanzania: The Example of Rungwe District. *African Studies Review* **50**(3) 51–73. ISSN 0002-0206, 1555-2462. DOI 10.1353/arw.2008.0019. https://www.cambridge.org/core/product/identifier/S0002020600001530/type/journal_article.

NAADS. 2003. The impact of HIV/AIDS on the agricultural sector and rural livelihoods in Uganda. Baseline Report, The National Agricultural Advisory Services (NAADS). https://resourcecentre.savethechildren.net/pdf/2345.pdf/.

Nagler, P., W. Naudé. 2017. Non-farm entrepreneurship in rural sub-Saharan Africa: New empirical evidence. *Food Policy* **67** 175–191. ISSN 03069192. DOI 10.1016/j.foodpol.2016.09.019. https://linkinghub.elsevier.com/retrieve/pii/S0306919216303876.

Namaazi, J. 2008. Use of inorganic fertilizers in Uganda. Brief 4, International Food Policy Research Institute. https://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/126281/filename/126492.pdf.

NARO. 2023. BugiZARDI. https://naro.go.ug/about-us/paris/bugizardi/.

Nelson, P. 1970. Information and Consumer Behavior. *Journal of Political Economy* **78**(2) 311–329. ISSN 0022-3808. https://www.jstor.org/stable/1830691. Publisher: The University of Chicago Press.

New Vision. 2022. Farmers tipped on guarding against fake agro-inputs. *New Vision* https://www.newvision.co.ug/null.

Newman, C., F. Tarp. 2020. Shocks and agricultural investment decisions. *Food Policy* **94** 101810. ISSN 03069192. DOI 10.1016/j.foodpol.2019.101810. https://linkinghub.elsevier.com/retrieve/pii/S0306919219306323.

Nguyen, G., T. T. Nguyen. 2020. Exposure to weather shocks: A comparison between self-reported record and extreme weather data. *Economic Analysis and Policy* **65** 117–138. ISSN 0313-5926. DOI 10.1016/j.eap.2019.11.009. https://www.sciencedirect.com/science/article/pii/S0313592619304205.

Nguyen, T.-T., T. T. Nguyen, U. Grote. 2020. Multiple shocks and households' choice of coping strategies in rural Cambodia. *Ecological Economics* **167** 106442. ISSN 09218009. DOI 10.1016/j.ecolecon.2019.106442. https://linkinghub.elsevier.com/retrieve/pii/S0921800919300606.

Nikoloski, Z., L. Christiaensen, R. Hill. 2017. Coping with Shocks: The Realities of African Life. In L. Christiaensen, L. Demery, eds., *Agriculture in Africa: Telling Myths from Facts*. The World Bank. ISBN 978-1-4648-1134-0 978-1-4648-1137-1. DOI 10.1596/978-1-4648-1134-0. http://elibrary.worldbank.org/doi/book/10.1596/978-1-4648-1134-0.

Nordhagen, S., U. Pascual. 2013. The Impact of Climate Shocks on Seed Purchase Decisions in Malawi: Implications for Climate Change Adaptation. *World Development* **43** 238–251. ISSN 0305750X. DOI 10.1016/j.worlddev.2012.08.002. https://linkinghub.elsevier.com/retrieve/pii/S0305750X12002045.

Okoboi, G., M. Barungi. 2012. Constraints to Fertilizer Use in Uganda: Insights from Uganda Census of Agriculture 2008/9. *Journal of Sustainable Development* **5**(10) p99. ISSN 1913-9071, 1913-9063. DOI 10.5539/jsd.v5n10p99. http://www.ccsenet.org/journal/index.php/jsd/article/view/19887.

Omotilewa, O. J., J. Ricker-Gilbert, J. H. Ainembabazi. 2019. Subsidies for Agricultural Technology Adoption: Evidence from a Randomized Experiment with Improved Grain Storage Bags in Uganda. *American Journal of Agricultural Economics* **101**(3) 753–772. ISSN 1467-8276. DOI 10.1093/ajae/aay108. https://onlinelibrary.wiley.com/doi/abs/10.1093/ajae/aay108. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1093/ajae/aay108.

Orem, J. N., J. M. Kirigia, R. Azairwe, C. M. Zikusooka, J. Bataringaya, P. O. Ogwang. 2012. Cost of malaria morbidity in Uganda. *Journal of Economics and Sustainable Development* **3**(2) 25.

Osei-Akoto, I., C. Adamba, R. D. Osei. 2013. The effect of health shocks on agricultural productivity: Evidence from Ghana. *International Journal of Agricultural Policy and Research* **1**(3) 067–079.

Osiemo, J., R. Ruben, E. Girvetz. 2021. Farmer Perceptions of Agricultural Risks; Which Risk Attributes Matter Most for Men and Women. *Sustainability* **13**(23) 12978. ISSN 2071-1050. DOI 10.3390/su132312978. https://www.mdpi.com/2071-1050/13/23/12978. Number: 23 Publisher: Multidisciplinary Digital Publishing Institute.

Ottaviani, J. I., V. Sagi-Kiss, H. Schroeter, G. G. Kuhnle. 2024. Reliance on self-reports and estimated food composition data in nutrition research introduces significant bias that can only be addressed with biomarkers. *eLife* **13** RP92941. ISSN 2050-084X. DOI 10.7554/eLife.92941. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC11186626/.

Oudmane, M., F. Mourji, A. Ezzrari. 2019. The impact of out-of-pocket health expenditure on household impoverishment: Evidence from Morocco. *International Journal of Health Planning & Management* **34**(4) e1569–e1585. ISSN 07496753. DOI 10.1002/hpm.2848. https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,uid&db=bsu&AN=140300192&site=ehost-live&authtype=ip,uid. Publisher: John Wiley & Sons, Inc.

Oyetunde-Usman, Z., K. O. Olagunju, O. R. Ogunpaimo. 2021. Determinants of adoption of multiple sustainable agricultural practices among smallholder farmers in Nigeria. *International Soil and Water Conservation Research* **9**(2) 241–248. ISSN 2095-6339. DOI 10.1016/j.iswcr.2020.10.007. https://www.sciencedirect.com/science/article/pii/S2095633920300824.

Parker, D., K. Jacobsen, M. Komwa. 2009. A Qualitative Study of the Impact of HIV/AIDS on Agricultural Households in Southeastern Uganda. *International Journal of Environmental Research and Public Health* **6**(8) 2113–2138. ISSN 1660-4601. DOI 10.3390/ijerph6082113. http://www.mdpi.com/1660-4601/6/8/2113.

Paumgarten, F., B. Locatelli, E. T. Witkowski, C. Vogel. 2020. Prepare for the unanticipated: Portfolios of coping strategies of rural households facing diverse shocks. *Journal of Rural Studies* **80** 91–100. ISSN 07430167. DOI 10.1016/j.jrurstud.2020.05.013. https://linkinghub.elsevier.com/retrieve/pii/S0743016718303619.

Pender, J., P. Jagger, E. Nkonya, D. Sserunkuuma. 2001. Development Pathways and Land Management in Uganda: Causes and Implications. EPTD Discussion Paper 85, International Food Policy Research Institute.

Peter Timmer, C. 1988. Chapter 8 The agricultural transformation. In *Handbook of Development Economics*, volume 1, 275–331. Elsevier. DOI 10.1016/S1573-4471(88)01011-3. https://www.sciencedirect.com/science/article/pii/S1573447188010113.

Peterman, A., S. W. Ng, T. Palermo, I.-H. E. Lee. 2013. Managing the Double Burden: Pregnancy and Labor-Intensive Time Use in Rural China, Mexico, and Tanzania. *Studies in Family Planning* **44**(4) 411–430. ISSN 00393665. DOI 10.1111/j.1728-4465.2013.00367.x. https://onlinelibrary.wiley.com/doi/10.1111/j.1728-4465.2013.00367.x.

Pitt, M., M. Rosenzweig. 1984. Agricultural Prices, Food Consumption and the Health and Productivity of Farmers. Bulletins 7471, University of Minnesota, Economic Development Center. https://econpapers.repec.org/paper/agsumedbu/7471.htm.

PMI. 2015. President's Malaria Initiative: Uganda Country Profile. Technical report, President's Malaria Initiative (PMI). https://reliefweb.int/report/uganda/presidents-malaria-initiative-uganda-country-profile.

Porter, C. 2012. Shocks, Consumption and Income Diversification in Rural Ethiopia. *Journal of Development Studies* **48**(9) 1209–1222. ISSN 0022-0388, 1743-9140. DOI 10.1080/00220388.2011.646990. http://www.tandfonline.com/doi/abs/10.1080/00220388.2011.646990.

Powell-Jackson, T., M. E. Hoque. 2012. Economic Consequences of Maternal Illness in Rural Bangladesh. *Health Economics* **21**(7) 796–810. ISSN 1099-1050. DOI 10.1002/hec.

1749. https://onlinelibrary.wiley.com/doi/abs/10.1002/hec.1749. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/hec.1749.

Rahut, D. B., J. P. Aryal, P. Marenya. 2021. Understanding climate-risk coping strategies among farm households: Evidence from five countries in Eastern and Southern Africa. *Science of The Total Environment* **769** 145236. ISSN 00489697. DOI 10.1016/j.scitotenv.2021.145236. https://linkinghub.elsevier.com/retrieve/pii/S0048969721003028.

Ravallion, M., S. Chaudhuri. 1997. Risk and Insurance in Village India: Comment. *Econometrica* **65**(1) 171–184. ISSN 0012-9682. DOI 10.2307/2171818. https://www.jstor.org/stable/2171818. Publisher: [Wiley, Econometric Society].

Ray, D. K., N. Ramankutty, N. D. Mueller, P. C. West, J. A. Foley. 2012. Recent patterns of crop yield growth and stagnation. *Nature Communications* **3**(1) 1293. ISSN 2041-1723. DOI 10.1038/ncomms2296. https://www.nature.com/articles/ncomms2296. Number: 1 Publisher: Nature Publishing Group.

Reinker, M., E. Gralla. 2018. A System Dynamics Model of the Adoption of Improved Agricultural Inputs in Uganda, with Insights for Systems Approaches to Development. *Systems* **6**(3) 31. ISSN 2079-8954. DOI 10.3390/systems6030031. http://www.mdpi.com/2079-8954/6/3/31.

Ross, N., P. Santos, T. Capon. 2012. Risk, ambiguity and the adoption of new technologies: experimental evidence from a developing economy. Foz do Iguau, Brazil. DOI 10.22004/ag.econ.126492.

Russell, S. 2004. THE ECONOMIC BURDEN OF ILLNESS FOR HOUSEHOLDS IN DEVELOPING COUNTRIES: A REVIEW OF STUDIES FOCUSING ON MALARIA, TUBERCULOSIS, AND HUMAN IMMUNODEFICIENCY VIRUS/ACQUIRED IMMUNODEFICIENCY SYNDROME. *The American Journal of Tropical Medicine and Hygiene* **71**(2_suppl) 147–155. DOI 10.4269/ajtmh.2004.71.147. https://www.ajtmh.org/view/journals/tpmd/71/2_suppl/article-p147.xml. Publisher: American Society of Tropical Medicine and Hygiene Section: The American Journal of Tropical Medicine and Hygiene.

Rutsaert, P., J. Donovan. 2020. Sticking with the old seed: Input value chains and the challenges to deliver genetic gains to smallholder maize farmers. *Outlook on Agriculture* **49**(1) 39–49.

ISSN 0030-7270. DOI 10.1177/0030727019900520. https://doi.org/10.1177/0030727019900520. Publisher: SAGE Publications Ltd.

Sachs, J., P. Malaney. 2002. The economic and social burden of malaria. *Nature* **415**(6872) 680–685. ISSN 1476-4687. DOI 10.1038/415680a. https://www.nature.com/articles/415680a. Number: 6872 Publisher: Nature Publishing Group.

Sanchez, P. A., G. L. Denning, G. Nziguheba. 2009. The African Green Revolution moves forward. *Food Security* **1**(1) 37–44. ISSN 1876-4525. DOI 10.1007/s12571-009-0011-5. https://ezproxy-prd.bodleian.ox.ac.uk:2120/article/10.1007/s12571-009-0011-5. Company: Springer Distributor: Springer Institution: Springer Label: Springer Number: 1 Publisher: Springer Netherlands.

Sanou, A., L. S. O. Liverpool-Tasie, R. Shupp. 2018. Eliciting Risk Attitudes in the Field: Surveys or Experimental Methods? An Empirical Comparison in Rural Niger. *The Journal of Development Studies* **54**(8) 1450–1470. ISSN 0022-0388, 1743-9140. DOI 10.1080/00220388.2017.1404034. https://www.tandfonline.com/doi/full/10.1080/00220388.2017.1404034.

Segawa, N. 2019. Bodies in a Taxi: What Happens When Funeral Transport Is Too Expensive. *Global Press Journal* https://globalpressjournal.com/africa/uganda/uganda-cant-afford-private-car-transport-dead-turn-public-transport/.

Seyi Olalekan, O., F. Olapade-Ogunwole, M. O. Raufu. 2011. SHOCKS AND COPING STRATEGIES OF RURAL HOUSEHOLDS: EVIDENCE FROM OGO-OLUWA LOCAL GOVERNMENT, OYO STATE, NIGERIA. *International Journal of Agricultural Management & Development* **1**(4) 259–266.

Shapiro, C. 1983. Premiums for High Quality Products as Returns to Reputations. *The Quarterly Journal of Economics* **98**(4) 659–679. ISSN 0033-5533. DOI 10.2307/1881782. https://www.jstor.org/stable/1881782. Publisher: Oxford University Press.

Sheahan, M., C. B. Barrett. 2017. Ten striking facts about agricultural input use in Sub-Saharan Africa. *Food Policy* **67** 12–25. ISSN 03069192. DOI 10.1016/j.foodpol.2016.09.010. https://linkinghub.elsevier.com/retrieve/pii/S0306919216303773.

Shiferaw, B., T. Kebede, M. Kassie, M. Fisher. 2015. Market imperfections, access to information and technology adoption in Uganda: challenges of overcoming multiple constraints. *Agricultural Economics* **46**(4) 475–488. ISSN 01695150. DOI 10.1111/agec.12175. https://onlinelibrary.wiley.com/doi/10.1111/agec.12175.

Shikuku, K. M. 2019. Information exchange links, knowledge exposure, and adoption of agricultural technologies in northern Uganda. *World Development* **115** 94–106. ISSN 0305750X. DOI 10.1016/j.worlddev.2018.11.012. https://linkinghub.elsevier.com/retrieve/pii/S0305750X18304169.

Simtowe, F. 2006. Can Risk-Aversion Towards Fertilizer Explain Part of the Non-Adoption Puzzle for Hybrid Maize? Empirical Evidence from Malawi. SSRN Scholarly Paper ID 939398, Social Science Research Network, Rochester, NY. https://papers.ssrn.com/abstract=939398.

Skoufias, E., A. R. Quisumbing. 2005. Consumption Insurance and Vulnerability to Poverty: A Synthesis of the Evidence from Bangladesh, Ethiopia, Mali, Mexico and Russia. *The European Journal of Development Research* **17**(1) 24–58. ISSN 1743-9728. DOI 10.1080/09578810500066498. https://doi.org/10.1080/09578810500066498.

Small, M. L., J. M. Calarco. 2022. *Qualitative Literacy: A Guide to Evaluating Ethnographic and Interview Research*. https://www.ucpress.edu/ebook/9780520390676/qualitative-literacy.

Somi, M. F., J. R. G. Butler, F. Vahid, J. Njau, S. P. Kachur, S. Abdulla. 2007. Is There Evidence for Dual Causation Between Malaria and Socioeconomic Status? Findings From Rural Tanzania. *The American Journal of Tropical Medicine and Hygiene* **77**(6) 1020–1027. DOI 10.4269/ajtmh.2007.77.1020. https://www.ajtmh.org/view/journals/tpmd/77/6/article-p1020.xml. Publisher: American Society of Tropical Medicine and Hygiene Section: The American Journal of Tropical Medicine and Hygiene.

Sparrow, R., E. V. de Poel, G. Hadiwidjaja, A. Yumna, N. Warda, A. Suryahadi. 2014. Coping with the Economic Consequences of Ill Health in Indonesia. *Health Economics* **23**(6) 719–728. ISSN 1099-1050. DOI 10.1002/hec.2945. https://onlinelibrary.wiley.com/doi/abs/10.1002/hec.2945. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/hec.2945.

Sseguya, H., D. S. Robinson, H. R. Mwango, J. A. Flock, J. Manda, R. Abed, S. O. Mruma. 2021. The impact of demonstration plots on improved agricultural input purchase in Tanzania: Implications for policy and practice. *PLOS ONE* **16**(1) e0243896. ISSN 1932-6203. DOI 10.1371/journal.pone.0243896. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0243896. Publisher: Public Library of Science.

Sserugo, P. 2023. Gov't lists disaster prone areas ahead of rainy season. *Monitor* https://www.monitor.co.ug/uganda/news/national/gov-t-lists-disaster-prone-areas-ahead-of-rainy-season-4169608.

Ssewanyana, S., I. Kasirye. 2020. Estimating Catastrophic Health Expenditures from Household Surveys: Evidence from Living Standard Measurement Surveys (LSMS)-Integrated Surveys on Agriculture (ISA) from Sub-Saharan Africa. *Applied Health Economics and Health Policy* **18**(6) 781–788. ISSN 1175-5652, 1179-1896. DOI 10.1007/s40258-020-00609-1. https://link.springer.com/10.1007/s40258-020-00609-1.

Staudacher, P., C. Brugger, M. S. Winkler, C. Stamm, A. Farnham, R. Mubeezi, R. I. L. Eggen, I. Günther. 2021. What agro-input dealers know, sell and say to smallholder farmers about pesticides: a mystery shopping and KAP analysis in Uganda. *Environmental Health* **20**(1) 100. ISSN 1476-069X. DOI 10.1186/s12940-021-00775-2. https://ehjournal.biomedcentral.com/articles/10.1186/s12940-021-00775-2.

Stifel, D., B. Minten. 2008. Isolation and agricultural productivity. *Agricultural Economics* **39**(1) 1–15. ISSN 0169-5150, 1574-0862. DOI 10.1111/j.1574-0862.2008.00310.x. https://onlinelibrary.wiley.com/doi/10.1111/j.1574-0862.2008.00310.x.

Strauss, J. 1986. Does Better Nutrition Raise Farm Productivity? *Journal of Political Economy* **94**(2) 297–320. ISSN 0022-3808, 1537-534X. DOI 10.1086/261375. https://www.journals.uchicago.edu/doi/10.1086/261375.

Streletskaya, N. A., S. D. Bell, M. Kecinski, T. Li, S. Banerjee, L. H. Palm-Forster, D. Pannell. 2020. Agricultural Adoption and Behavioral Economics: Bridging the Gap. *Applied Economic Perspectives and Policy* **42**(1) 54–66. ISSN 2040-5790, 2040-5804. DOI 10.1002/aepp.13006. https://onlinelibrary.wiley.com/doi/10.1002/aepp.13006.

Sturgess, P., R. Sparrey. 2016. What is Resilience? Technical report, DFID. DOI 10.12774/e od_tg.may2016.sturgessandsparrey. https://www.gov.uk/dfid-research-outputs/what-is-resilience.

Subramanian, S., T. Huijts, M. Avendano. 2010. Self-reported health assessments in the 2002 World Health Survey: how do they correlate with education? *Bulletin of the World Health Organization* **88**(2) 131–138. ISSN 0042-9686. DOI 10.2471/BLT.09.067058. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2814481/.

Suri, T. 2011. Selection and Comparative Advantage in Technology Adoption. *Econometrica* **79**(1) 159–209. ISSN 0012-9682. DOI 10.3982/ECTA7749. http://doi.wiley.com/10.3982/ECTA7749.

Suri, T., C. Udry. 2022. Agricultural Technology in Africa. *Journal of Economic Perspectives* **36**(1) 33–56. ISSN 0895-3309. DOI 10.1257/jep.36.1.33. https://pubs.aeaweb.org/doi/10.1257/jep.36.1.33.

Sánchez, P. A. 2010. Tripling crop yields in tropical Africa. *Nature Geoscience* **3**(5) 299–300. ISSN 1752-0908. DOI 10.1038/ngeo853. https://www.nature.com/articles/ngeo853. Number: 5 Publisher: Nature Publishing Group.

Tadesse, G., G. T. Abate, T. Zewdie. 2020. Biases in self-reported food insecurity measurement: A list experiment approach. *Food Policy* **92** 101862. ISSN 0306-9192. DOI 10.1016/j.foodpol.2020.101862. https://www.sciencedirect.com/science/article/pii/S0306919220300464.

Tadesse, M. A., B. A. Shiferaw, O. Erenstein. 2015. Weather index insurance for managing drought risk in smallholder agriculture: lessons and policy implications for sub-Saharan Africa. *Agricultural and Food Economics* **3**(1) 26. ISSN 2193-7532. DOI 10.1186/s40100-015-0044-3. http://www.agrifoodecon.com/content/3/1/26.

Taffesse, A. S., F. Tadesse. 2017. Pathways Less Explored—Locus of Control and Technology Adoption. *Journal of African Economies* **26**(suppl_1) i36–i72. ISSN 0963-8024, 1464-3723. DOI 10.1093/jae/ejx013. https://academic.oup.com/jae/article-lookup/doi/10.1093/jae/ejx013.

Takahashi, K. 2016. Mobile Phone Expansion, Informal Risk Sharing, and Consumption Smoothing: Evidence from Rural Uganda.

Tanaka, Y., A. Munro. 2014. Regional Variation in Risk and Time Preferences: Evidence from a Large-scale Field Experiment in Rural Uganda. *Journal of African Economies* **23**(1) 151–187. ISSN 0963-8024, 1464-3723. DOI 10.1093/jae/ejt020. https://academic.oup.com/jae/article-lookup/doi/10.1093/jae/ejt020.

Target Malaria. 2020. Target Malaria: Uganda. https://targetmalaria.org/wp-content/uploads/2020/11/Uganda_FS-National-Sept20_HighRes.pdf.

Teh, W. L., E. Abdin, A. P.v, F. D. S. Kumar, K. Roystonn, P. Wang, S. Shafie, S. Chang, A. Jeyagurunathan, J. A. Vaingankar, C. F. Sum, E. S. Lee, R. M. v. Dam, M. Subramaniam. 2023. Measuring social desirability bias in a multi-ethnic cohort sample: its relationship with self-reported physical activity, dietary habits, and factor structure. *BMC Public Health* **23**. DOI 10.1186/s12889-023-15309-3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9979418/. Publisher: BMC.

Tjernström, E., M. Carter, T. J. Lybbert. 2015. The Dirt on Dirt: Soil Characteristics and Variable Fertilizer Returns in Kenyan Maize Systems. AMA Innovation Lab Working Paper. https://basis.ucdavis.edu/publication/policy-brief-diverse-soils-and-inputs-challenge-recommendations-maize-farmers-kenya.

Townsend, R. M. 1994. Risk and Insurance in Village India. *Econometrica* **62**(3) 539–591. ISSN 0012-9682. DOI 10.2307/2951659. https://www.jstor.org/stable/2951659. Publisher: [Wiley, Econometric Society].

Townsend, R. M. 1995. Consumption Insurance: An Evaluation of Risk-Bearing Systems in Low-Income Economies. *The Journal of Economic Perspectives* **9**(3) 83–102. ISSN 0895-3309. https://www.jstor.org/stable/2138427. Publisher: American Economic Association.

Tusting, L. S., J. Rek, E. Arinaitwe, S. G. Staedke, M. R. Kamya, J. Cano, C. Bottomley, D. Johnston, G. Dorsey, S. W. Lindsay, J. Lines. 2016. Why is malaria associated with poverty? Findings from a cohort study in rural Uganda. *Infectious Diseases of Poverty* **5**(1) 78. ISSN 2049-9957. DOI 10.1186/s40249-016-0164-3. https://idpjournal.biomedcentral.com/articles/10.1186/s40249-016-0164-3.

Twesigye, J., J. M. Twikirize, R. Luwangula, S. Kitimbo. 2019. Building resilience through indigenous mechanisms: The case of Bataka groups in Western Uganda. In J. M. Twikirize,

H. Spitzer, eds., *Social work practice in Africa: indigenous and innovative approaches*, 145–160. Fountain Publishers, Kampala, Uganda. ISBN 978-9970-617-92-0.

Tyack, N., M. Bozzola, T. Swanson, H. Ting. 2025. Certification and credibility: do seed certification systems in Uganda help signal quality to farmers? DOI 10.2139/ssrn.5090685. https://papers.ssrn.com/abstract=5090685.

UBOS. 2016. The National Population and Housing Census 2014 – Main Report. Technical report, Uganda Bureau of Statistics, Kampala, Uganda. https://unstats.un.org/unsd/demographic/sources/census/wphc/Uganda/UGA-2016-05-23.pdf.

UBOS. 2018. Uganda National Household Survey 2016/2017 Report. Technical report, Uganda Bureau of Statistics, Kampala, Uganda.

UBOS. 2020. Annual Agricultural Survey 2018. Technical report, Uganda Bureau of Statistics, Kampala, Uganda.

UBOS. 2021. 2021 Statistical Abstract. Technical report, Uganda Bureau of Statistics, Kampala, Uganda.

UBOS. 2022. Annual Agriculture Survey (AAS) 2020. Technical report, Uganda Bureau of Statistics. https://www.ubos.org/wp-content/uploads/publications/07_2023AAS_2020_REPORT.pdf.

Udry, C. 1990. Credit Markets in Northern Nigeria: Credit as Insurance in a Rural Economy. *The World Bank Economic Review* **4**(3) 251–269. ISSN 0258-6770. https://www.jstor.org/stable/3989877. Publisher: Oxford University Press.

Udry, C. 1995. Risk and Saving in Northern Nigeria. *American Economic Review* **85**(5) 1287–1300. ISSN 00028282. https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,uid&db=bsu&AN=9602051808&site=ehost-live&authtype=ip,uid. Publisher: American Economic Association.

Uganda Districts Information Handbook. 2021. *Uganda Districts Information Handbook*. Fountain Publishers, Kampala, Uganda, expanded edition edition.

Ulimwengu, J. M. 2009. Farmers' health and agricultural productivity in rural Ethiopia. *African Journal of Agricultural and Resource Economics* **3**(2). DOI 10.22004/ag.econ.56902. Num Pages: 18.

UN. 2022. Goal 2 | Department of Economic and Social Affairs. https://sdgs.un.org/goals/goal2.

Upton, J., S. Constenla-Villoslada, C. B. Barrett. 2022. Caveat utilitor: A comparative assessment of resilience measurement approaches. *Journal of Development Economics* **157** 102873. ISSN 03043878. DOI 10.1016/j.jdeveco.2022.102873. https://linkinghub.elsevier.com/retrieve/pii/S030438782200044X.

Urama, C. E., Y. Adewoyin, E. R. Ukwueze, J. C. Ene. 2019. Socioeconomic status and health shocks; analysis of coping strategies in rural households of Enugu State, Nigeria. *African Population Studies* **33**(1). ISSN 2308-7854. DOI 10.11564/33-1-1367. https://aps.journals.ac.za/pub/article/view/1367. Number: 1.

USAID. 2023. Resilience | What We Do. https://www.usaid.gov/resilience.

Van Campenhout, B. 2016. Fertility, Agricultural Labor Supply, and Production: Instrumental Variable Evidence from Uganda. *Agricultural and Resource Economics Review* **45**(3) 581–607. ISSN 2372-2614. DOI 10.1017/age.2016.26. https://www.cambridge.org/core/product/identifier/S2372261416000266/type/journal_article.

Van Campenhout, B., E. Bizimungu. 2018. Risk and returns of sustainable crop intensification: The case of smallholder rice and potato farmers in Uganda. *Development Policy Review* **36**(S2) O605–O633. ISSN 1467-7679. DOI 10.1111/dpr.12356. https://onlinelibrary.wiley.com/doi/abs/10.1111/dpr.12356. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/dpr.12356.

Van Campenhout, B., E. Bizimungu, D. Birungi. 2016. Risk and sustainable crop intensification: The case of smallholder rice and potato farmers in Uganda. IFPRI Discussion Paper 01521, International Food Policy Research Institute.

Van Campenhout, B., W. Walukano, F. Nattembo, L. Nazziwa-Nviiri, J. Blom. 2017. The Role of Information in Agricultural Technology Adoption: Experimental Evidence from Rice Farmers in Uganda. IFPRI Discussion Paper 01684, International Food Policy Research Institute.

Van Damme, W., L. Van Leemput, I. Por, W. Hardeman, B. Meessen. 2004. Out-of-pocket health expenditure and debt in poor households: evidence from Cambodia. *Tropical Medicine*

& International Health **9**(2) 273–280. ISSN 1360-2276, 1365-3156. DOI 10.1046/j.1365-3156.2003.01194.x. https://onlinelibrary.wiley.com/doi/10.1046/j.1365-3156.2003.01194.x.

Veljanoska, S. 2022. Do Remittances Promote Fertilizer Use? The Case of Ugandan Farmers. *American Journal of Agricultural Economics* **104**(1) 273–293. ISSN 1467-8276. DOI 10.1111/ajae.12214. https://onlinelibrary.wiley.com/doi/abs/10.1111/ajae.12214. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/ajae.12214.

Verschoor, A., B. D'Exelle, B. Perez-Viana. 2016. Lab and life: Does risky choice behaviour observed in experiments reflect that in the real world? *Journal of Economic Behavior & Organization* **128** 134–148. ISSN 01672681. DOI 10.1016/j.jebo.2016.05.009. https://linkinghub.elsevier.com/retrieve/pii/S0167268116300889.

Verteramo Chiu, L. J., S. V. Khantachavana, C. G. Turvey. 2014. Risk rationing and the demand for agricultural credit: a comparative investigation of Mexico and China. *Agricultural Finance Review* **74**(2) 248–270. ISSN 00021466. DOI http://dx.doi.org/10.1108/AFR-05-2014-0011. https://www.proquest.com/docview/2076939265/abstract/7B6DB5E5F661441DPQ/1. Num Pages: 23 Place: Bingley, United Kingdom Publisher: Emerald Group Publishing Limited.

Visser, M., H. Jumare, K. Brick. 2020. Risk preferences and poverty traps in the uptake of credit and insurance amongst small-scale farmers in South Africa. *Journal of Economic Behavior & Organization* **180** 826–836. ISSN 01672681. DOI 10.1016/j.jebo.2019.05.007. https://linkinghub.elsevier.com/retrieve/pii/S0167268119301465.

Wagstaff, A. 2007. The economic consequences of health shocks: Evidence from Vietnam. *Journal of Health Economics* **26**(1) 82–100. ISSN 0167-6296. DOI 10.1016/j.jhealeco.2006.07.001. https://www.sciencedirect.com/science/article/pii/S0167629606000737.

Wagstaff, A., M. Lindelow. 2014. Are Health Shocks Different? Evidence from a Multi-shock Survey in Laos. *Health Economics* **23**(6) 706–718. ISSN 1099-1050. DOI 10.1002/hec.2944. https://onlinelibrary.wiley.com/doi/abs/10.1002/hec.2944. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/hec.2944.

Ward, P. S., V. Singh. 2014. Risk and Ambiguity Preferences and the Adoption of New Agricultural Technologies: Evidence from Field Experiments in Rural India. IFPRI Discussion Paper 01324, International Food Policy Research Institute.

Wekesa, E., W. Mwangi, H. Verkuijl, M. K. Danda, H. De Groote. 2003. Adoption of Maize Production Technologies in the Coastal Lowlands of Kenya. Technical Report 56109, CIMMYT: International Maize and Wheat Improvement Center, Mexico. https://ideas.repec.org/p/ags/cimmmr/56109.html. Publication Title: Miscellaneous Reports.

Wielgosz, B., E. Kato, C. Ringler. 2014. Agro-ecology, household economics and malaria in Uganda: empirical correlations between agricultural and health outcomes. *Malaria Journal* **13**(1) 251. ISSN 1475-2875. DOI 10.1186/1475-2875-13-251. https://malariajournal.biomedcentral.com/articles/10.1186/1475-2875-13-251.

Wielgosz, B., M. Mangheni, D. Tsegai, C. Ringler. 2012. Malaria and Agriculture: A Global Review of the Literature With a Focus on the Application of Integrated Pest and Vector Management in East Africa and Uganda. IFPRI Discussion Paper 01232, International Food Policy Research Institute.

Willis, D. W., N. Hamon. 2019. Evidence for the impact of malaria on agricultural household income in sub-Saharan Africa. *Gates Open Research* **3** 9. ISSN 2572-4754. DOI 10.12688/gatesopenres.12907.1. https://gatesopenresearch.org/articles/3-9/v1.

Woldemichael, A., S. Gurmu. 2018. An Empirical Analysis of Health Shocks and Informal Risk Sharing Networks. *African Development Review / Revue Africaine de Développement* **30**(1) 100–111. ISSN 10176772. DOI 10.1111/1467-8268.12315. https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,uid&db=bsu&AN=129060066&site=ehost-live&authtype=ip,uid. Publisher: Wiley-Blackwell.

World Bank. 2005. Uganda : Policy Options for Increasing Crop Productivity and Reducing Soil Nutrient Depletion and Poverty. Technical report, World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/8647. Accepted: 2012-06-21T15:39:37Z.

World Bank. 2018. Uganda Economic Update (12th ed.): Developing the Agri-Food System for Inclusive Economic Growth. Technical report, The World Bank. https://openknowledge.worldbank.org/bitstream/handle/10986/31003/132140-WP-P168202-UGANDAECONOMICUPDATE.pdf?sequence=1&isAllowed=y.

World Bank. 2022. World Development Indicators. https://databank.worldbank.org/reports.aspx?source=world-development-indicators.

World Health Organization. 2021. World malaria report 2021. Technical report, World Health Organization. https://www.who.int/publications-detail-redirect/9789240040496.

Wossen, T., S. Di Falco, T. Berger, W. McClain. 2016. You are not alone: social capital and risk exposure in rural Ethiopia. *Food Security* **8**(4) 799–813. ISSN 1876-4525. DOI 10.1007/s12571-016-0587-5. https://doi.org/10.1007/s12571-016-0587-5.

Wossen, T., T. T. Gatiso, M. Kassie. 2019. Estimating returns to fertilizer adoption with unobserved heterogeneity: Evidence from Ethiopia. *Food and Energy Security* **8**(2) e00156. ISSN 2048-3694. DOI 10.1002/fes3.156. https://onlinelibrary.wiley.com/doi/abs/10.1002/fes3.156. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/fes3.156.

Wuepper, D., H. Yesigat Ayenew, J. Sauer. 2018. Social Capital, Income Diversification and Climate Change Adaptation: Panel Data Evidence from Rural Ethiopia. *Journal of Agricultural Economics* **69**(2) 458–475. ISSN 1477-9552. DOI 10.1111/1477-9552.12237. https://onlinelibrary.wiley.com/doi/abs/10.1111/1477-9552.12237. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/1477-9552.12237.

Yamano, T., T. Jayne. 2004. Measuring the Impacts of Working-Age Adult Mortality on Small-Scale Farm Households in Kenya. *World Development* **32**(1) 91–119. ISSN 0305750X. DOI 10.1016/j.worlddev.2003.07.004. https://linkinghub.elsevier.com/retrieve/pii/S0305750X03001992.

Yamano, T., D. Sserunkuuma, K. Otsuka, G. Omiat, J. H. Ainembabazi, Y. Shimamura. 2004. The 2003 REPEAT Survey in Uganda: Results. Technical report, Foundation for Advanced Studies on International Development, Japan.

Yilma, Z., A. Mebratie, R. Sparrow, D. Abebaw, M. Dekker, G. Alemu, A. S. Bedi. 2014. Coping with shocks in rural Ethiopia. *The Journal of Development Studies* **50**(7) 1009–1024. ISSN 0022-0388, 1743-9140. DOI 10.1080/00220388.2014.909028. http://www.tandfonline.com/doi/abs/10.1080/00220388.2014.909028.

Zeitlin, A., S. Caria, R. Dzene, P. Janský, E. Opoku, F. Teal. 2010. Heterogeneous returns and the persistence of agricultural technology adoption. CSAE Working Paper 2010-37, Centre for the Study of African Economies, University of Oxford. https://ideas.repec.org/p/csa/wpaper/2010-37.html. Publication Title: CSAE Working Paper Series.

Zeweld, W., G. Van Huylenbroeck, G. Tesfay, S. Speelman. 2019. Impacts of socio-psychological factors on smallholder farmers' risk attitudes: empirical evidence and implications. *Agrekon* **58**(2) 253–279. ISSN 0303-1853, 2078-0400. DOI 10.1080/03031853.2019.1570284. https://www.tandfonline.com/doi/full/10.1080/03031853.2019.1570284.

Zimmerman, F. J., M. R. Carter. 2003. Asset smoothing, consumption smoothing and the reproduction of inequality under risk and subsistence constraints. *Journal of Development Economics* **71**(2) 233–260. ISSN 0304-3878. DOI 10.1016/S0304-3878(03)00028-2. https://www.sciencedirect.com/science/article/pii/S0304387803000282.