PONTIFÍCIA UNIVERSIDADE CATÓLICA DO RIO DE JANEIRO
DEPARTAMENTO DE ECONOMIA

MONOGRAFIA DE FINAL DE CURSO

AN OVERVIEW OF RISK AND CONSUMPTION SMOOTHING MECHANISMS IN RURAL MOZAMBIQUE

Isabella Rego Monteiro
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An overview of risk and consumption smoothing mechanisms in rural Mozambique

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Abstract

This paper examines households' exposure to risk in rural Mozambique and its effect on their social indicators such as the possession of consumer goods (bicycles, motorcycles, cellphones), hygiene habits, health conditions (anemia and malaria), child mortality, household head literacy and storage capacity. The usage of consumption smoothing mechanisms is analyzed in regards to its effect on both the variability of income and food security and more lasting social outcomes that were present in the original data set (consumer good possession, hygiene conditions, storage capacity and the head's literacy). I find that farmers in Mozambique are extremely vulnerable to risk but the time-span of these fluctuations is not the same throughout the whole country. Higher monthly income risk is found to be linked with overall worse social indicators. Furthermore, the usage of Risk Management mechanisms, including crop diversification, irrigation, and occupation diversification from both the head and other household members, is shown to be associated with lower variations of income and food security. Risk Coping is also assessed by using Townsend's (1995) full risk-sharing model, which indicates risk pooling among individuals in the same geographical area is quite high. Both Risk Management and Risk Coping mechanisms are found to attenuate risk's effect on health, educational and economic status indicators.

1 Introduction

Mozambique is one of the world's poorest [1] countries in per capita terms. In addition, it is among the most risk prone areas worldwide, being notoriously struck by extreme climate events [2]. Not less important is the country's disease burden, as illnesses may indefinitely prevent economically active citizens from working: Mozambique exhibits one of the highest prevalence rates of HIV [3] and Malaria[4]. The population is also heavily reliant on agriculture (81% of Mozambique's population is at least partially involved in it [5] and 85.9% [6] lives in rural areas) and because agricultural output is very concentrated in time and starkly dependent on climate events, these activities inherently generate unstable income.

This means that not only do Mozambicans deal with low levels of average income, but that they also have to cope with time-inconsistencies in their access to resources, originating from the country's natural and social characteristics and from the economical importance of farming. This scenario is aggravated by the lack of access to financial markets: only 41.67% [7] of Mozambique's population had access to traditional financial services in 2017, making it harder for farmers to transfer income intertemporally and among households. If left unattended, such income fluctuations can lead to unreliable consumption patterns, which in turn may hurt food security and the ability to pay for larger expenses, such as health-related costs and school fees.

Mozambique's government has repeatedly expressed worries about food security, documented in a series of official publications [8] geared towards establishing directives for Mozambique's agricultural development. In these publications, much emphasis is given to the fact that the food security issue is worsened by the nation's dependency on imports of staple foods to meet the citizens' demand, due to low productivity within-borders. With

[1] In 2019, it ranked as the 6th poorest country according to the World Bank.

[2] Global Climate Risk Index.

[3] According to CIA's World Factbook, Mozambique has the second highest absolute number of people living with HID/AIDS.

[4] According to Global Burden of Disease Study 2017, 71.5 out of 100000 people in Mozambique have died of Malaria from 1991 to 2017.

[5] Sitoe, 2005

[6] CGAP 2015

[7] According to The Global Financial Inclusion

[8] The following official documents all cite expanding input usage as one of the main strategies to achieve food security: "Política Agrária e Estratégia de Implementação" (PAEI), "Estratégia da Revolução Verde" (ERV), "Estratégia de Desenvolvimento Rural", " Estratégia de Segurança Alimentar e Nutricional II ", "Plano Estratégico para Desenvolvimento do Sector Agrário" (PEDSA), "Plano de Acção para Redução da Pobreza" (PARP).

this in mind, the government's approach to food security has been mostly to chase higher productivity by encouraging the usage of inputs, notoriously through subsidies. This supply take on food security, nonetheless, fails to address that instabilities may be at the heart of the agricultural business in disaster-prone Mozambique and that a more accurate public policy might be achieved by combining input subsidies to an increased availability and usage of consumption smoothing tools and government safety nets.

Indeed, many key questions must be elucidated before a policy path is chosen. Firstly, an accurate estimate of income irregularities and their consequences should be made. To do so, I used a binary variable that contained information on the individual having received income in each month of the year. The fluctuations of income during the year were then calculated by obtaining the coefficient of variation of said monthly income. I find that fluctuations in monthly income are quite high across Mozambique, but seem to be higher in Northern districts of the country. These results are available in Section 4.2.

Nevertheless, to obtain a more precise idea of how these irregularities may actually impact people's lives, their association with access to food and more general social outcomes must be known. For instance, are idiosyncratic fluctuations of income linked with higher food insecurity or is risk successfully pooled among individuals when it does not affect an entire community?

This question is addressed in Section 5.2 by analyzing the co-movement of a person's food consumption levels with her own income. An accentuated co-movement of the family's incomes and food intake throughout a year would be consistent with it not being able to maintain steady levels of basic consumption when faced with non-permanent changes in monthly revenues. It appears, however, that individual food security is independent of individual income levels, remaining strongly connected only to aggregate food security in a district, which would point to risk sharing as a fairly common practice.

Moreover, not dealing with fluctuating levels of income can go beyond temporary food security issues by creating pervasive scenarios known as poverty traps (Duflo and Banerjee 2011). Families among the extremely poor are especially vulnerable to this due to their difficulty to bounce back from negative shocks and to the increased importance of stability in their already scarce consumption patterns (Collins et al, 2009). If that is the case, an initial adverse shock will cause a family's descent into poverty by hampering its abilities to invest in human capital and productivity-increasing in-

puts. Income fluctuations' ties with wealth, health, hygiene and educational outcomes are looked at in Section 5.3. In general, I find that more unstable revenues throughout a year are correlated with less consumer goods in a household and worse hygiene habits.

A third aspect that must come under scrutiny is the usage of consumption smoothing mechanisms, both through Risk Management and Risk Coping strategies. Section 5.1 attempts to shed a light on this matter by investigating different Risk Management choices and if they correlate with lower fluctuations on both income and food security. I find that the diversification of occupations by the household head seems to be linked with more stable earnings, while decisions regarding agriculture, such as using irrigation and diversifying crops may generate reliable eating patterns. Risk Coping also appears to be used: data on this type of action was inferred in the previously discussed results of Section 5.2, which point to risk pooling as being vastly used in Mozambique.

Consumption Smoothing may also have a positive effect on social outcomes other than nourishment: these effects are further explored in Section 5.3. Generally, households that diversify crops, thus shielding themselves from shocks in any particular crop's yields, seem to also have more access to consumption goods and storage facilities. Household's choice of occupations (concerning both the family head and other members) are also associated with more access to consumption goods, good sanitation facilities and areas to store surplus crop, although these effects appear to be more widespread when considering only the household head. Similarly, Risk Coping mechanisms (measured by the family having sent remittances to other houses) are also significantly correlated with the ownership of various items and with having crop left from previous harvests.

Similar accounts of consumption smoothing mechanisms to those of this paper have already been carried out for Southern and Southeast Asian countries; however, the analysis regarding sub-Saharan Africa remains scarce and most papers that address it restrict the scope of research to insurance [9]. The distinction between African nations and Asian ones is necessary not only due to geographical and cultural differences, but also because these two groups are distinctly different when it comes to food security [10], access

[9] Karlan et al. (2013), Udry and Kazinga (2006), Janzen and Carter (2018), to name a few.

[10] The Global Food Security Index ranks Thailand in number 52nd and India in 72nd, while Mozambique is number 105th, next to many other sub-Saharan countries.

to finance [11], usage of inputs, disease burden[12], family composition and kinship ties. These differences in key elements call for further studies of the way risk presents itself in East Africa and how smallholders deal with it in order to obtain more or less stable consumption patterns.

[11] According to The Global Financial Inclusion, 81.59% of Thailand has access to conventional finance institutions, that number is 79.88% for India, while in Mozambique only 41% of population has access to finance.

[12] Global Burden of Disease's metric indicates that Mozambique has one of the biggest Disability-Adjusted Life Years in the world (65000), which indicates the number of premature deaths and of people living with disabilities. In comparison, disease burden in India and Thailand are fairly small: ranging from 23000 to 39000

2 Related Literature

This work relates to risk and consumption smoothing literatures. Assessing risk is an important first step, as the extent to which income varies from one period to another and the uncertainty associated with it is what makes financial instruments a necessary part of human life. This is particularly important in Mozambique, since its inhabitants' incomes are very tied to agriculture [13] and climate risks are especially high[14].

Sources of risk commonly include uninsurable risk coming from the unpredictable policies of developing countries and a combination of risk in input prices, production yields and production prices in the local markets (Alderman and Paxson, 1992). In Mozambique's case, the prevailing production risks are droughts, floods and cyclones, which are more common in southern provinces[15] but affect the entire country. Market risk is exacerbated by dependency on trade with other nations[16] namely by importing staple foods and exporting cash crops, which leads to vulnerability to international price and exchange rate volatility.

When looking at consumption patterns, the already mentioned high exposure to income risk is expected to generate equally unstable spendings, unless something is actively done to avoid it. Common sense would generally point to developing countries exhibiting large co-movement between income and consumption due to a lack of financial access. However, research indicates lower than expected correlations between income and consumption in a given period in time (Morduch, 1995), which could mean that informal instruments are being used to make transfers of resources.

Nonetheless, two different factors might be at the root of a seemingly stable consumption (Morduch, 1995. Alderman and Paxson, 1992). Determining which is at play becomes extremely important, as one may indicate that, in spite of lacking formal institutions, markets are complete (leaving no space for government intervention) and the other may point to individuals not fulfilling their complete production potential due to simple market failures. This distinction must be made in Mozambique, as an incorrect diagnosis may have severe public policy implications.

The two most prominent works that make such a distinction between consumption smoothing strategies, Morduch, 1995 and Alderman and Pax-

[13] 81 % of its population is involved in agriculture (A, Armand. et al. 2019)

[14] According to the Global Climate Risk Index.

[15] Flood Affected Provinces - UN OCHA 2013, Famine Early Warning System Networks (FEWS NET) 2020

[16] AGRICULTURAL SECTOR RISK ASSESSMENT: METHODOLOGICAL GUIDANCE FOR PRACTITIONERS, World Bank 2016

son, 1992, define these mechanisms in virtually the same way. Firstly, a stable consumption may be obtained after a negative shock occurs by using financial instruments (credit, savings, physical assets and insurance) to spread said shock across different time periods or individuals. Since Risk Coping mechanisms such as credit and insurance generate similar empirical data[17], it could be difficult to tell which is predominantly responsible for the observed data (Bardhan P. Udry, C. 1999).

The second and more costly alternative to achieve steady levels of expenditures consists in altering production choices to ones that entail less risky outcomes (thus generating more stable income) but have a lower expected return. Engaging in Risk Management means that farmers are choosing to deal with risk ex-ante in a number of different ways: diversifying crops and plots, investing sub-optimally in production inputs (Karlan et al, 2013), using risk diminishing inputs (for instance irrigation) more than they normally would and delaying plantation as a way to gain more information on that year's climate realizations. Other more permanent decisions include seeking employment in many different sectors, partaking in tied labor contracts and even encouraging family members to migrate to other areas.

Taking the two strategies into account, markets would be complete if both consumption decisions were independent from the period's level of income, compatibly with Friedman's Permanent Income Hypothesis, and production decisions were determined by profit maximization. In this situation, an individual would first maximize its profits and then maximize its utility subject to his income. This is known as the separation property of the agricultural household model, which happens when most markets are complete (Bardhan P. Udry, C. 1999). However, that does not seem to be the case for the majority of low-income families in developing countries (Morduch, 1995, Bardhan P. Udry, C. 1999) and decisions on production and consumption are usually intertwined[18].

The literature on Risk Management (the ex-ante approach on risk) is mainly focused on the effects it has on agricultural investment and yields. An experiment conducted by Karlan et al (2013) demonstrated that the main constraint to optimal investment was the existing risk which made any investment likely to go to waste if the states of nature turned out to be unfa-

[17] Such as small correlation between household income and household consumption and, if transitory shocks are household-specific and permanent shocks are not, correlation between individual and village consumption (Deaton and Paxson). This discussion will be more explored later on in the paper.

[18] Financial instrument restriction need not be the only explanation for such empirical findings, as prudent individuals may deliberately choose to sacrifice consumption in the face of an exogenous shock instead of engaging in actions that might further diminish their assets (Alderman and Paxson, 1992. Udry e Kazianga, 2006).

vorable (Karlan et al, 2013). Other permanent effects that risk may have are on the choice of employment (both diversifying occupations and choosing long term contracts[19]) and migration[20].

Permanent impacts of risk management could be evaluated for Mozambique in regards to work offer, choice of inputs and production diversification by evaluating how the usage of these strategies correlates to the non-maximization of profits. This could be done by testing if households subject to the same input and output prices, and whose plots are identical, choose the same exact amount of agricultural inputs (Kien T. Le 2010), which would offer an estimate of the validity of the household separation property. However, in this paper, the question of ex-ante strategies implications for profit will not be dealt with, calling for further analysis in the future. We will, on the other hand, address how Risk Management strategies shape income and food security uncertainties and how they can help soothe more permanent damage that could originate from risk.

The literature on Risk Coping (the actions taken after a negative shock happens) points to the buying and selling of assets as an important strategy. Deaton's model (1991)[21] suggests that consumption would be determined both by current income and assets accumulated up to that point in time. The model's findings indicate that a small amount of assets accumulated would be enough to smooth consumption across time, provided that negative shocks did not occur many times in a row (Deaton, 1991). However,

[19]Ray and Mukherjee (1994) specify two contracts that entail the same type of activities from workers who are perfect substitutes for one another. The first one is a long term contract for which employees are payed a steady rate year-round, which is lower than market rates for casual laborers in peak season (when they must work solely for the employer) and higher (¿0) in low season, when they are also allowed to work for extra wages. When adjusted for the discount rate, both salaries should be roughly similar, but the utility for tied laborers would be higher on account of the implicit insurance created by the contract. In this model, a fraction of the labor market would always be composed by casual laborers. Incentives to deviate from the contract would be curbed by the expectation of non-compliance being readily available to future employers. The ratio of tied labor would therefore depend on both monthly fluctuations of economic activity and information availability (greater in small and complex economies than in middle-income ones). Other models treat tied-laborers as residual workers necessary when economic activity is very weather dependent (Bardhan, 1984) or question their substitutability by arguing that an efficiency wage is embedded in tied contracts (Guha, 1989).

[20]Rosenzweig and Stark (1989) find that the majority of migrations happening in rural India are not of individuals going to urban locations (which could be due to urban-rural salary gaps) but moving from one rural village to another to get married. Furthermore, most incoming transfers received by Indian families in moments of financial strain are found to have been sent by family members residing in different rural areas, which seems consistent with the wish to create insurance contracts that can be easily enforced and monitored.

[21]Consider a scenario, which is thought to be an adequate model for agrarian economies: limited credit provision and prudent but impatient consumers whose incomes are generated by a stochastic process. If consumption were greater than an individual's wage, his total asset holdings would be lower in the next period due to impatient preferences. Conversely, if he had enough salary to cover his expenses, the assets would stay equal or grow.

when the model is confronted with empirical data it falls short of explaining the complexity behind the usage of assets to smooth consumption[22]. In Mozambique, it seems unlikely that assets like livestock would be used as a buffer stock, given that widespread illnesses make it hard for cattle to be kept[23], but asset selling may hold true for grain stocks, even though many households do not have adequate storage facilities. [24]

The single most discussed topic concerning Risk Coping in this literature is credit. The premise of higher marginal returns on investment when capital stocks are low led to a long standing belief that more developed countries would prefer investing in lower-income economies, which would in turn unleash their productive potential and unequivocally cause growth. This prediction's failure led some to attribute the problem to a lack of collateral, hence the solution advocated by microcredit pioneer Muhammad Yunus of targeting collateral-free loans to the poor[25] (Aghion and Morduch, 2005).

However, an increasing amount of research indicates that these supposed higher return rates should not be taken as granted as they might be heterogeneously distributed among citizens in developing countries (Karlan and Morduch, 2010), especially when incorporating human capital and economies of scale into the model (Rutherford, 1999)[26]. Formal credit markets and Microcredit in Mozambique are not a main concern of this paper, as they already are the subject of extensive study.

Nonetheless, the intertemporal transfer of resources may present itself in a number of subtle ways. ROSCAs (Rotating Savings and Credit Associations) are perhaps the most common instrument used and a good example of the importance of informal social relationships in low-income economies

[22] Udry e Kazianga (2006) demonstrate that in Burkina Faso, little consumption smoothing was observed, mostly coming from selling grain stock (despite families usually having enough livestock to completely smooth that period's consumption. This prudent wish to protect productive assets is also observed in Janzen e Carter (2018) with data from Northern Kenya: individuals well below poverty line are less likely to sell their scarce productive assets than their better-off (but still poor) counterparts, and prefer to suffer in the present rather than sacrifice their only production means.

[23] Sitoe, 2005

[24] TIA 2015: only 60% of Mozambican households had somewhere to store surplus grain (this number increases to 61% in the North and decreases to 51% in southern provinces).

[25] Overall, microcredit's promise was to combine the abundance of resources present in formal financial institutions with social pressure and monitoring mechanisms of informal institutions, namely through group lending. This would limit ex-ante risks and, because of the individuals' ability to choose their partners, it allows to discriminate interest rates for higher quality debtors and risky ones (Aghion and Morduch, 2005. Ghatak 1998). The main inspiration taken from informal instruments is the use of social networks to monitor and pressure borrowers.

[26] Economies of scale may generate multiple equilibria and human capital may generate altogether different production functions for distinct individuals in the same low levels of capital environments. Indeed, higher cognitive capacities and human capital levels are associated with better returns to investment (Karlan and Morduch, 2010).

[27]. In this arrangement, each person contributes a predefined amount in every group meeting[28]. Usual economic theory suggests that all individuals partaking in a ROSCA would be better-off when compared to autarkic savings, with the exception of the last one to receive the lot who would be in the same situation if he were to save on his own [29](Aghion and Morduch, 2005). ROSCAs would therefore be efficient ways of saving to buy an indivisible good but not any more useful than saving on one's own for dealing with risk (Coate and Loury, 1993). As we will see, ROSCAs are quite common in Mozambique.

Looking at family composition may also help understand savings. Two main types of savings should be differentiated: low frequency savings (or the long term deposits responsible for guaranteeing stable consumption levels throughout one's entire life cycle), and high frequency savings (or the short term savings that protect the permanent income level of consumption from fleeting shocks).

Households in low-income agrarian economies typically consist of family members with a wide range of ages. The mixture of individuals in their economic active years and older means that, usually, there is not much need to save for old age[30]. Therefore, low frequency savings are not considered as important as high frequency ones (Gersovitz, 1988). An increased adult mortality due to AIDs has been responsible, in the past few decades, for creating a larger need for low frequency savings (Karlan and Morduch, 2010). This consideration could prove very important in Mozambique's case due to the pervasiveness of HIV/AIDS in the nation. Unfortunately, a detailed panel data of household demographics is not yet available.

A third important way of Risk Coping is pooling risk among individuals.

[27] Since most rural communities have a strong culture of social security networks, individuals are usually required to help their extended family with any extra resources they might have, for this reason, being in possession of large sums at home is not ideal, as they might be requested by members of the community (Mas 2015, Bouman, 1977). Thus, once their basic monthly needs are met, instruments that allow them to save in small, regular installments and return a lump sum before a big expense are much used (Rutherford, 1999), especially if these savings are mandatory (like ROSCAs and deposit collectors) and thus create a mental rule for the destination of one's surplus income, avoiding decision fatigue and present bias(Mas, 2015).

[28] At the end of each round one of them is selected to receive the total collected (through bidding, random selection or consensual agreement). Because there is no need to store the money, the accountability and organizational demands of ROSCAs are kept to a minimal.

[29] Possible incentive problems of ROSCAs are the following: assuming impatient preferences, the last one on the receiving list might have an incentive to drop out of the contract once he finds out about his position and people who have already received their share might not want to continue paying (in other words, they might default). The latter is efficiently curbed by social pressure mechanisms.

[30] Long term intertemporal transfers are usually generational, as children are often viewed as a manner of saving and inheritances might be a way older individuals have of making sure the family will continue to support them through inactive years.

When facing large enough risks and with limited resilience capacity, insurance may be the only way out[31]. If families were sharing risk, individual incomes should not play a big part on determining individual consumption (only through their effect on aggregate village income). This scenario would be efficient if individual incomes were not correlated, meaning that each family would specialize in a different activity rather than have a diverse portfolio of crops that closely resembled every other family's (Alderman and Paxson 1992. Townsend, 1995).

Economic literature, however, is not very optimistic about how much could be insured in rural economies: incomes are usually considered to move together because of similar weather realizations within each village (Townsend, 1995). Alderman and Paxson (1992) find that individual consumption's correlations with both individual income and aggregate consumption are high, consistently with all families cultivating a similar portfolio of crops (they attribute their findings to existence of information asymmetry within villages).

A more optimistic scenario is presented by Townsend (1995): in India and Thailand income co-movement between households is less than expected. A regression of average village consumption and individual income on individual consumption shows considerable consumption smoothing in these areas. Similarly, Karlan and Morduch (2010) indicate that families seem to have complete informal insurance [32] for small health shocks but also to be less capable of dealing with shocks that are very severe (insuring only 38% of their losses in those cases).

Townsend's model for complete insurance will be tested in this paper in the context of Mozambique's rural population. Unfortunately, there is no way to test for heterogeneity in health shock insurance, since there is no specific data for health issues or their seriousness.

Partial insurance seems to be the way found to deal with information asymmetries that hinder complete insurance [33], usually relying on social safety nets [34] (Paxson and Alderman, 1992). Bardhan and Udry (1999) argue that almost efficient risk pooling can be obtained through mechanisms

[31] Credit assumes the individual will be able to work himself out of debt in the future, but many negative health shocks cause individuals to be less productive or not able to work at all (Collins et al).

[32] However, insurance capacity seem to heterogeneous: urban areas and rural entrepreneurs show less signs of insurance, prompting questions about whether economic development slows potential for informal insurance (Townsend, 1995). Much like the findings in Ray, this is probably due to information loss when economies become more complex.

[33] Here, literature on partial insurance techniques were inserted in the risk management section, because they involve decisions on how and where to offer one's work (straying from what would be optimal in a complete market situation and thus from profit maximization).

[34] Provided the motivation behind them is purely selfish: to share risk.

other than perfectly enforced contracts, such as reciprocal transfers conditional on known income outcomes of families inside a kinship. This will be addressed for Mozambique by considering families who partake in the sending of remittances to other households.

Insurance also has the advantage of avoiding possibly harmful consumption smoothing mechanisms previously discussed. Studies have shown that it may discourage sub-optimal investment associated with Risk Management [35] and also have an impact on previously cited asset selling behavior triggered by income shocks [36], making it possible for the poorest to use this mechanism to smooth consumption without sacrificing their subsistence means. Because of the stark impacts of insurance in shaping the way risk is dealt with, its study must be at the center of any evaluation of Mozambicans relationship to risk and its consequences on food security and human capital.

[35] A RCT conducted by Karlan et al (2013) tried to estimate the extent to which credit constraints and insurance influence sub-optimal investment in farm inputs by randomly allocating different combinations of subsidies and index based insurance. Results were surprising. The model's initial hypothesis that subsidies would increase both risky inputs (whose return depends on production outcomes. Eg: investing in fertilizers won't generate any returns if there is a draught) and non-risky inputs (that allow farmers to hedge risks. Eg: irrigation guarantees a minimum production even with the worst possible weather outcomes) did not prove to be true. Merely providing subsidies led to a total investment in agricultural inputs similar to the ones found in control groups. This showed that credit constrains are not so binding in regards to investment decisions. However, the group who received both the subsidy and an index based insurance contract increased considerably their investment in farm inputs, indicating that risk may hinder farmers from using more sophisticated inputs.

[36] Janzen and Carter (2018) demonstrate that, when randomly offered micro insurance, the most vulnerable farmers were more likely to smooth consumption when such shocks occurred (as opposed to letting consumption fluctuate), and experienced a modest drop in usage of assets as buffer stocks. On the other hand, better-off farmers decreased sharply their asset selling habits.

3 Data

The main database used is TIA (Trabalho de Inquérito Agrícola), an annual sample survey conducted by Mozambique's Ministry of Agriculture (MINAG). Some years did not have individual weights available, so they were excluded from the complete sample. The remaining years were 2002, 2003, 2005, 2008, 2012 and 2015. Because not every database contained the same variables, I used primarily the most recent year, which was also more thorough. The full pooled data was only used for calculating coefficients of variance of crop yields (a year to year production risk assessment). A panel data was also created from monthly dummies for income and food security, which were originally present in the 2015 dataset.

A second source for data was Consultative Group to Assist the Poor (CGAP)'s 2015 Smallholder Farmer Survey, a sample survey which provided a wider selection of variables, mainly used for descriptive statistics for the population and its various subsets. A third source for data was the "Inquérito de indicadores de imunização, malária e hiv/sida", (IMASIDA) 2015, a sample survey provided by the DHS Program, which I use to better understand the impact of different types of risk on health and household wealth indicators, using district risk scores derived from the TIA data.

4 Background

Mozambique has 11 provinces (one is the City of Maputo) and 154 districts. Its economy is primarily rural and poor: 81% of the population produces income by foraging and cultivating the land and 70 % is classified as extremely poor (Sitoe, 2005). The country's food system is also not self-sufficient and a big portion of basic food consumed in the southern provinces is imported from other nations. This raises questions concerning Mozambique's food security. The effort to raise the agricultural sector's productivity, however, has been set back by smallholders' scarce use of agricultural inputs [37], namely irrigation, fertilizers and pesticides, which are practically only used when cultivating cash crops.

Fertilizer use is roughly at 1% all over the country, but other inputs vary from province to province, with southern areas using irrigation more frequently (15.4% against the north's 4.7%) as well as concentrating cattle ownership and its usage to plow the land. Northern districts, in spite of having worse economic indicators, are naturally more suitable for agriculture production since extreme climate events are less common in these areas. The descriptive statistics present in section 10 show an overview of input usage as well as susceptibility to extreme events, both at national and regional level.

Risk in agricultural economies is usually assumed to be very high. However, a more thorough assessment is needed to verify the degree to which smallholders are exposed to it. Furthermore, the origin of income fluctuations must be addressed as the instability may come from either a monthly concentration of the year's income or from irregular climate patterns throughout the years. All the results presented below are available in the descriptive statistics section.

4.1 Year-to-year crop yield risk

Using the pooled TIA data for crop yields (in kilograms) I was able to obtain a district average year-to-year crop yield risk for each crop production in a given year. These yearly district averages were then used to obtain a coefficient of variation of crop yields through the years for the 141 of Mozambique's districts from my sample. Three crops were chosen for this analysis (maize, cassava and rice), based on self-reported crop importance

[37] The Strategic Plan for the Development of the Agrarian Sector (PEDSA 2011-2020) cites the low usage of agricultural inputs as the main reason for Mozambique's low productivity.

[38]. The district's coefficients of variation (CV) for each crop, show that production yields fluctuate quite a lot for the country's three main crops. Maize is the less risky alternative out of the three, with an average CV of 0.375. Conversely, cassava and rice had considerably higher CVs: 0.659 and 0.652 respectively. A similar analysis conducted by Townsend (1994) closely resembles the magnitude of risk found in Mozambique: three crops in rural India were found to have CVs of 1.01, 0.51 and 0.7, leading Townsend to conclude that the production risk for these plants was considerably high.

While averaging may be useful to get a broader view on the country's production risks, an accurate assessment of Mozambique's heterogeneities is only possible when observing geographically referenced data. Figures 1 presents the results for Maize, the most widespread cultivation. The CV distribution for cassava and rice can be found in section 9 (figures 6 and 7), as both are similar to what is shown below.

It seems from the figures that the Northern provinces have lower variations in yearly production, which may be in part due to their smaller propensity for extreme events when compared to the rest of the country. Indeed, the average Maize yield CV for Northern Provinces is 0.573, while Southern provinces present higher variations in maize yields from a year to another, with a CV of 0.742. The CVs for each crop at national and regional level are also available in section 10. It is important to note that obtaining the coefficient of variation from aggregated data (as was done here because the first comparable unit through the years was at district-level) underestimates the actual risk (Coble, Dismukes and Thomas 2007).

4.2 Month-to-month income fluctuation risk

Another source of insecurity is the fact that farm income is very time-concentrated. I do not have data for monthly crop yields. However, a measure of income fluctuations can be inferred by using a monthly income variable present in the 2015 TIA data set. An individual coefficient of variation is therefore obtained considering a dummy variable which signals if they the household had income in that specific month of 2015. These individual CVs are averaged for each district using individual weights. Here, one need not worry about underestimating risk, because a panel data was available at individual level.

[38]TIA 2015: the crops were ranked the three most important ones for Mozambique's farmers. Maize was reported as the most important crop for the family for 59.6% of Mozambicans, 9.1% of them claimed Cassava was the most important crop for their families and 8.4% selected rice as their most important crop.

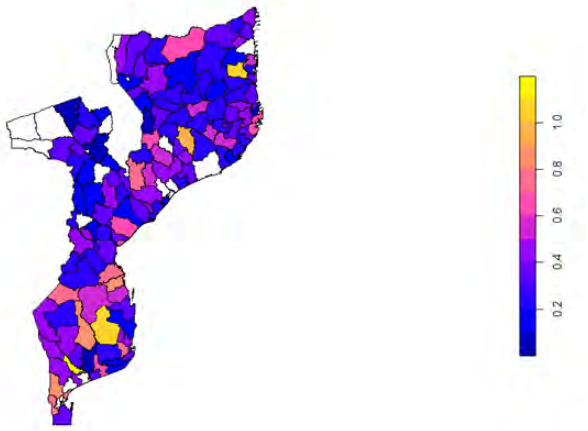

Figure 1: Coefficient of variation of Maize production (district average)
The data in white is missing.

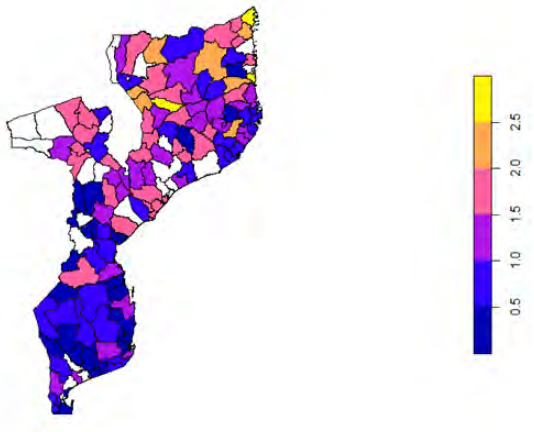

Figure 2: Coefficient of variation of Monthly Income (district average)

What follows is that the inverse is true for month-to-month income variations: the North is considerably more prone to fluctuations than the South. Southern province's average CV (0.4989) is quite lower than Northern average (1.4972). A likely explanation for this is that southern provinces' inhabitants are starkly more engaged in non-farm activities (descriptive statistics in section 10).

4.3 Crop yield correlation

The potential for risk mitigation through crop diversification is assessed by verifying the extent to which production yields of different crops co-move. I do this by dropping the individuals that only produce one out of the three selected crops (maize, cassava and rice). The Pearson Correlations are obtained by normalizing each individual's production using the district mean for that crop and obtaining the correlations of yields of the crops each individual produces (Barry K. Goodwin Ashok K. Mishra, 2002). The individual correlations are then averaged to obtain district level correlations between the crop pairs. Correlations would range from -1(perfect hedge opportunity) to 1 (no point in diversifying), with zero meaning that crops yields are independent from each other.

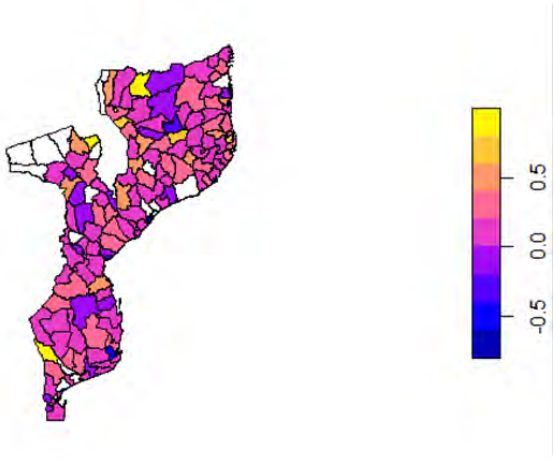

Figure 3: Correlation between Maize and Cassava Yields

The results below indicate that the opportunity for diversification as a risk management mechanism is considerable, as yields appear to be almost independent from each other. Diversification opportunities seem to exist and be roughly the same magnitude both in the North and in the South of the country, at least for the two most popular crops (cassava and maize). Figures for correlations involving rice look similar but have a higher amount of missing data due to spatial concentration of rice production (section 9).

4.4 Diversification - Herfindahl Index

To determine the extent to which smallholder farmers diversify risk by having a diverse portfolios of plants in their land, data containing all crops farmed by each household was examined. The total area of the farm was available, as well as areas for each cultivated plot. The percentage s of each crop i in the total area of the individual's farm was then used to calculate the Herfindahl Index for every household as follows:

$$H = 1 - \sum s_i^2$$

Figure 4 shows that crop diversification is quite homogeneous throughout Mozambique. Most districts seem to be closer to a highly diversified farm (Herfindahl Index of 1) than to a monoculture (Herfindahl Index of 0).

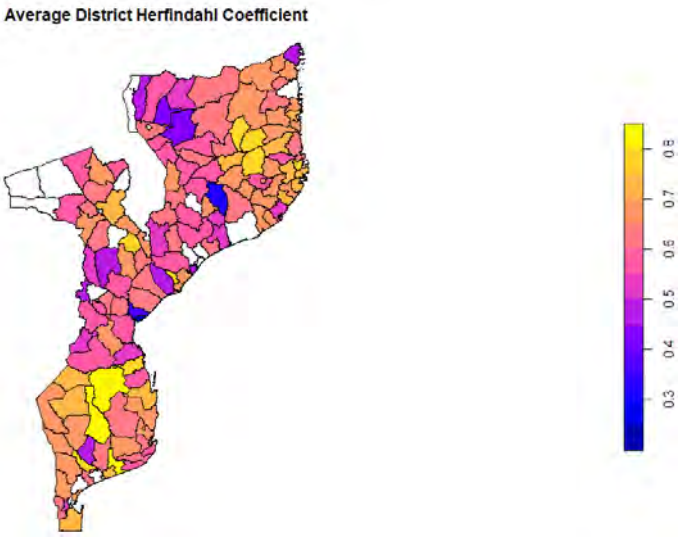

Figure 4: Average Herfindahl Index by district

The country average Herfindahl Index is 0.62, and the arithmetic means for Northern and Southern districts are quite close: 0.6641 for the three northern provinces and 0.6038 for southern ones, indicating that diversification is mostly similar all over Mozambique.

4.5 Consumption Risk: Coefficient of Variation of Food Security

Similarly to the monthly income data, the TIA database also carries information about self-reported food security levels during each month of 2015. Using these monthly binary variables, I created a panel data that will be used in its panel form in section 5. However, for the sake of obtaining a measure of risk, the monthly food security panel was used to calculate a

coefficient of variation in food intake for each individual. Figure 5 shows that, unlike income, food security variations during a year are quite similar all over the country.

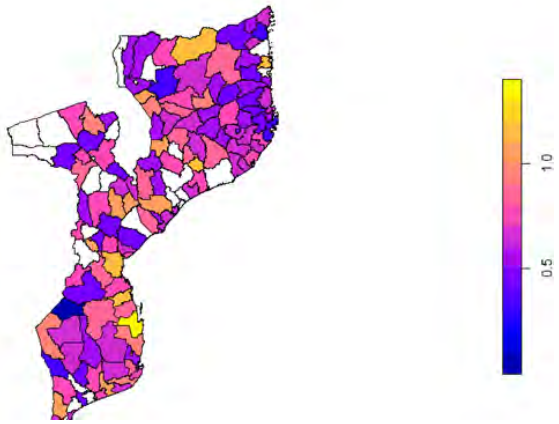

Figure 5: Coefficient of variation of Monthly Food Security (district average)

4.6 Financial Intermediaries: Usage and Trustworthiness

A closer look at the usage of financial intermediaries is critical to understanding smallholder farmers' options when it comes to maintaining their consumption above a certain threshold. The choice of which financial mediator to use is in turn determined by availability and perceived trustworthiness of each one. The intermediaries between a user and their chosen financial instrument can be qualified into more or less distinct categories, with commercial banks being a classic example of formal financial institutions, micro-finance falling into the semi-formal category, and a plethora of different informal mechanisms being available in different regions of the planet.

In Mozambique, the most widespread financial intermediary is formal banking: on average 21% of Mozambicans had a bank account in 2015 (but the number is as high as 35% when looking at the Southern districts of the country). Unsurprisingly, when asked about their opinions on banks, the percentage of people who claimed they did not know if they trusted banks was the second lowest of the country: only 27% of the people in Mozambique do not know if they trust commercial banks, only behind their knowledge of friends and family's trustworthiness (22.4% of smallholders are not sure if they trust their kin when it comes to financial matters). However, this scenario cannot be attributed to banks and family being perceived as trustworthy when it comes to financial transactions. In fact, both banks and the

kin rank highest when it comes to distrust.

On the other hand, Microfinance and Xitique (Mozambique's equivalent to a Rotating Savings and Credit Association) are more unknown to the general public: 40% and 38.8% of Mozambicans do not know whether or not to trust microfinance institutions and Xitiques, respectively. Distrust for these financial organizations is considerably higher in the North of Mozambique than in the rest of the country, with a difference of roughly 18% from the rest of the country for both intermediaries. Indeed, Xitiques are a lot more popular in Southern districts than in the rest of Mozambique: compared to the country's average of 17% having taken part in a Xitique during their lifetime, this number is raised to 28.9% when considering only the South.

Other informal mechanisms are not as widespread as Xitique: moneylenders are used by 11% of the population (and are even more uncommon in southern districts) and the usage of savings collectors is neglectable in Mozambique. Overall, it is apparent that most people in Mozambique still do not use financial intermediation in their daily lives, leaving their consumption smoothing necessities reliant on individual decision making (such as production choices and employment choices) and informal interactions between parties. Much of this is certainly attributable to a lack of physical or financial access to these institutions. However, information definitely plays a decisive part in the determination of perceived trustworthiness of such intermediaries, and a shortage of accurate information may discourage the usage of otherwise very valuable institutions.

5 Empirical Framework

5.1 Risk Management (or ex-ante strategies)

When trying to achieve steady consumption patterns, one may choose to do so by adopting a series of strategies that result in an income that is roughly the same throughout the year. In this section, I investigate three ways of dealing with risk so as to generate a steadier income from the very begging. Firstly, the ability to obtain a more predictable income is tested in regards to crop diversification, usage of irrigation, and two measures of occupation choice (which enable us to further analyze if the member who takes on multiple occupations is decisive in the way this will impact income stability). Secondly, using the CVs of monthly food security I will test to see if households who engage in the aforementioned risk management practices achieve also a less variable food security index.

I start by estimating a regression with the individual's CV of income as a dependent variable and different ex-ante mechanisms as explanatory variables:

$$\begin{aligned} CV.Income_i = \alpha_1 + \gamma_1 Herfindahl_i + \gamma_2 HHNonAgrOccup_i \\ + \gamma_3 PercentOnlyAgri_i + \gamma_4 Irrigation_i + \beta_i X_i + \epsilon_i \end{aligned} \tag{1}$$

Where X_i is a vector with controls for individual characteristics (age of household head, schooling and gender, number of household members, if they are residing in a rural area, if the head has had agrarian training and if the household has a cellphone). $Herfindahl_i$ represents the Herfindahl Index calculated in section 4, a measure of the household's agricultural diversification (1 stands for an extremely diverse farm and 0 for monoculture). $HHNonAgrOccup_i$ and $PercentOnlyAgri_i$ are both measures of occupation diversification. The first is a dummy for whether the household head reported engaging in one or more income generating activities other than agriculture. The second consists of the percentage of economically active household members who have reported working exclusively with agriculture. A dummy which indicates if the household used irrigation on their crops was also included.

To assess if employing these strategies is enough to smooth, at least partially, individuals' monthly food consumption, I test if the same independent variables are able to explain the individual's food security CV. The basic regression is very similar, but this time the dependent variable is a measure of monthly consumption risk.

$$CV.Food.Security_i = \alpha_1 + \gamma_1 Herfindahl_i + \gamma_2 HHNonAgrOccup_i + \gamma_3 PercentOnlyAgri_i + \gamma_4 Irrigation_i + \beta_i X_i + \epsilon_i \quad (2)$$

If these ex-ante consumption smoothing instruments were relevant ways of achieving a steady level of purchases, then their usage would be associated (controlling for all observable variables) with lower levels of income and consumption fluctuations (CVs).

5.2 Risk Coping

Among the Risk Coping strategies, it is usually considered that the pooling of risk is unlikely in rural areas of developing countries (Alderman and Paxson, 1992). The proponents of this theory argue that because inhabitants of a same village are subject to the same climate events and depend heavily on agriculture, their earnings are likely to co-move starkly. Furthermore, information asymmetry could be enough to curb insurance even in small-scale economies. However, some say that the transfer of resources happening both inside and across villages may be larger than what is thought and motivated by non-altruistic reasons.

Townsend (1994) finds that individuals' incomes co-move less than expected and creates a test for assessing the degree to which risk is being shared among people in the same geographical area.

$$Consumption_{i,t} = \alpha_1 + \gamma_1 Income_{i,t} + \gamma_2 \overline{Consumption_{d,t}} + \beta_i X_i + \epsilon_i$$

Where the dependent variable is a dummy for the individual's consumption in a given month of 2015, γ_1 is the coefficient measuring the effect of the individual's income during the period on his consumption and γ_2 measures the extent to which the district's average consumption in each month is linked to how much an individual inside it will consume. If risk pooling were happening, one's expenditures would be independent from their income in the same month. Instead, they would solely depend on the aggregate village consumption, which would in turn be determined by the total village income.

Data on consumption was not available in the TIA database so I focused on the self reported monthly food security panel data. For monthly income, I also used the monthly dummies (previously used to create the income CV) in their panel form. The average consumption variable was created by taking the weighted average at district level of the reported food availability in each month. The following controls (vector Xi) were added: schooling levels of the household head, gender, age, number of household members, if they are residing in a rural area, if the head has had agrarian training and if the household has a cellphone. Individual and month fixed effects were gradually added and both were present in the more complete specification of the regression. If perfect insurance were taking place, $\widehat{\gamma_1}$ would equal zero and $\widehat{\gamma_2}$ would equal 1.

$$Food.Security_{i,t} = \alpha_1 + \gamma_1 Income_{i,t} + \gamma_2 \overline{Avg.Food.Security_{d,t}} + \gamma_3 Month + \beta_1 Individual_i + \beta_i X_i + \epsilon_i \quad (3)$$

5.3 Household's health and wealth indicators and their relationship to risk

Large income fluctuations have several consequences for rural households. Indeed, untended risk can easily catapult a lower-middle class family into poverty if enough negative shocks occur (Deaton 1991, Duflo and Banerjee 2011). Therefore, in this section I analyze the relation of risk with a series of wealth and health indicators present in the data. Furthermore, the ability of various risk coping and risk management strategies to reduce risk's effect on health, educational and wealth characteristics will be studied.

5.3.1 Health Indicators

For this analysis another sample survey was used: the "Inquérito de indicadores de imunização, malária e hiv/sida" 2015. The IMASIDA is a rich dataset containing medical and household variables. Health and wealth indicators from the IMASIDA were used as dependent variables to be explained by the previously mentioned income CV from the TIA 2015 (our measure of monthly income variation).

As the IMASIDA is a completely different dataset from the TIA, the smallest possible level to which I could link the CVs of monthly income between the two data sets was district, the smallest administrative unit of

both surveys. Albeit a rough estimate, these district-level CV might still be able to partially account for difference in individual wellness indicators.

$$HW_i = \alpha_1 + \gamma_1 CV.Income_d + \beta_i X_i + \delta Cluster + \epsilon_i \quad (4)$$

HW_i stands for either a health or a wealth indicator. The explanatory variable is a district-level measure of monthly risk . Controls were added for similar results inside a same geographical cluster of the IMASIDA sample survey, for schooling, gender and age of the household head, as well as the number of members of the family and if the family owns a bicycle. The dependent variables for each equation are the following: ”All children under the age of 5 sleep under a net”, ”Anything done to make water drinkable”, ”One or more household members has malaria”, ”One or more household members has anemia”, ”One or more children deceased”.

5.3.2 Consumption, hygiene and literacy Indicators

Income Variability Effect

A similar analysis to the one in the previous subsection was conducted, this time with data from the 2015 TIA dataset. The regression estimated is very similar to equation 8, with the important advantage that the income CV is at individual level.

$$HW_i = \alpha_1 + \gamma_1 CV.Income_i + \beta_i X_i + \delta District + \epsilon_i \quad (5)$$

Once again, HW_i encompasses different wellness measures (”Has a bicycle”, ”Has a motorcycle”, ”Has a cellphone”, ”Has no latrine or an unimproved one (precarious sanitation facility)”, ”Anything done to make water drinkable”, ”Has a place to store surplus crop”, ”Still has stored grain from last harvest”, ”Household head is able to read”). The control variables are the district and a vector of household characteristics consisting of age, gender, schooling and agricultural training of the household head, as well as the number of members of the family. An individual with higher month-to-month income fluctuations is expected to be worse-off than somebody with a lower CV district in terms of social outcomes.

Income Variability Effect & Consumption Smoothing Mechanisms

$$HW_i = \alpha_1 + \gamma_1 CV.Income_i + \gamma_2 Herfindahl_i + \gamma_3 HHNonAgrOccup_i$$
$$+\gamma_4 PercentOnlyAgri_i + \gamma_5 Irrigation_i + \gamma_6 Sent.Remittances_i + \beta_i X_i +$$
$$\delta District + \epsilon_i \quad (6)$$

The equation above adds consumption smoothing mechanisms to our basic model (equation 5). By doing this, it is possible to evaluate how much Risk Management (Crop diversification, Household Head Occupation Diversification, Household Member's Occupation Diversification, Irrigation and if the household sent remittances to another) and Coping (Remittances and reciprocal gifts as a way of incomplete insurance) strategies act to revert damage done by risk on more lasting social outcomes.

6 Results

6.1 Risk Management (or ex-ante strategies)

Figure 10 (section 9) presents the estimates for the models specified in Section 5.1. Every pair of equations defines the model slightly differently by adding district fixed effects in the second column.

Column 1 and 2 present results on income variation. It seems that having a very diversified portfolio of crops has no correlation with income variability. Another income smoothing mechanism that relates directly to cultivation is also not significant: families who use irrigation do not appear to have more stable levels of income. On the other hand, measures of activity diversification seem to be more able to explain said fluctuation. Indeed, the household head being involved in a non-agricultural activity decreases in 0.95 the coefficient of variation of income when controlling only for household characteristics. The effect stays the same when adding district controls.

The other occupation diversification criteria is centered around how many economically active members of the family dedicate all their working hours to agriculture (instead of being partially involved in it or working in another sector). It follows from table 10 that a household in which all members work only with agriculture is not significantly different from another family in which every member is at least partially involved in other income generating activities.

The same effects are not true when considering the households' food security patterns, presented in columns 3 and 4. The coefficient of variation in food security is not significantly correlated to the head's non-agricultural efforts. This seems to imply that while his or hers occupation is determinant on initial income smoothing abilities; other mechanisms come into play when it comes to stabilizing food intake, making homes whose leader focuses exclusively on agriculture as capable as any of doing so. Other household members' diversification of activities are also not relevant for food security fluctuations.

On the other hand, while crop diversification did not prove significant for predicting a household's income variation, families who cultivate multiple crops are linked to lower fluctuations of food security (going from a very monoculture to a very diversified farm decreases CV of food security in 0.11, when controlling for district). Irrigation also proves to be important to determine whether or not the family faces ups and downs in their food security: a family who uses irrigation has a CV of food security 0.077 lower

than ones who do not.

6.2 Risk Coping

Figure 11 (section 9) shows the results for the risk pooling test proposed by Townsend. We control for household characteristics such as the head´s schooling, age and gender, ownership of a cellphone and number of family members and gradually add controls for month and individual. It is possible to see that, all things apparently equal, one's own income is not related to the ability to achieve food security during the same time span in any of the specifications of the model.

Conversely, when looking at the food security average for the district, its effect on individual consumption is clear. Without any fixed effects, an increase in 10 percentage points of the district's average food security of makes it 9.7% more likely that a family residing in it will have had enough to eat, this estimate remains significant when adding individual fixed effects and month fixed effects, although the magnitude decreases slightly: increasing the district's average food security in 10 percentage points raises the probability that the individual himself had food security in a given month by 9.59%.

This result points to notably high levels of risk sharing among individuals in Mozambique, as a family's income being abnormally less than their average is not correlated with them dipping below a food security threshold. For the latter to happen, it appears to be necessary that the negative shock is experienced by the whole geographical area.

6.3 Household's health and wealth indicators and their relationship to risk

6.3.1 Health Indicators

As monthly income CV was only traceable to another dataset at district-level, it is very likely that the results in figure 12 do not capture the consequences of monthly risk on health indicators. In fact, what appears from the estimation of equation 4 is that the district showing large variations in income in a month to month basis does not seem to be related to health indicators and habits.

The only dependent variable for which district income variability seems to be determinant is someone in the house having Malaria. Higher variations of district income (higher CV) are linked to a lower prevalence of

Malaria. This is likely due to omitted variables, namely the usage of Mosquito nets, which is higher in Northern areas (31.4% of children under 5 sleep under nets in Northern districts against 22% in Southern Mozambique). Because of this, higher monthly income variations in districts in Northern Mozambique may be mistakenly associated with less pervasive Malaria levels.

6.3.2 Consumption, hygiene and literacy Indicators

Income Variability Effect (figure 13)

The individual-level income variation seems to be much more able to explain variations in social outcomes. When controlling for household characteristics and a district fixed effect, income CV has no correlation to having a bicycle or a cellphone. On the other hand, higher variations of one's income are linked to lower probabilities of having a motorcycle.

Higher fluctuations of income also make it more likely that the sanitation facilities an individual has access to do not meet the millennium development goals. The fluctuation of monthly earnings also does not have a significant effect on water treatment, storage space and having leftover crop. More surprisingly, households with a higher income variability are more likely than others to have an alphabetized head, although the effect is very small.

Income Variability Effect & Consumption Smoothing Mechanisms (figure 14)

Equation 6 is estimated by adding the effect of consumption smoothing strategies to our previous model. Results are in figure 14 (section 9). We find that the previous effect of Monthly income variations on the probability of having a motorcycle and unsatisfactory sanitation facilities disappear. When controlling for individual characteristics and consumption smoothing mechanisms, we find that higher monthly income variations are now associated with higher probabilities of having harvest left and of the household head being alphabetized.

In spite of these counter-intuitive conclusions about Income CV's effects on social outcomes, one can still benefit from looking at the estimations for consumption smoothing effects, which seem to be more self-explanatory. As expected, smallholders with a more diversified plot are also statistically more likely to have a bicycle, surplus harvest and storage space for grain.

Crop diversification has an unexpected effect: having a more diversified plot decreases the probability that the household head would know how to read. The usage of irrigation only has one significant effect: houses who use it are 14% less likely to have storage place for leftover grain harvests.

Households where the head also works in a non agricultural activity seem to be overall better-off than their counterparts. The head's diversifying of occupations increases by 8.9% the probability of having a bicycle, by 6.5% the probability of having a motorcycle, by 9% the probability of having a cellphone and by 8% the probability of having grain storage space. The head diversifying occupations also makes it less likely that the household would not meet the standards of sanitation facilities aimed by the millennium development goals. The head's occupation choices also have effects on a household still having grain from the last harvest, albeit at a lesser significance level: diversifying employments makes a family 8% more likely to still have grain left at a 10% significance level.

Household members' diversification seems to be less unequivocally important for social outcomes than the chief's, as it only has two statistically significant results. A household in which all members work exclusively with agriculture is 21.6% less likely to have a phone than a household in which all members are at least partially involved in other activities. Having all you household members only work with agriculture also makes it 11.4% more likely to not meet minimal sanitation requirements than a family in which all members diversify occupations.

Sending remittances may indeed be a sign that the household engages in reciprocal gift giving that could resemble incomplete insurance: households who do so have remarkably higher probabilities of having goods such as bicycles (7.1% more likely), motorcycles (6.7% more likely) and cellphones (8.4% more likely). Significant effects have also been found on regards to still having grain left from the last harvest: it increases this possibility 10%.

7 Conclusion

To understand farmer's exposure to risk, two different timelines were evaluated. First, yearly production uncertainty was determined by examining pooled data for yields of maize, cassava and rice from 2002 to 2015. Southern districts were found to face higher variability in yearly crop yields. This implies that farmers living in such areas are exposed to good and bad harvesting years, which could be weather-related.

On the other hand, Northern districts face higher variability in monthly income, which might be a reflection of a very time-concentrated economic activity, as non-farm occupations are less common in these areas than in the South (figure 16). Nevertheless, the coefficient of variation of food security is similar for most regions in the country, and it does not present particular regional patterns.

The main agricultural crops seem to have yields that are close to independent, making diversification a possibly effective strategy for obtaining more stable consumption (figure 3, 8 and 9) [39]. Indeed, albeit not significant for income stability, more stable levels of food security can seemingly be achieved by engaging in crop diversification, as it is apparent from figure 10. This indicates that districts whose farmers plant a relatively small portfolio of crops, in areas in which correlations between yields are low, could benefit the most in terms of food security from being encouraged to diversify.

Some districts in the North and most districts in central provinces of Mozambique are examples of places that would benefit from increasing their crop diversity. These areas present more homogeneous crop selections than the rest of Mozambique, while having inter-crop yield correlations roughly equal to any other region. Providing them with incentives to diversify and with knowledge on crops whose yields co-move less may be examples of "low-hanging fruit" policies towards improving their food security.

Overall, food security seems to be more affected by decisions regarding agricultural production, as irrigating is also significantly tied to smaller ups and downs in food-intake. In terms of the effects of these mechanisms on more lasting social outcomes studied in figure 13, it may be the case that these production choices are more decisive when it comes to crop storage space and being able to have grain left months after it was harvested.

[39] If the choice of diversifying interferes with profit maximization is an important question that could be uncovered by examining if the household separation property holds.

On the other hand, the household's head occupation appears to have a big impact on income stability and no significant one on food security. Its effect on the possession of consumer goods such as bicycles and motorcycles and longer-term facilities such as sanitation is also noticeable. Remittances, which are thought to be an indicator of partial risk-sharing inside family networks also appear to have a larger impact on consumer goods. Data also points to risk-pooling among individuals being relatively high, and it is possible to see in table 11. However, it is not possible to infer from the available data if the existent risk pooling is created through gift giving safety-nets, tied-labor contracts or formal instruments.

In more general lines, more stable food security levels seem to be linked with agricultural production choices: crop diversification and usage of risk-attenuating inputs (irrigation). Income stability, on the other hand, looks to be influenced in an important way by the occupational choice of households' heads, more so than that of other family members.

Aside from possible effects on food security, income instability is also likely associated with worse wealth and sanitation indicators (figure 13). It also appears from figure 14 that if unstable incomes indeed make smallholders worse-off in terms of social indicators, using consumption smoothing mechanisms can help counter these lasting negative effects efficiently.

Although impossible to accurately infer from the data, it may be the case that production choices have the effect of reducing food insecurity, but, because they fail to have a large enough impact on income, their abilities to avoid poverty traps are reduced (their effects seem to be mostly tied to agricultural outcomes and storage). On the other hand, a stable income achieved by diversifying occupations may not be enough to guarantee momentary stableness of food-intake, but may prevent lasting negatives outcomes that come from exposure to risk. Nevertheless, more data is needed to correctly make that assumption.

Further studies should also be done to address if Risk Management's effectiveness to counter risk comes with a trade-off of diminishing smallholder's profits, as it is an important next step to evaluate if these strategies can be systemically promoted by policymakers. To do so, one would have to measure the extent to which the separation property between household decisions and agricultural ones remains intact in rural Mozambique.

Lastly, our evaluation of risk's impact on social outcomes was focused on the effects of a time-concentrated economic activity. However, interesting conclusions could also be drawn by looking at what the effects of income variations from year to year could signify for individual and district-

level welfare, as longer term instabilities could have different implications on well-being and be attenuated by different mechanisms than short-term ones.

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9 Figures and Tables

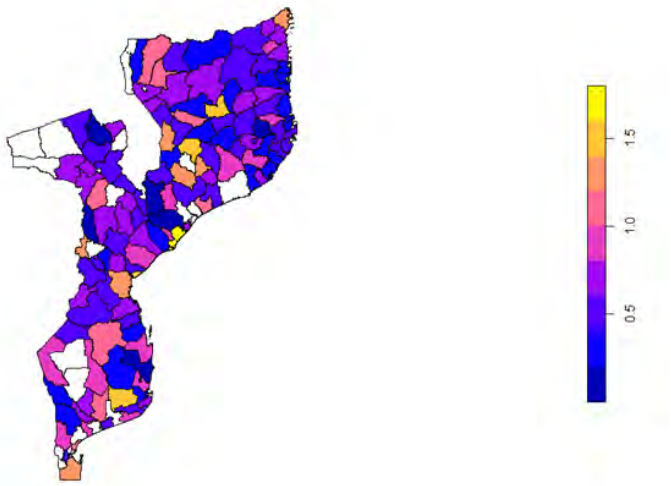

Figure 6: Coefficient of variation of Cassava production (district average)

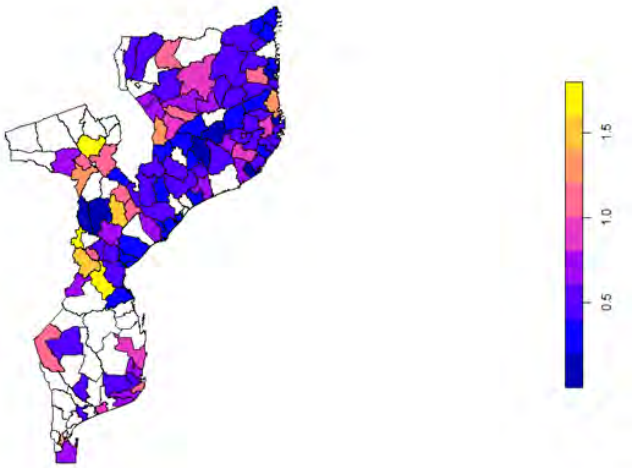

Figure 7: Coefficient of variation of Rice production (district average)

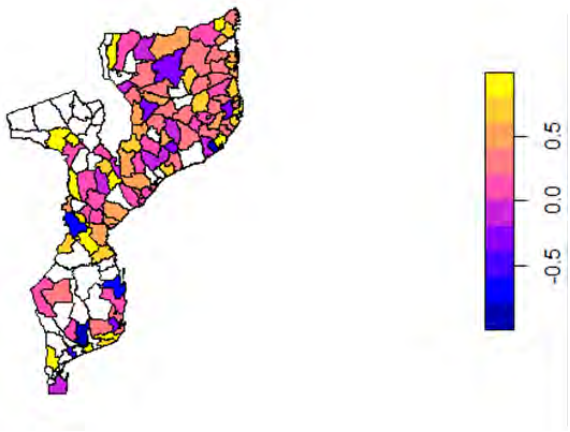

Figure 8: Correlation between Maize and Rice Yields

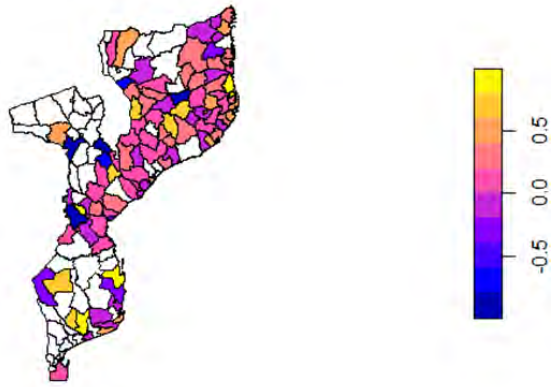

Figure 9: Correlation between Cassava and Rice Yields

	Dependent variable:			
	Income CV		Food Security CV	
	(1)	(2)	(3)	(4)
Herfindahl Index (1= very diversificated crops)	0.017	-0.177	-0.200***	-0.119*
	(0.137)	(0.135)	(0.047)	(0.061)
Uses Irrigation	-0.024	0.027	-0.103***	-0.077**
	(0.105)	(0.100)	(0.036)	(0.036)
Household head engages in non-agricultural activities	-0.955***	-0.952***	0.011	0.003
	(0.060)	(0.065)	(0.035)	(0.042)
Percentage of household members who work exclusively with agriculture	-0.073	-0.081	0.019	0.011
	(0.127)	(0.131)	(0.041)	(0.045)
Constant	1.912***	2.364***	0.917***	0.735***
	(0.199)	(0.205)	(0.076)	(0.086)
District Fixed effects	No	Yes	No	Yes
Observations	1,755	1,755	2,057	2,057
R^2	0.370	0.487	0.028	0.118
Adjusted R^2	0.366	0.449	0.023	0.063
Residual Std. Error	20.249 (df = 1743)	18.875 (df = 1633)	9.636 (df = 2045)	9.437 (df = 1935)
Note:				*p<0.1; **p<0.05; ***p<0.01

Figure 10: Regression 1: Risk Management (ex-ante) strategies

OLS estimation of equations 1 and 2. Each equation is estimated in pairs: the first column using solely household characteristics while the second column adds a control for district. The regression uses data from the 2015 TIA sample survey. Dependent Variables: CV of individual income (first 2 regressions) and CV of individual food security (last 2). Explanatory variables: measures of ex-ante strategies: Individual's Herfindahl Index, Household head involved in non-agricultural activities, % of economically active members of household who only work with agriculture, if the household uses irrigation. Initial controls: household's head total schooling in years, her age, a dummy for gender, number of household members, if the household is rural, if the head received agrarian training and if they have a cellphone.The regression is weighted using individual weights provided by the sample survey. Standard errors are clustered at district level.

	Dependent variable:			
	Individual Food Security			
	(1)	(2)	(3)	(4)
Individual Income	-0.026	-0.020	-0.025	-0.019
	(0.017)	(0.019)	(0.017)	(0.019)
Average District Food Security	0.978***	0.971***	0.980***	0.959***
	(0.024)	(0.026)	(0.042)	(0.048)
Constant	-0.019	-0.195**	-0.0004	-0.163
	(0.040)	(0.092)	(0.053)	(0.101)
Individual Fixed effects	No	Yes	No	Yes
Monthly Fixed effects	No	No	Yes	Yes
Observations	9,558	9,558	9,558	9,558
R^2	0.284	0.389	0.285	0.389
Adjusted R^2	0.284	0.352	0.283	0.352
Residual Std. Error	9.552 (df = 9548)	9.085 (df = 9018)	9.555 (df = 9537)	9.086 (df = 9007)
Note:				*p<0.1; **p<0.05; ***p<0.01

Figure 11: Regression 2: Risk Coping - Townsend's assessment of Risk Sharing (Panel Data)

OLS estimation of equation 3. Even columns control for individual fixed effects and columns 3 and 4 control for month fixed effects. Standard Errors are clustered at individual level. Controls: household's head total schooling in years, her age, a dummy for gender, number of household members, if the household is rural, if the head received agrarian training and if they have a cellphone.

	Dependent variable:				
	Sleep under net	Anything done to make water drinkable	Malaria	Anemia	Any Deceased kids
	(1)	(2)	(3)	(4)	(5)
Income CV	0.161	0.250	-0.296***	-0.354	0.583
	(0.504)	(0.428)	(0.108)	(0.386)	(0.668)
Constant	0.545	-0.111	1.000***	1.060***	-0.125
	(0.343)	(0.289)	(0.074)	(0.263)	(0.464)
Observations	1,163	1,162	1,163	1,158	1,067
R^2	0.293	0.142	0.535	0.169	0.247
Adjusted R^2	0.137	-0.048	0.431	-0.016	0.065
Residual Std. Error	536.156 (df = 951)	451.277 (df = 950)	115.338 (df = 951)	411.009 (df = 946)	516.273 (df = 859)
Note:					*p<0.1; **p<0.05; ***p<0.01

Figure 12: Regression 3: Risk's effect on Health Indicators (IMASIDA 2015)
OLS estimation of equation 4, with different dependent variables in each column ("sleep under net", "anything done to make water drinkable", "family member has malaria", "family member has anemia", "any deceased kids"). We control for household characteristics such as the head´s schooling, age and gender, number of family members, geographical cluster, ownership of a bicycle. Standard Errors were clustered by district.

	Dependent variable:							
	Has bicycle	Has motorcycle	Has a cellphone	Precarious Sanitation Facility	Anything done to make water drinkable	Has a place to store surplus crop	Has grain from last harvest	Household head is able to read
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Income CV (household-level)	-0.002	-0.040***	-0.007	0.039***	-0.014	0.006	0.022	0.017*
	(0.015)	(0.012)	(0.015)	(0.013)	(0.012)	(0.015)	(0.015)	(0.010)
Constant	0.124	0.035	0.185	0.445***	0.200**	0.033	0.207*	-0.096
	(0.092)	(0.106)	(0.209)	(0.163)	(0.101)	(0.152)	(0.118)	(0.106)
District Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,897	1,897	1,897	1,897	1,897	1,897	1,897	1,897
R^2	0.209	0.227	0.348	0.358	0.198	0.254	0.210	0.650
Adjusted R^2	0.157	0.176	0.305	0.316	0.145	0.205	0.158	0.627
Residual Std. Error (df = 1779)	10.743	7.615	9.884	8.742	8.183	10.432	10.891	7.147
Note:								*p<0.1; **p<0.05; ***p<0.01

Figure 13: Regression 3:Risk's effect on consumption, hygiene and literacy indicators (TIA 2015)
OLS estimation of equation 5, with different dependent variables in each column. We control for household characteristics such as the head´s schooling, age, gender and agricultural training, number of family members and district. Standard Errors were clustered by district.

	Dependent variable:							
	Has bicycle	Has motorcycle	Has a cellphone	Precarious Sanitation Facility	Anything done to make water drinkable	Has a place to store surplus crop	Has grain from last harvest	Household head is able to read
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Income CV (household-level)	0.022	-0.023	0.011	0.015	-0.007	0.023	0.039**	0.023*
	(0.018)	(0.014)	(0.017)	(0.013)	(0.014)	(0.020)	(0.018)	(0.014)
Herfindahl Index (1= very diversificated crops)	0.168***	-0.003	-0.016	-0.021	-0.054	0.190***	0.208***	-0.098*
	(0.061)	(0.050)	(0.065)	(0.069)	(0.063)	(0.070)	(0.074)	(0.058)
Uses Irrigation	0.012	0.050	0.056	-0.041	0.064	-0.142**	0.004	0.042
	(0.049)	(0.060)	(0.070)	(0.049)	(0.049)	(0.063)	(0.066)	(0.050)
Household head engages in non-agricultural activities	0.089***	0.065**	0.090**	-0.081**	0.025	0.080**	0.070*	0.040
	(0.032)	(0.027)	(0.037)	(0.033)	(0.025)	(0.035)	(0.041)	(0.033)
Percentage of household members who work exclusively with agriculture	-0.019	-0.068	-0.216***	0.114*	-0.048	0.013	0.039	0.053
	(0.067)	(0.066)	(0.054)	(0.059)	(0.051)	(0.064)	(0.072)	(0.041)
Sent Remittances to other households	0.071*	0.067***	0.084***	0.020	0.028	0.047	0.100***	0.0002
	(0.039)	(0.022)	(0.026)	(0.029)	(0.030)	(0.037)	(0.035)	(0.027)
Constant	-0.090	-0.033	0.163**	0.454***	0.177*	-0.038	0.086	-0.090
	(0.111)	(0.079)	(0.082)	(0.096)	(0.093)	(0.113)	(0.133)	(0.075)
District Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755
R^2	0.224	0.237	0.344	0.331	0.203	0.257	0.233	0.655
Adjusted R^2	0.166	0.180	0.295	0.281	0.144	0.201	0.176	0.630
Residual Std. Error (df = 1632)	10.727	7.514	9.959	8.559	7.839	10.257	10.755	7.164
Note:								*p<0.1; **p<0.05; ***p<0.01

Figure 14: Regression 3:Risk's effect on consumption, hygiene and literacy indicators + consumption smoothing (TIA 2015)

OLS estimation of equation 5, with different dependent variables in each column. Consumption smoothing variables were added to each regression as explanatory variables (Crop diversification, Household Head Occupation Diversification, Household Member's Occupation Diversification, Irrigation and if the household sent remittances to another). We control for household characteristics such as the head´s schooling, age, gender and agricultural training, number of family members and district. Standard Errors were clustered by district.

10 Variables and Descriptive Statistics

In this section, all variables not originally present in the main datasets whose creation was not previously described will be explained as to how they can be obtained from the data.

Someone in the family has anemia: using data from the IMASIDA 2015 about family each members' anemia test, I created a dummy that is 1 if any family member has a mild, moderate or severe case of anemia.

Deceased children: the IMASIDA 2015 contains a variable for deceased daughters and one for deceased sons. I added both, creating a variable containing the number of deceased children in a household.

Herfindahl: Using data from the TIA 2015 database on 6671 individuals I used the adjusted area cultivated for each crop by each household to arrive at how much each crop contributes (%) to the usage of the total land available to the household. The percentiles were later used to calculate the Herfindahl index for each household (by adding the square of each crops' percentile land usage). An index closer to one means that the household diversifies their crop portfolio greatly.

Percentile of Household members whose main activity is agriculture: each member of a household is qualified in the TIA 2015 database as being mainly involved in agriculture, secondarily, or not at all. Total observations in database are 38189. After removing NA observations (which indicate individuals under a certain age or not economically active), there are 25730 observations left. A dummy is created for which everyone whose main activity is agriculture is 1 and everyone else's value is 0. The total number of household members is used to calculate a percentile for each household. We have 7130 different households in the filtered data.

Household head engages in non-agricultural activities: dummies in the TIA 2015 database for various activities are condensed into one if the individual engages in any of the below described activities: "Works abroad", "Public employee", "Mechanic or works in construction", "Accountant, Secretary", "Cook, Gardner", "Works with forestry or animals", "Miner", "Driver", "Other specialized activities" , "other payed activities"

Coefficient variation income: (TIA 2015) From panel dummies (“had income in month x”), a coefficient of variance is obtained for each individual (ratio of the standard deviation to the mean).
Education: A variable from the 2015 TIA dataset ranging from 0 to 13 (zero being no education and 13 having reached university) plus the number 19 for people who are alphabetized but cannot provide an amount of years for education. For a more intuitive meaning, I dropped all the observations whose education was classified as “19” (12733 observations out of 38198).

Coefficient variation consumption: (TIA 2015) From panel dummies (“month x was a month of food insecurity”) which I switched to (“month x was a month of food security”) by inverting the binary values and thus achieving a variable for consumption, a coefficient of variance is obtained for each individual (ratio of the standard deviation to the mean).

Uses irrigation: (TIA 2015) data was available for irrigation for each crop cultivated by the household. If they used irrigation for any crop, my uses irrigation dummy is 1, if not, it is 0.

Precarious Sanitation Facility: (TIA 2015) Combines data for household sanitation facilities. If one does not have one, if it is an open pit or if it is not an improved latrine it was considered precarious. I based this evaluation on the Millennium Goals for sanitation.

DHS	N	Mean
Head Male		
Mozambique	7169	62%
Northern Provinces	2011	70%
Southern Provinces	2003	51.6%
Age Head		
Mozambique	7169	42.3
Northern Provinces	2011	40.7
Southern Provinces	2003	47.0
Years of Education Head		
Mozambique	7169	4.007
Northern Provinces	2011	4.047
Southern Provinces	2003	4.352
Non Agricultural Occupation		
Mozambique	7169	12.2%
Northern Provinces	2011	10.8%
Southern Provinces	2003	16.3%
Children under 5 sleep under net		
Mozambique	7169	27.3%
Northern Provinces	2011	31.4%
Southern Provinces	2003	22.0%
Anything done to make water safe		
Mozambique	7169	76.6%
Northern Provinces	2011	79.7%
Southern Provinces	2003	52.6%
Someone has Malaria		
Mozambique	7169	21.5%
Northern Provinces	2011	28.5%
Southern Provinces	2003	8.6%
Someone has Anemia		
Mozambique	7169	33.9%
Northern Provinces	2011	36.4%
Southern Provinces	2003	26.8%
Number of deceased children		
Mozambique	7169	0.27
Northern Provinces	2011	0.31
Southern Provinces	2003	0.18
Live in a rural area		
Mozambique	7169	85.9%
Northern Provinces	2011	87.9%
Southern Provinces	2003	80.2%
Has bank account		
Mozambique	7169	21.1%
Northern Provinces	2011	13.9%
Southern Provinces	2003	35.4%

Table 1: Descriptive statistics from de DHS sample survey, weighted averages

TIA 2015	N	Mean
Head Male		
Mozambique	7130	70.8%
Northern Provinces	2003	74.3%
Southern Provinces	2150	64.8%
Age Head		
Mozambique	7130	42.6
Northern Provinces	2003	40.6
Southern Provinces	2150	45.5
Years of Education Head		
Mozambique	7034	4.088
Northern Provinces	1970	3.385
Southern Provinces	2142	5.117
Non Agricultural Occupation Head		
Mozambique	7130	28.1%
Northern Provinces	2003	17.1%
Southern Provinces	2150	50.5%
% Members who work only with agriculture		
Mozambique	7130	55.4%
Northern Provinces	2003	71.2%
Southern Provinces	2150	23.5%
CV Income		
Mozambique	1281	1.0456
Northern Provinces	321	1.4661
Southern Provinces	493	0.6520
CV Consumption		
Mozambique	1281	0.6572
Northern Provinces	321	0.6230
Southern Provinces	493	0.6038
Diversification (Herfindahl)		
Mozambique	6671	0.625
Northern Provinces	1927	0.666
Southern Provinces	1939	0.606
Maize CV		
Mozambique	141	0.6596
Northern Provinces	54	0.5731
Southern Provinces	34	0.7420
Cassava CV		
Mozambique	139	0.3770
Northern Provinces	53	0.3298
Southern Provinces	33	0.5111
Rice CV		
Mozambique	133	0.6552
Northern Provinces	51	0.5994
Southern Provinces	33	0.7569
Affected by floods		
Mozambique	7130	30.2%
Northern Provinces	2003	41.0%
Southern Provinces	2150	4%

Table 2: Descriptive statistics from de TIA sample survey, weighted averages

TIA 2015	N	Mean
Has a Bicycle		
Mozambique	7130	33.3%
Northern Provinces	2003	35.3%
Southern Provinces	2150	14.5%
Has a Motorcycle		
Mozambique	7130	8%
Northern Provinces	2003	13%
Southern Provinces	2150	2%
Has a Cellphone		
Mozambique	7130	57%
Northern Provinces	2003	41.1%
Southern Provinces	2150	89.9%
Precarious Sanitation Facility		
Mozambique	7130	66.9%
Northern Provinces	2003	79.3%
Southern Provinces	2150	41%
Anything done to make water drinkable		
Mozambique	7130	14.3%
Northern Provinces	2003	11.7%
Southern Provinces	2150	17.2%
Storage place crop		
Mozambique	7034	60.2%
Northern Provinces	1970	61.6%
Southern Provinces	2142	52.1%
Has grain left from last harvest		
Mozambique	7130	38%
Northern Provinces	2003	55%
Southern Provinces	2150	12.3%
Head Literacy		
Mozambique	7130	56.6%
Northern Provinces	2003	44%
Southern Provinces	2150	75.9%
Uses Irrigation		
Mozambique	7130	5%
Northern Provinces	2003	4.7%
Southern Provinces	2150	15.4%
Sent remittances to other households		
Mozambique	7130	20.4%
Northern Provinces	2003	25.9%
Southern Provinces	2150	15.3%
Number people in household		
Mozambique	7130	4.8769
Northern Provinces	2003	4.7429
Southern Provinces	2150	4.7947
Affected by drought		
Mozambique	7130	35.8%
Northern Provinces	2003	20.5%
Southern Provinces	2150	49.0%

	N	Mean			
Banks		**Trusts**	**Neutral**	**Distrusts**	**Does not Know**
Mozambique	2.574	15.4%	21.9%	35.9%	27%
Northern Provinces	884	22.5%	22.3%	34.5%	26.8%
Southern Provinces	667	5.3%	26.8%	38.0%	23.4%
Microfinance		**Trusts**	**Neutral**	**Distrusts**	**Does not Know**
Mozambique	2.574	15.2	25%	19.4%	40%
Northern Provinces	884	20.6%	26.2%	37.8%	28.9%
Southern Provinces	667	14.7%	37.3%	17.4%	30%
Xitique		**Trusts**	**Neutral**	**Distrusts**	**Does not Know**
Mozambique	2.574	20.3%	22.0%	18.3%	38.8%
Northern Provinces	884	26.9%	22.6%	36.3%	27.2%
Southern Provinces	667	19.3%	37.3%	12%	31.1%
Friends and Family		**Trusts**	**Neutral**	**Distrusts**	**Does not Know**
Mozambique	2.574	17.3%	21.4%	37.5%	22.4%
Northern Provinces	884	17%	20.9%	41.5%	20.3%
Southern Provinces	667	15.1%	32.2%	29.2%	23.1%

Member of Xitique	**N**	**Mean**
Mozambique	2.574	17.1%
Northern Provinces	884	18.3%
Southern Provinces	667	28.9%
Used Savings Collectors	**N**	**Mean**
Mozambique	2.574	2%
Northern Provinces	884	1.3%
Southern Provinces	667	4%
Used moneylender	**N**	**Mean**
Mozambique	2.574	11%
Northern Provinces	884	11.6%
Southern Provinces	667	2.5%
Uses Fertilizers		
Mozambique	6671	1%
Northern Provinces	2003	2.1%
Southern Provinces	2150	0.9%
Uses Pesticides		
Mozambique	6671	2.0%
Northern Provinces	2003	3.3%
Southern Provinces	2150	0.4%
Uses Herbicides		
Mozambique	6671	0.2%
Northern Provinces	2003	0.4%
Southern Provinces	2150	0.02%