4. Household Vulnerability

by Alexander Sarris and Panayotis Karfakis

4.1 Introduction

Having described households' endowment base, the risks they face, their livelihood systems and coping strategies as well as their welfare and poverty levels in Chapters 2 and 3, Chapter 4 explores the status of vulnerability of households in Tanzania, the combined result of these different factors. To do so, we calculate a measure of household vulnerability and estimate for each household its probability of falling below a poverty level in the next period. The vulnerability measure can be used to construct a vulnerability profile of the population and identify appropriate policy interventions and targeting rules.

The subject of risk and especially the contribution of risk to poverty dynamics are of growing importance in the literature on poverty. Risks contribute to poverty in a number of ways. Firstly, risks may blunt the adoption of technologies and strategies of specialization necessary for agricultural efficiency (Carter, 1997). For example, households with limited options for consumption smoothing grow lower return, but safer crops (sweet potatoes, sorghum and millet) than the richer households which usually have more options for consumption smoothing. Risks may motivate farmers to apply less productive technologies in exchange for greater stability (Morduch, 2002, Larson and Plessman, 2002). The cost of such an income-smoothing strategy can be high and a farmer may forgo up to 20 percent of his or her expected income to obtain a smoother income stream (Dercon, 1996). Secondly, risks may function as a mechanism for economic differentiation within a population, deepening the poverty and food insecurity of some individuals even as aggregate food availability improves (Carter, 1997). Thus, in the absence of risk management instruments, risk events may plunge particularly vulnerable households into poverty (Holzmann and J∅rgensen, 2000). The policy message emanating out of these insights are that risks are detrimental to the welfare of (poor) households and that ensuring security of consumption is an essential ingredient of any poverty alleviation strategy (World Bank, 2001).

A household facing a risky situation is subject to future loss of welfare. The likelihood of experiencing future loss of welfare, generally weighted by the magnitude of expected welfare loss, is called vulnerability. The degree of vulnerability depends on the characteristic of the risk and the household ability to respond to risk through the risk management strategies discussed above. Household vulnerability has thus been decomposed by Heitzman *et al*. (2002) into a "risk chain" comprising (a) uncertain events (b) the options for managing risks or risk responses and (c) the outcome in terms of welfare loss. Households face risks namely exposure to uncertain events. To contend with risks households make use of a number of risk management options. Risks combined with responses lead to outcome. Thus a household is said to be vulnerable to the outcome of an uncertain event, if it does not have sufficient resources to adequately contend with the outcome of the event. In other words, the extent to which a household is vulnerable to an uncertain event, namely the extent to which the household can become and/or remain poor, depends on the size of the shock and how effective the household is in managing the uncertain event both *ex-ante*, as well as *ex-post*.

While the development community has largely settled on the appropriate indices to measure poverty [namely the Foster Greer and Thorbecke (1984) (FGT) indices], no consensus has yet emerged about the appropriate way to measure vulnerability. Essentially two approaches have emerged in the literature, which consider vulnerability. The first associates vulnerability with high expected poverty (Christiaensen and Boisvert, 2000; Chaudhuri, *et al*. 2002), while the second with low expected utility (Ligon and Schechter, 2003). The latter requires information about individual risk preferences. Given that individuals are often uncertain about their preferences, especially those related to stochastic events,[it is hard to imagine that human knowledge can be so perfect that tomorrow's hunger or pain can be felt today (Kanbur, 1987)] we opt to follow the expected poverty approach below.[1]

A comprehensive qualitative assessment of households' risk environment, their coping strategies, and the resulting household vulnerability in Tanzania, was first undertaken under the 2002/2003 PPA (URT, 2004). It concluded that vulnerability is the result of the number and intensity of the impoverishing forces households face versus the number and effectiveness of their response options. It identified environmental and macroeconomic conditions, governance, ill health, lifecycle conditions and cultural beliefs and practices as important impoverishing forces (i.e. forces pushing people down the ladder of well-being). To manage these impoverishing forces the PPA finds that households make use of assets (including human, social, political, natural, physical and financial assets). Thus poverty itself limits people's capacity to improve and safeguard their well-being. In addition, it is seen that people's capacity to manage impoverishing forces diminishes as they struggle to survive successive waves of shocks and stresses. The PPA further emphasized that there are some disadvantaged social groups in the country that due to their low access to assets are particularly vulnerable. These include children, persons with disabilities, unemployed youths, elderly persons, persons with chronic illnesses, widowed women, drug addicts and alcoholics.

This study supplements this analysis through a quantitative assessment with a particular emphasis on cash crop growing households. The late 1990s and early 2000s have been characterized by a precipitous decline in many cash crop prices such as coffee and cashew nuts grabbing headlines and renewing calls for direct market interventions to support small holder cash crop growers. Nonetheless, as illustrated by the findings from the PPA, cash crop growers are not only exposed to commodity price declines, but as other households, they face many risks and a holistic perspective on household vulnerability is thus called for.

In the second section we briefly review the concept of vulnerability and we discuss our methodology. The proposed methodology complements and improves on the applications by Chaudhuri. *et al*. (2002) and Christiaensen and Subbarao (2005), through the inclusion of covariate risks, by utilizing historical information on prices yields and production. The data is described in Section 4.3 and Section 4.4 provides empirical estimates of households' vulnerability and discusses the various aspects of the estimates and results. Section 4.5 summarizes the conclusions.

[1] Christiaensen and Subbarao (2005) provide a more elaborate discussion of the normative assumptions underpinning the different approaches to vulnerability measurement.

4.2 Methodology

There are two basic ideas that appear consistently in the vulnerability literature. First the groups of poor and the vulnerable are not the same. Secondly, although poverty is a static concept (a situation into which somebody already finds himself), vulnerability is a dynamic concept (referring to a situation in which somebody can potentially fall into). As such the most popular vulnerability measures estimate the probability that a welfare variable (usually consumption), will fall below an ex-ante defined poverty line.

In general there are two approaches that have been tried to assess and estimate vulnerability. The first considers vulnerability as the probability of consumption falling below a poverty threshold (Christiaensen and Subbarao, 2004, Chaudhuri, *et al*. 2002), while the second considers vulnerability as low expected utility (Ligon and Schechter, 2003). Hoogeveen *et al* (2004) provide guidelines for constructing vulnerability measures, and a review of the shortcomings of the measures developed until now. Hoddinott and Quisumbing (2003) provide a more formalized survey of vulnerability together with the econometric methodology behind the currently developed measures. Finally Kurosaki (2006) reviews the quickly expanding literature on different vulnerability measures, favouring their use as advancing poverty measurement from a static to a dynamic framework. He argues for the usefulness of all (for different policy purposes), and thus for the inability to choose an overall acceptable definition. In the sequel we follow the first approach.

Both of the approaches to vulnerability indicated above consider as the object of study household consumption, which is determined by individual characteristics, and is subject to covariate or idiosyncratic risk factors. The idea is to construct an appropriate probability distribution of consumption. In a second step taking into account the probability distribution of consumption, vulnerability indicators that relate to the family of the FGT, are estimated for groups of households.

Vulnerability can be defined as the probability that consumption at period t+1 denoted as ct+1, will fall below an *ex ante* defined poverty line (z):

$$V_{ht} = \Pr(c_{h,t+1} \leq z) \tag{4.1}$$

Extensions of the methodology are provided by Prithcett *et al* (2000), who expand the time horizon based on the fact that the higher length of the time horizon is associated with more risk and thus with higher vulnerability.

Given an efficient estimate of the probability distribution of consumption a vulnerability index for a household h at time t can be computed by applying the following FGT type of formula.

$$V_{h,t,\nu} = F(z)\int_{\underline{c}_t}^{z}(z - c_t)^{\nu}\,\frac{f(c_{h,t})}{F(z)}\,dc_t \tag{4.2}$$

where f is the density and F the cumulative distribution of consumption. As such, vulnerability measures the probability of falling below the benchmark poverty line (if ν =0), or this probability weighted by the depth of the shortfall (if ν ≠0).

However popular the FGT measures, there is a debate concerning their properties as well as their interpretation (see for instance the discussion in Ligon and Schechter 2003). Furthermore in a recent paper Cafiero and Vakis (2006) suggest that a major issue with these measures is that no matter how much retrospective information is available (for instance with long panel data), vulnerability measures are not forward looking since they are based always on past realized welfare outcomes, shocks and characteristics. Similarly Alwang, Siegel and Jørgenson (2001) suggest that: "Vulnerability is the continuous forward looking state of expected outcomes. *Ex post* welfare losses are neither necessary nor sufficient for the existence of vulnerability. Past welfare losses, in and of themselves, are not sufficient to identify a household as vulnerable." All of these critiques have to do with the inherent upredictability of some events that have not occurred in the past, and for which one cannot form probability distributions. As such, even though any vulnerability measure is richer in information in comparison with a simple poverty line, it cannot be forward looking. On these grounds Cafiero and Vakis (2006) suggest the use of traditional poverty lines, but upwards adjusted by an amount that captures the cost of insurance for the uninsured risks (even if insurance markets are not present). However, even this risk premium cannot be estimated on the basis of events that have never occurred in the past and hence have unknown probability.

Irrespective of their disadvantages the FGT class of indices are popular due mainly to their simplicity and comprehensiveness. Also an advantage of these indices is that they do not depend on individual utility functions.

Our methodology builds on the approach of Christiaensen and Subbarao (2005) and Chaudhuri et. al. (2002). We shall specify a stochastic consumption function, and we shall try to identify the idiosyncratic and the covariate components of risk.

Consider the specification of household consumption. We assume that consumption in some period t for household h, is a stochastic variable that depends on a set of variables X specific to the household, as well as a set of idiosyncratic and covariate shocks S.

$$\ln c_{ht} = X_{ht}\beta + S_{ht}\gamma + e_{ht} \tag{4.3}$$

where c_{ht} is per capita or per equivalent adult consumption expenditure of the household in period t, X_{ht} is a set of household characteristics that can be considered exogenous to the household at time t (including for instance past levels of various assets, other household variables etc.), S_{ht} is a vector of identifiable idiosyncratic shocks, as well as variables affected by covariate shocks experienced by the household between times t-1 and t, β and γ are vectors of parameters to estimate, and e is a zero mean error term that captures idiosyncratic shock factors that affect consumption apart from the ones explicitly included in S.

The variance of e is assumed to also depend on X_h as follows.

$$\sigma^2_{e,h} = X_h\theta \tag{4.4}$$

Both Christiaensen and Subbarao (2005) and Chaudhuri *et al.* (2002) have utilized a three step feasible generalized least squares (FGLS) procedure to estimate β and θ. This involves first estimating (4.3) by OLS. Then (4.4) is estimated by OLS by using the squared residuals from the estimation of (4.3) as left hand variables. The predictions $X_h\hat{\theta}$ from this regression are used to re-estimate (4.4) by OLS after dividing each observation as well as the right hand variables in (4.4) by $X_h\hat{\theta}$. The new estimates of θ are asymptotically efficient, and are used to weigh (4.3) and re-estimate it by weighted least squares, to obtain asymptotically efficient estimates of β and γ. Once this is done, the expected value of consumption and its variance given X_h are equal to

$$E[\ln c_h / X_h] = X_h\hat{\beta} + E(S_{ht})\gamma \tag{4.5}$$

$$Var[\ln c_h / X_h] \equiv \hat{\sigma}^2_{e,h} + \gamma' Var(S_{ht})\gamma = X_h\hat{\theta} + \gamma' Var(S_{ht})\gamma \tag{4.6}$$

where the expectations are conditional ones, namely given information at the beginning of time t, and V(S) is the conditional covariance matrix of the shocks S, These expressions were utilized by Christiaensen and Subbarao (2005) and Chaudhuri *et al*. (2002) to estimate the probability that consumption will fall below some poverty threshold, which was defined as the vulnerability of the household.

Notice that the above procedure accounts for both idiosyncratic shocks affecting households, as well as covariate ones, as long as the conditional variance of S can be estimated. It is not easy to estimate the variance of S, and it is there that we shall try to extend the current practice.

Suppose that S can be decomposed into two vectors Y, and Z, where Y includes k variables that are themselves, or are directly affected by, independent covariate shocks, while Z includes identifiable idiosyncratic shocks. Idiosyncratic shocks that cannot be separately identified, and hence are not included in Z are subsumed in the error term e. We omit the time subscript for ease of notation.

$$S_h = [Y_h, Z_h] \tag{4.7}$$

We can also partition the coefficient vector γ conformably to the above decomposition.

$$\gamma = [\gamma_Y, \gamma_Z] \tag{4.8}$$

For instance Y could include some rainfall related variable, or production/income of a crop whose yield is subject to environmental variations, but also whose price varies in ways exogenous to the household. Under the above assumptions the conditional mean and variance of consumption can be written as follows.

$$E[\ln c_h / Z_h] = X_h\hat{\beta} + E[Y_h / X_h]\hat{\gamma}_Y + E[Z_h / X_h\}\hat{\gamma}_Z \tag{4.9}$$

$$Var[\ln c_h / Z_h] = \sum_{i=1}^{k} \hat{\gamma}^2_{i,Y} Var[Y_{h,i} / X_h) + X_h\hat{\theta} + \sum_{j=1}^{m} \hat{\gamma}_{j,Z} Var[Z_h / X_h] \tag{4.10}$$

where k denotes the number of variables affected by independent covariate shocks included in Y and m is the number of independent idiosyncratic shocks included in Z. The first component of the right hand side of (4.10) represents the contribution of covariate shocks to the variance of consumption, while the last two represent the contribution of idiosyncratic shocks. Chistiaensen and Subbarao (2005) included covariate as well as idiosyncratic shocks in their analysis, and used external information on these shocks to implement (4.10). The problem is to estimate the relevant parameters β, θ, and γ, as well as estimating the variances of each independent covariate and idiosyncratic shock variable included in the Y and Z vectors.

Given (4.9) and (4.10), the vulnerability of the household will be defined as follows

$$V_h = \Pr ob(\ln c_h < \ln z / X_h) \tag{4.11}$$

The most important covariate shocks affecting farm households in Tanzania (and probably everywhere else), are weather induced reductions in crop yields, and variations in market prices of products. As every farm household produces a variety of crops it is difficult to account for all individual crop specific risks for each farmer. What we propose, instead, is to include total crop income as an explanatory variable in the consumption equation, as the main variable subject to covariate shocks. Crop income is the most important component of income in rural areas in Tanzania, and the most important sources of covariate risks, constituting more than 50 percent on average total (cash and non-cash) income among rural households in the two regions studied. We then propose to determine for each household the covariate and idiosyncratic components of the variance of this crop income, based on the survey data, as well as household specific crop production patterns, and exogenous time series information on prices and yield variations. Finally we will combine the total variance of crop income with the idiosyncratic component of consumption risk, in order to ascertain the total vulnerability faced by each household. If we let Y in the equations above denote the total crop income of the farm household (a scalar), then the whole discussion above carries through as a special case.

In summary the procedure that we shall follow is the following.

First we estimate from a cross-section the consumption per adult equivalent of each household by a relation of the following form.

$$\ln c_{ht} = X_{ht}\beta + \gamma_Y \ln Y_{ht} + Z_{ht}\gamma_Z + e_{ht} \tag{4.12}$$

where Y is the household (gross)[1] crop income per acre (the land cultivated is included in the X variables), X is a shorthand for all other explanatory household variables, and Z denotes the identifiable idiosyncratic shocks affecting the household in period t.

Given that the error of this equation is likely to be correlated with the variable Y, this equation will be estimated by instrumental variables, by estimating in a first step the variable Y. Hence the equation actually estimated is a modified version of (4.12)

$$\ln c_{ht} = X_{ht}\beta + \gamma_Y \ln \hat{Y}_{ht} + Z_{ht}\gamma_Z + e_{ht} \tag{4.13}$$

where the hat above Y denotes the fitted values from the first stage regression. This first stage regression includes all the X and Z variables plus the instruments. Ideally all covariate shocks affecting crop income but not consumption, such as weather shocks could be included in the instruments of the first stage of the estimation of Y.

[1] We also utilized net crop income, which is gross crop income after subtracting the values of purchased intermediate inputs, but this led to some losses of degrees of freedom, while not affecting in any substantive way the results.

Once (4.13) is estimated the residuals are squared and the following equation is estimated by OLS.

$$\hat{e}_h^2 = X_h\theta_{OLS} + \eta_h \tag{4.14}$$

After (4.14) is estimated by OLS, it is re-estimated in the following "corrected" form.

$$\frac{\hat{e}_h^2}{X_h\hat{\theta}_{OLS}} = \left(\frac{X_h}{X_h\hat{\theta}_{OLS}}\right)\theta + \frac{\eta_h}{X_h\hat{\theta}_{OLS}} \tag{4.15}$$

This produces efficient estimates of θ denoted by $\hat{\theta}_{FGLS}$. Since $X_h\hat{\theta}_{FGLS}$ is a consistent estimate of $\sigma_{e,h}^2$, we use the estimates of this, namely

$$\hat{\sigma}_{e,h} = \sqrt{X_h\hat{\theta}_{FGLS}} \tag{4.16}$$

to re-estimate (4.13) as follows:

$$\frac{\ln c_{ht}}{\hat{\sigma}_{e,h}} = \left(\frac{X_{ht}}{\hat{\sigma}_{e,h}}\right)\beta + \left(\frac{\ln \hat{Y}_{ht}}{\hat{\sigma}_{e,h}}\right)\gamma_Y + \left(\frac{Z_{ht}}{\hat{\sigma}_{e,h}}\right)\gamma_Z + \frac{e_{ht}}{\hat{\sigma}_{e,h}} \tag{4.17}$$

Given the estimates of β, γ and θ obtained from (4.17) and (4.15) respectively, we can estimate the expected value and variance of log of consumption using (4.9) and (4.10). Note that equation (4.13) implicitly includes, via the parameter γ_Y, the consumption smoothing behaviour of the household. Hence the subsequent estimate of vulnerability refers to vulnerability that remains after the various consumption smoothing mechanisms to income shocks have been employed.

Given (4.17), if it is assumed that consumption is lognormally distributed, equation (4.11) can be estimated directly. Note also from (4.10) that the first component of the right hand side can be considered as the contribution of covariate shocks to overall variance of consumption, while the second component is the idiosyncratic risk.

As crop income is a major component of total income, and hence consumption variability, the determination of its variance is quite important for the estimation of consumption variations, and hence vulnerability. To estimate the expected value and the variance of the log of crop income, we first compute the expected value and variance of crop income using the technique applied by Sarris (2002) and Rapsomanikis and Sarris (2007). Let agricultural (gross) crop income of a household h be denoted by Y_h. Then this can be written as follows.

$$Y_h = \sum_{i=1}^{n} P_{h,i}Q_{h,i} \tag{4.18}$$

where the quantities Q of each product and the prices P are specific to each household, and n is the number of crop products produced by the household.

For the sequel, we assume that *ex-ante*, both price and production of each product are stochastic, and that the distribution of the price of each product is independent of the distribution of the quantity produced by the household[1]. Let the average shares of each crop product *i* in total crop income be s_i , the normalized quantity of product *i* produced by q_i (the normalization is by dividing the amount Q produced in any period by the average value of production), and the normalized price of product *i* by p_i (which is defined as the price P of the product in a period divided by the average value of price). We shall omit household specific indices for ease of notation. Then the normalized deviation of total crop income from its mean, for each household, under the assumption that the quantities produced by the household in period t are independent of the prices faced by the household in the same period can be written as follows (where the expectations as well as the bars above stochastic variables denote conditional expected values for one period ahead):

$$\hat{Y} \equiv \frac{Y - E(Y)}{E(Y)} = \frac{\sum_i P_i Q_i - E(\sum_i P_i Q_i)}{E(\sum_i P_i Q_i)} = \frac{\sum_i P_i Q_i - \sum_i \overline{P_i}\,\overline{Q_i}}{\sum_i \overline{P_i}\,\overline{Q_i}} =$$

$$= \sum_i s_i (\Delta p_i \Delta q_i + \Delta p_i + \Delta q_i) \tag{4.19}$$

Given (4.19), the squared coefficient of variation of income can be written as follows.

$$CV^2(Y) = \sum_i \sum_j s_i s_j E\left[(\Delta p_i \Delta q_i + \Delta p_i + \Delta q_i)(\Delta p_j \Delta q_j + \Delta p_j + \Delta q_j) \right] \tag{4.20}$$

If we assume symmetry of the distributions of the various price and quantity terms, the only terms that will contribute to the expression in (4.20) are those that include even number of terms in the products of the price and quantity terms. Hence (4.20) can be rewritten as follows.

$$CV^2(Y) = \sum_i \sum_j s_i s_j E\left[\Delta p_i \Delta p_j \Delta q_i \Delta q_j + \Delta p_i \Delta p_j + \Delta p_i \Delta q_j + \Delta p_j \Delta q_i + \Delta q_i \Delta q_j \right] \tag{4.21}$$

Clearly the CV of income is just the square root of (4.21) and the standard deviation of crop income is the product of the CV and the average value of crop income.

Denote by σi the coefficient of variation of production of the i'th crop produced by the household, by κ_{ij} the correlation coefficient between the production of the i'th crop and the j'th other crop produced by the household, by v_i the coefficient of variation of the domestic price facing the household of the i'th product, and by ψij the correlation coefficient between the prices of the i'th and j'th products. The various terms of the extended coefficient of variation formula (4.21), under the independence assumptions made, can be evaluated as follows:

$$E(\Delta p_i \Delta p_j \Delta q_i \Delta q_j) = \psi_{ij} v_i v_j \kappa_{ij} \sigma_i \sigma_j \tag{4.22}$$

$$E(\Delta p_i \Delta p_j) = \psi_{ij} v_i v_j \tag{4.23}$$

---

[1] This assumption, of course, is only an approximation, but it holds for most products where production decisions must be made several months in advance of actual production and sale. It is made for simplicity as otherwise the formulas would become too unwieldy.

$$E(\Delta p_i \Delta q_j) = 0 \tag{4.24}$$

$$E(\Delta q_i \Delta q_j) = \kappa_{ij} \sigma_i \sigma_j \tag{4.25}$$

The above formulas allow the complete specification of each household's variance of crop income, conditional on the characteristics of each household. This, however, is not the complete end of the story, as equation (4.17) involves the log of crop income rather than the simple value of income. The above method yields the mean and the variance of crop income, which for simplicity we denote as μ_Y and σ_Y^2. If it can be assumed that the distribution of total crop income is log normal, then by using the standard statistical formulas of the lognormal distribution (e.g. Lindgren, 1998) we can express the expected value and the variance of the log of Y as follows.

$$E(\ln Y) = \ln \mu_Y - \frac{1}{2} \ln(1 + \frac{\sigma_Y^2}{\mu_Y^2}) \tag{4.26}$$

$$Var(\ln Y) = \ln(1 + \frac{\sigma_Y^2}{\mu_Y^2}) \tag{4.27}$$

The above formulas complete the full specification of the model and the methodology for computing the vulnerability.

4.3 Data

As was indicated in Chapter 2 households in Ruvuma tend to be poorer than those in Kilimanjaro, as reflected in the lower value of their total income and wealth, their lower average annual per capita expenditures and their higher poverty incidence.

In addition to the household survey data, and for the estimation of crop income variability, we also collected time series data on market prices, as well as time series on regional production and rainfall. The monthly price series data cover 15 agricultural commodities and the period from January 1983 to October 2002, yielding in total 238 observations for each commodity. These price series were subject to a large number of missing values. In order to fill the missing values a method of repeated autoregressions of order 2 was used.

The price series data cover the major cities of the Kilimanjaro region (namely Arusha, Gonja and Moshi) and similarly for Ruvuma (Songea, Mbinga and Tunduru). In order to derive a representative price index for the region for each commodity we used the row median price of the cities in each region for which we had data. Each regional price series was deflated using the monthly consumer price index from the international financial statistics of the IMF CD-ROM database (May 2004 edition), with 2000 average prices as the base (The CPI was normalized to equal 1 in average for year 2000). Price series for coffee were downloaded from the International Coffee Organization website (www.ico.org), and refer to prices paid to growers in Tanzania for the Arabica variety.

For production variability we utilized regional yield time series covering the period 1992-2001. Clearly not all yield variations are due to covariate shocks. However, aggregate yields are averages over many individual yields which are subject to both covariate shocks as well as idiosyncratic shocks. If the idiosyncratic shocks are random across households, then the aggregate yield variability should reflect random covariate shocks such as weather, as well as non-random responses to aggregate economic conditions (e.g. prices of fertilizers, etc.). While we did extensive analysis of this at the cross section level there is no reliable time series data on the basis of which to isolate the effects of such variables on aggregate yields. Hence the reported variances are likely overestimates of the true covariate shocks.

Table 4.1a and 4.1b provide summary statistics of the time series and yield data. It can be seen that the volatility of prices as well as production, in both regions is very large, with standard deviations of prices and production often larger than 40 percent of the average value of the underlying variable. It thus appears that covariate risk is substantial in Tanzania, and could account for significant vulnerability.

From the time series data we calculated coefficients and coefficients of variation for the prices of commodities, as well as cross correlation coefficients. Similarly for the production of the various products. These coefficients were utilized in conjunction with the shares of production in total crop income of the different crops for each household, obtained from the survey, to compute the mean and variance of crop income for each household. It is clear that the production and crop profile of each household will depend on the year of the survey, and may not give a good description of the longer term structure of production of the household. In other words the shares in formula (4.21) may be biased. There is not much one can do about this except average over several years, and since a two year panel was available in our survey we took the average shares over the two years.

4.4 Empirical results.

Table 4.2 indicates for each income decile, the average gross total income per adult equivalent (ae), the average crop income per ae, and the average CV of crop income. The first notable observation is that the share of crop income in total income declines considerably as total income increases. Despite the fact that there is a very large disparity between the average gross incomes of the top and the bottom deciles (about 49 to 1 in Kilimanjaro and 26 to 1 in Ruvuma), the disparity in crop incomes per ae are smaller (about 25 to 1 in Kilimanjaro and about 10 to 1 in Ruvuma). More importantly the CVs of crop incomes seem to be quite similar across deciles, despite differences in crop patterns. The CV of crop income is quite large at 44.6 percent on average for households in Kilimanjaro, and 35 percent on average for households in Ruvuma. The lower value of the average CV of crop income in Ruvuma is justified by the more stable rainfall and hence yield patterns there. For instance the CV of the regional yield of maize, the main food staple in both regions, is 44 percent in Kilimanjaro and only 14 percent in Ruvuma, as indicated in Table 4.1b.

Table 4.3 exhibits the results of the (instrumental variable) regressions on consumption and the squared residuals of consumption as per equations (4.15) and (4.17). The key variable for the vulnerability analysis is the coefficient in the consumption regressions of crop income per acre. Concerning the consumption per equivalent adult, it can be seen that it depends positively and significantly on aggregate crop productivity, the size of land, the size of household, several wealth variables such as the lagged value of the number of animals owned and the lagged value of consumer durables, the age of the household head (significant in Ruvuma), access to credit variables, and some education variables.

The Durbin-Wu-Hausman test of the exogeneity of the crop productivity strongly rejects the hypothesis of exogeneity, so IV is appropriate. Table 4.4 presents the first stage regressions for the IV estimates. We use as instruments a variety of exogenous land characteristics, as well as weather shock variables, and lagged dummies for whether the farm household used fertilizer and chemicals, as well as the lagged number of coffee and cashew trees. The Sargan test does not invalidate the use of these instruments.

It must be mentioned that in the consumption regressions the IV regression coefficient of crop income per acre is significantly larger in the IV regressions compared to the OLS estimates (the OLS estimates for these coefficients are 0.028 for Kilimanjaro and 0.174 for Ruvuma, compared to 0.144 and 0.411 for the IV regressions in table 4.3 for the two regions).

The consumption regressions explain about 47 and 51 percent of the variance of consumption in Kilimanjaro and Ruvuma respectively. The regressions of the squared residuals from the consumption regressions on the same explanatory variables as the ones in the consumption regressions (excluding the variables that are related to covariate and idiosyncratic shocks) reveal that fewer of the variables are significant. In Kilimanjaro the dependency ratio, the value of the dwelling, the number of small animals, and the membership in a social group are significant, while in Ruvuma, the only two significant variables are the dummies for whether the household receives remittances and whether the household has easy access to seasonal credit. The regressions explain a rather small proportion of the error less than 10 percent in both regions). This suggests that unexplained components of consumption variability dominate any parts that maybe due to structural household specific factors.

Tables 4.5 and 4.6 indicate the average vulnerability index in Kilimanjaro and Ruvuma by district, along with the proportions of the variance of consumption that are due to covariate factors, the average consumption per capita and the average headcount measures of poverty rates in both years of the survey. The first observation is that average vulnerability in Kilimanjaro is much lower than in Ruvuma (31 percent versus 60 percent). This is in line with the much larger poverty incidence in Ruvuma compared to Kilimanjaro that was indicated earlier (63.3 percent versus 39.5 percent).

As Chaudhuri *et al.* (2002) have indicated, in a normal year one would expect that the average vulnerability in a region, based on a concept as the one used here, should be similar to the headcount ratio of poverty. From the tables it can be seen that the poverty incidence in 2003 and 2004 in Ruvuma is quite similar to the average vulnerability, while in Kilimanjaro the average poverty incidence in both periods is about 25 percent larger than the average vulnerability level.

The reason for this maybe the fact that in Ruvuma in both years of the surveys the rainfall patterns appeared normal, while for Kilimanjaro both years of the survey seem to have been years of low rainfall. In Ruvuma while less than 4 percent of households in both years of the surveys declared that the rainfall was much below normal, in Kilimanjaro the same percentage was 21 percent in the first survey and 35 percent in the second survey. The consequence of this could be that the observed production of several key crops (e.g. maize) for several households could be lower than normal, with the implication that the shares for some major products utilized for the calculation of the variance of income, as well as the variance itself (and hence vulnerability), could be smaller than what would be calculated if the production had been normal.

Concerning regional variations, it can be seen that these are much more marked in Kilimanjaro, compared to Ruvuma, despite the fact that Ruvuma exhibits much higher overall vulnerability indicators. The ratio of the average vulnerability index between the most vulnerable district in Kilimanjaro (Same) and the least vulnerable (Hai) is more than 2.5, while the same ratio in Ruvuma, between Tunduru (most vulnerable) and Mbinga (least vulnerable) is around 1.4. The reason for this could also be the much more erratic and unstable pattern of rainfall in Kilimanjaro, compared to Ruvuma.

Another striking difference between Kilimanjaro and Ruvuma is that in Kilimanjaro the share of the covariate factors in the overall variance of consumption (which, of course induces the vulnerability) is much lower at 11 percent than the share in Ruvuma, which is 30 percent on average. This, despite the fact that Kilimanjaro exhibits much more unstable rainfall patterns than Ruvuma. A factor in this difference is the share of crop income in total income, which is around 58 percent in Kilimanjaro versus 71 percent in Ruvuma. However, such a large difference in the share of covariate factors cannot be accounted simply by the different shares of crop income in total income, The second major factor is the risk coping and consumption smoothing strategies of households in the two regions. Notice from table 4.3 that the coefficient of crop productivity in the consumption regression is three times larger in Ruvuma, compared to Kilimanjaro. This implies that a given negative crop income shock results in much smaller consumption reduction in Kilimanjaro than in Ruvuma. Hence covariate crop income related shocks affect the variance of consumption to a much less extent in Kilimanjaro.

Tables 4.7 and 4.8 present the same results as Tables 4.5 and 4.6, organized by economic status, rather than region. In both regions the average vulnerability of the poor is much larger than that of the non-poor, as expected, and the average vulnerability of both poor and non-poor is much larger in Ruvuma compared to vulnerability of the same groups in Kilimanjaro. In Kilimanjaro net food buyers appear to be more considerably more vulnerable than net food sellers, but in Ruvuma this is not the case. The reason seems to be that in Kilimanjaro the average per capita expenditure is lower and the poverty incidence is higher among net food buyers, while the opposite seems to be the case in Ruvuma. Distinguishing producers according to different types of cash crop production, results in no observable difference in Kilimanjaro. However, in Ruvuma, it is clear that cashew nut producers are much more vulnerable than coffee and tobacco producers. This is because cashew nut producers are much poorer than coffee and non cash crop producers in Ruvuma.

It is notable that the share of total consumption variance that is due to covariate factors does not differ much by functional group in Kilimanjaro but differs considerably more in Ruvuma. For instance it appears that coffee producers in Ruvuma are much more subject to covariate risks compared to all other types of producers in that region. The reason has to do with the share of cash and total income from crops, which is much higher among coffee producers in Ruvuma (87 percent) compared to that of coffee producers in Kilimanjaro (66 percent).

The final set of results concerns the number of households that are likely to become poor, given their current poverty status. In other words we examine the issue of how many of the current non-poor or poor are likely to become or stay poor in the next period. Of course, to answer this question, one must define a threshold probability level which defines the likelihood that a household's consumption will fall below the poverty level.

Table 4.9 indicates that with a vulnerability threshold of 0.4, out of all the rural households that are initially non-poor (and these constitute 115.9 thousand households, namely the sum of the numbers 100.8 and 15.1 thousand indicated in the first row of table 4.9, or 60.5 percent of all rural households in Kilimanjaro), about 13 percent, are likely to become poor (namely have a probability larger than 40 percent of becoming poor) in the next period. For the poor households (which in Kilimanjaro constitute 39.5 percent of all households initially), more than half (60.3 percent) are likely to remain poor in the next period (namely have a 40 percent or higher chance of being poor), while the remaining 40 percent are likely to be non-poor in the next period. Hence in Kilimanjaro, 31.7 of the households have a chance of 40 percent or larger of being poor in the next period.

In Ruvuma the table indicates a much bleaker picture. While 63.3 percent are classified as poor, 66.6 percent of the households have a probability larger than 0.4 of being poor in the next period, namely a higher share of those in current poverty. The share is much higher among the already poor, but even among the currently non-poor (who are 46.7 percent of the households) a full 38.5 percent is likely to be poor in the next period. Clearly rural households in Ruvuma are quite vulnerable to poverty. If we define as “hard core poor” those that are currently poor and are expected to be poor in the next period, then it can be seen that these constitute 23.8 percent of the households in Kilimanjaro (more than half of the poor), while in Ruvuma they constitute about 52.5 percent of the households or 82.9 percent of the poor. Clearly poverty is much more persistent and entrenched in Ruvuma.

If we repeat the analysis of Table 4.9 with vulnerability thresholds of 0.5 and 0.6 then we find, as expected, that all the numbers in the second columns under each region in table 4.9 go down but not by too much. For instance, with a threshold of 0.5, the number of the “hard core poor” in Kilimanjaro go down to 21 percent (from 23.8 percent under a threshold of 0.4) and in Ruvuma to 49.8 percent (from 52.5 percent). With a threshold of 0.6 the number of hard core poor go down to 19 percent in Kilimanjaro and 47 percent in Ruvuma. Hence irrespective of the threshold level hard core vulnerability and poverty is significant overall and much more so in the poorer region of Ruvuma.

4.5 Conclusions and policy implications

We applied a methodology that integrates a major source of covariate shocks, with established techniques for estimating idiosyncratic shocks to estimate vulnerability of rural households in two regions of Tanzania. Both of these regions are subject to significant covariate risks, and rural households are exposed to them. The major covariate risk relates to weather induced production variations as well as price variations that give rise to agricultural income variations. Such risks make households vulnerable, and force households to adopt ex-ante risk exposure strategies (such as income and crop diversification) and consumption smoothing strategies. It is interesting to inquire whether in spite of these strategies households are still vulnerable to both covariate as well as idiosyncratic risks.

The results of this paper revealed that vulnerability is quite high in the rural regions of Tanzania, and considerably higher in the region which is regarded as generally poorer, namely Ruvuma. Of considerable interest is the finding that the proportion of the consumption variability that is due to covariate shocks is much smaller in the Kilimanjaro region, compared to the poorer Ruvuma region, where it comprises the bulk of consumption variability. Vulnerability appears to differ considerably among different regions in Kilimanjaro as well as in Ruvuma, but the differences are much higher in Kilimanjaro, despite the fact that this is a generally better off region. Vulnerability also is much more a function of overall income status in Kilimanjaro, with the richer rural households exhibiting much lower vulnerability than the poor ones, something that does not occur in Ruvuma, where all income deciles exhibit considerable degrees of vulnerability. Among different types of rural households those that are cashew nut producers appear to be much more vulnerable, compared to coffee and tobacco producing households. Finally it was shown that the likely persistence of poverty from period to period is much lower in Kilimanjaro compared to Ruvuma. The levels of hard core poverty, defined as those among the poor who are likely to stay poor are considerable in both regions, and more than half of all poor households in both regions are likely to remain poor in a subsequent period. Finally it was revealed that the levels of vulnerability are high even among the non-poor especially in the poorer overall region, Ruvuma.

The policy implications of the chapter is that policies to deal with vulnerabilities, such as appropriate safety nets, while more appropriate in the poorer regions, are needed n all regions. It also appears that there is a degree of hard core poverty that may need special attention with policies to tackle the long term causes of that poverty. Given that vulnerability is more district specific in Kilimanjaro than in Ruvuma, it also appears to be the case that targeted social safety nets are a more appropriate policy in Kilimanjaro, while in Ruvuma it would be best to implement non-targeted overall safety net policies.

Table 4.1a: Descriptive statistics of the time series data of prices and production

	Kilimanjaro			Ruvuma		
	Av. Price	StDev	CV*	Av. Price	StDev	CV*
	Tsh/kg			Tsh/kg		
Maize	186.6	101.1	0.54	140.7	72.4	0.51
Beans	577.2	201.7	0.35	581	175.1	0.30
Coffee	1364.1	432.4	0.32	1364.1	432.4	0.32
Bananas	81.6	67.8	0.83	82.8	50.7	0.61
Millet	689	300.2	0.44	380.5	238.1	0.63
Rice	663.7	344.6	0.52	643.1	214.9	0.33
Cassava	280.5	118.5	0.42	262.2	139.9	0.53
Sweet potatoes	284.1	123.2	0.43	294.8	223.3	0.76
Irish potatoes	390.5	101.8	0.26	379.8	100.9	0.27
Groundnuts	1031.4	395.6	0.38	825.4	307.8	0.37
Onions	670.6	342.6	0.51	878.1	425.3	0.48
Tomatoes	516.9	215.4	0.42	477.2	183.9	0.39
Cowpeas	692.5	254.5	0.37	518	231.8	0.45
Cabbages	373.4	184.2	0.49	529.4	418.9	0.79
Oranges	55	29.8	0.54	102.9	83.2	0.81

* CV=coefficient of variation

Prices are deflated using the monthly Tanzanian CPI from the IMF statistics database (edition May 2004). Prices are monthly starting from January 1983 to October 2002 and deflated using the monthly Tanzanian CPI from the IMF statistics database (edition May 2004). Production data are yearly (from 1961 to 2004).

Source: Computed by authors.

Table 4.1b: Descriptive statistics of the time series data of regional yields

	Kilimanjaro			Ruvuma		
	Av. yield	StDev	CV	Av. yield	StDev	CV
	Kg/ha			Kg/ha		
Maize	1230.5	538.7	0.44	1732.2	248.3	0.14
Sorghum	829.6	207.9	0.25	1311.5	370.9	0.28
Millet	1498.3	1200.6	0.80	1126.1	167.1	0.15
Rice	3086.8	868.6	0.28	1472.3	505.6	0.34
Sweet potatoes	2500	624.5	0.25	1632.1	550.5	0.34
Pulses	681.7	257.2	0.38	795.7	147.7	0.19
Banana	2614.8	447.7	0.17	2669.9	405	0.15
Cassava	2404	372	0.15	2449.2	315.8	0.13
Coffee*	8535	4692.7	0.55	7618.3	1847.3	0.24
Wheat	795.1	234.1	0.29			
Cashew*				6005.2	2117.3	0.35

Regional yields come from yearly data (from 1992 to 2001).
* For coffee and cashew nuts regional production (in tonnes) is reported and used for the estimations (there was no available data on area planted).

Source: Computed by authors.

Table 4.2: Coefficient of crop income variation by deciles of gross income per adult equivalent

	Kilimanjaro				Ruvuma			
	Mean gross income per ae[1)] (Tsh000)	Mean crop income per ae (Tsh000)	Share of crop in total gross income (%)	Coefficient of variation of crop income	Mean gross income per ae (Tsh000)	Mean crop income per ae (Tsh000)	Share of crop in total gross income (%)	Coefficient of variation of crop income
1	16.7	11.6	69.5	46.5	21.4	17.3	80.8	34.1
2	38.5	20.1	52.2	47.6	37.2	28.1	75.5	34.5
3	57.2	28.2	49.3	45.5	50.5	34.5	68.3	37.2
4	77.1	36.9	47.9	40.7	64.0	44.1	68.9	35.4
5	100.8	49.5	49.1	42.5	79.3	51.2	64.6	34.9
6	125.2	50.8	40.6	46.1	99.0	62.6	63.2	35.1
7	159.7	61.9	38.8	41.3	124.0	80.0	64.5	34.7
8	213.6	81.7	38.2	44.7	159.1	94.9	59.6	33.9
9	315.9	115.3	36.5	46.2	223.9	134.4	60.0	33.6
10	821.3	288.3	35.1	44.4	553.0	182.4	33.0	36.8
Total	193.9	74.9	38.6	44.6	144.7	74.4	51.4	35.0

1) adult equivalent

Source: Computed by authors.

Table 4.3: Determinants of the average consumption per adult equivalent and its variance

	Kilimanjaro		Ruvuma	
	(1)	(2)	(3)	(4)
	Log annual per adult equivalent consumption	Log consumption variance	Log annual per adult equivalent consumption	Log consumption variance
Log value crop inc. per acre	0.14443		0.41144	
	(2.21)**		(3.06)***	
Log acres of land cultivated lagged	0.13711	-0.25275	0.36323	-0.26494
	(3.92)***	(1.21)	(6.31)***	(1.31)
Dependency ratio	-0.08519	-0.70718	-0.07999	0.28385
	(1.35)	(1.74)*	(1.05)	(0.68)
Log age of head	-0.04894	0.18761	-0.14860	0.00345
	(0.82)	(0.49)	(2.47)**	(0.01)
Log adult equivalent hh size	-0.86148	-0.09611	-0.85613	0.09447
	(19.61)***	(0.34)	(17.49)***	(0.33)
Log years education of head	0.00196	-0.13200	0.06867	-0.08856
	(0.07)	(0.76)	(2.34)**	(0.53)
Female-headed household	-0.02663	0.14370	0.00022	0.40578
	(0.57)	(0.48)	(0.00)	(0.85)
Log value of dwelling	0.00969	0.18665	0.00727	-0.01985
	(0.77)	(2.40)**	(0.60)	(0.27)
Log value of cons durables lagged	0.11881	-0.05711	0.09874	-0.01592
	(7.32)***	(0.61)	(4.38)***	(0.18)
Log number of big animals lagged	0.07959	-0.17580	0.05390	0.02082
	(3.59)***	(1.27)	(1.41)	(0.10)
Log number of small animals lagged	0.02862	0.21793	0.00319	0.08215
	(2.33)**	(2.80)***	(0.19)	(1.02)
Receiving remittances dummy	0.00562	0.02860	0.16508	-0.46429
	(0.16)	(0.12)	(3.80)***	(1.84)*
Dummy: 1=belong to sacco	0.09136	-0.12462	0.12071	-0.16286
	(1.95)*	(0.40)	(2.30)**	(0.53)
Access to seasonal credit	0.12337	0.29923	0.00297	0.65226
	(2.92)***	(1.15)	(0.07)	(2.59)***
Dummy if any adult female completed primary educ	0.11978	-0.05131	0.04752	0.08461
	(3.22)***	(0.22)	(0.36)	(0.10)
Dummy: 1=death shock since 1998	0.01524		0.05713	
	(0.47)		(1.41)	
Dummy: 1=illness shock since 1998	-0.00173		0.08692	
	(0.05)		(2.19)**	
At least one member in social group	0.00764	-0.33677	-0.04218	0.08647
	(0.26)	(1.84)*	(1.22)	(0.43)
Dummy coffee production	-0.02160	0.21446	-0.13944	-0.29042
	(0.49)	(0.77)	(1.43)	(0.56)
Dummy cashew production			0.01911	0.27484
			(0.24)	(0.57)
Dummy tobacco production			-0.36206	0.06503
			(3.28)***	(0.09)
Constant	5.39559	-4.88696	4.24651	-2.68939
	(14.97)***	(2.78)***	(7.30)***	(1.62)
Observations	957	957	892	892
R-squared	0.47	0.08	0.51	0.07

Absolute value of t statistics in parentheses * significant at 5%; ** significant at 1%

Tests of endogeneity for log crop inc per acre

	Kilimanjaro	Ruvuma
Durbin-Wu-Hausman		
Chi-sq(1)	3.88652	3.91466
P-Value	0.04868	0.04787

Source: Computed by authors.

Table 4.4: First stage regressions for crop income per acre and cultivated land

	(1)	(2)
	Log value crop inc. per acre	Log value crop inc. per acre
Log acres of land cultivated lagged	-0.26591	-0.35678
	(3.37)***	(7.44)***
Dependency ratio	0.15848	0.21066
	(1.04)	(2.10)**
Log age of head	-0.02291	-0.12032
	(0.16)	(1.44)
Log adult equivalent hh size	0.09325	0.06214
	(0.87)	(0.88)
Log years education of head	0.06997	0.04250
	(1.03)	(1.02)
Female-headed household	-0.12916	0.07120
	(1.14)	(0.64)
Log value of dwelling	0.04644	0.01535
	(1.57)	(0.90)
Log value of cons durables lag	0.10459	0.11457
	(3.00)***	(5.43)***
Log nb big animals lag	-0.01171	0.11993
	(0.21)	(2.38)**
Log nb small animals lag	-0.02862	0.08132
	(0.95)	(4.33)***
Receiving remittances dummy	0.04604	-0.00604
	(0.53)	(0.10)
Dummy: 1=belong to sacco	0.07712	0.08730
	(0.67)	(1.19)
Access to seasonal credit	0.05176	0.04564
	(0.50)	(0.77)
Dummy if any adult female completed primary educ.	0.11867	-0.10640
	(1.34)	(0.56)
Dummy: 1=death shock since 1998	0.00011	-0.00905
	(0.00)	(0.15)
Dummy: 1=illness shock since 1998	0.06776	-0.07531
	(0.81)	(1.36)
At least one member in social group	0.00690	0.00703
	(0.10)	(0.14)
Proportion of irrigated land	0.05290	0.15840
	(0.47)	(1.13)
Dummy rain on parcel is below normal	-0.30395	-0.02149
	(3.90)***	(0.42)
Dummy rain on parcel is much below normal	-0.43679	-0.16799
	(4.39)***	(1.37)
Proportion of good or medium quality land	0.38902	0.25223
	(2.44)**	(3.06)***
Proportion of flat or gently sloped land	-0.04653	0.09556
	(0.49)	(1.76)*
Proportion of land with any improvements	0.15751	0.03526
	(1.80)*	(0.72)
Dummy for lagged chemical fertilizer	0.21457	0.06612
	(2.27)**	(1.23)
Dummy for lagged other chemicals	0.08355	0.08005
	(1.02)	(1.47)
Log no of coffee trees per acre lagged	0.02455	0.00410
	(0.86)	(0.14)
Dummy coffee production	0.00936	0.27139
	(0.06)	(1.50)
Dummy cashew production		-0.08226
		(0.62)
Dummy tobacco production		0.31106
		(2.12)**
Log no of cashew trees per acre lagged		0.07075
		(2.08)**
Constant	3.51831	3.46714
	(5.07)***	(8.44)***

Table 4.4 (continued) First stage regressions for crop income per acre

	(1)	(2)
	Log value crop inc. per acre	Log value crop inc. per acre
Observations	957	892
R-squared	0.28	0.40

Robust t statistics in parentheses * significant at 5%; ** significant at 1%
Source: Computed by authors.

Tests for the validity of instruments for log crop inc per acre			
Kilimanjaro		**Ruvuma**	
Tests of over-identifying restrictions		Tests of over-identifying restrictions	
Sargan Chi-sq(8)	11.755	Sargan Chi-sq(9)	9.036
P-Value	0.1625	P-Value	0.4339

Source: Computed by authors.

Table 4.5: Vulnerability by district in Kilimanjaro

District	Vulnerability index	Proportion of consumption variance due to covariate factors	Per capita total expenditure	Per capita total gross income	Poverty incidence in 2003 (headcount)	Poverty incidence in 2004 (headcount)
Rombo	0.45	0.12	190.3	127.3	0.56	0.59
Mwanga	0.40	0.07	217.3	156.0	0.43	0.45
Same	0.55	0.06	169.2	154.7	0.61	0.55
Moshi rural	0.22	0.13	249.3	176.5	0.32	0.36
Hai	0.16	0.12	259.4	177.7	0.24	0.23
Total	0.31	0.11	227.9	162.6	0.40	0.41

Source: Computed by authors

Table 4.6: Vulnerability by district in Ruvuma

District	Vulnerabilit y index	Proportion of consumption variance due to covariate factors	Per capita total expenditure	Per capita total gross income	Poverty incidence in 2003 (headcount)	Poverty incidence in 2004 (headcount)
Songea rural	0.55	0.32	183.5	152.8	0.58	0.58
Tunduru	0.77	0.18	128.2	88.2	0.77	0.77
Mbinga	0.51	0.36	193.1	127.3	0.56	0.56
Namtumbo	0.64	0.27	152.6	100.3	0.70	0.66
Total	0.60	0.30	170.0	118.4	0.63	0.63

Source: Computed by authors

Table 4.7: Vulnerability by economic status in Kilimanjaro

	Number of hhlds	Mean vulnerability	Proportion of consumption variance due to covariate factors	Per capita total expenditure	Per capita total gross income
ALL	191,585	0.31	0.11	227.9	162.6
Non-poor	115,903	0.15	0.12	298.5	212.4
Poor	75,682	0.55	0.11	119.9	86.4
Coffee producers	117,299	0.31	0.13	224.6	158.7
Non-coffee producers	74,287	0.29	0.09	233.2	168.7
Net Food Sellers	30,570	0.13	0.12	272.8	383.5
Net Food Buyers	161,015	0.34	0.11	219.4	120.6

Source: Computed by authors

Table 4.8: Vulnerability by economic status in Ruvuma

	Number of hhs	Mean vulnerability	Proportion of consumption variance due to covariate factors	Per capita total expenditure	Per capita total gross income
ALL	173,932	0.60	0.30	170.0	118.4
Non-poor	63,801	0.34	0.33	282.2	201.6
Poor	110,131	0.75	0.28	105.4	70.2
Coffee producers	57,213	0.50	0.37	199.1	130.1
Cashew nuts producers	44,057	0.74	0.18	132.0	92.2
Tobacco producers	7,091	0.69	0.14	137.9	127.4
Non cash crop producers	66,847	0.58	0.33	172.3	124.3
Net Food Sellers	59,047	0.57	0.30	148.9	119.9
Net Food Buyers	114,885	0.62	0.30	180.9	117.6

Source: Computed by authors

Table 4.9: Vulnerability to poverty of different types of households under a probability threshold of 0.4

	Kilimanjaro		Ruvuma	
	Vulnerability <0.4	Vulnerability >0.4	Vulnerability <0.4	Vulnerability >0.4
Initial household classification				
Non-poor	100,822	15,081	39,224	24,577
Percent of non-poor	87.0	13.0	61.5	38.5
Percent of total	52.6	7.9	22.6	14.1
Poor	30,021	45,661	18,834	91,297
Percent of poor	39.7	60.3	17.1	82.9
Percent of total	15.7	23.8	10.8	52.5
All households	130,843	60,743	58,058	115,874
% of total	68.3	31.7	33.4	66.6
Total number of households	**191,585**		**173,932**	

Source: Computed by authors.

References

Alwang, J., Siegel, P.B. & Jorgensen, S. 2001. *Vulnerability: a view from different disciplines.* Social Protection Unit, Human Development Network, World Bank 2001.

Cafiero, C. & Vakis, R. 2006. *Risk and vulnerability considerations in poverty analysis: Recent advances and future directions*. World Bank, SP Discussion paper, No. 0610.

Carter, M. 1997. Environment, technology and the social articulation of risks in West Africa agriculture. *Economic Development and Cultural Change*: 45 (3).

Chaudhuri, S., Jalan, J. & Suryahadi, A. 2002. *Assessing household vulnerability to poverty from cross-sectional data: A methodology and estimates from Indonesia*. Dept. of Economics, Columbia University, Discussion paper, No. 0102-52.

Christiaensen, L., & Subbarao, K. 2005. Toward an understanding of household vulnerability in rural Kenya. *Journal of African Economies*, 14-4: pp. 520-558.

Christiaensen, L. & Boisvert, R.N. 2000. *On measuring households food vulnerability: Case evidence from northern Mali.* Cornell University. Department of Agricultural and Managerial Economics, Working Paper, No. WP 2000–05.

Dercon, S. 1996. Risks, crop choice and savings: Evidence from Tanzania*. Economic Development and Cultural Change* 44(3): 485-513.

Dercon, S. 2005. *Risk, insurance and poverty: A review*. in Dercon, S. (ed.) 2005. Insurance against Poverty, Helsinki: Oxford University Press and World Institute of Development Economics Research, United Nations University.

Foster, J., Greer, J. & Thorbecke, E. 1984. A class of decomposable poverty measures. *Econometrica*, 52(3), 761-766.

Griffin, J.P. 1986. *Well-being: Its Meaning, Measurement and Moral Importance*. Oxford: Clarendon Press.

Heitzmann, K., Canagarajah, R.S. & Siegel, P.B. 2002. *Guidelines for assessing the sources of risks and vulnerability.* Social Protection Discussion Paper No. 0218, The World Bank, Washington.

Hoddinott, J. & Quisumbing, A. 2003. *Methods for micro-econometric risk and vulnerability assessments: A review with empirical examples.* World Bank Policy Research Working Paper No. 0324.

Hoffmann, V., Karfakis, P. & Christiaensen, L. 2007. *Assets livelihoods and poverty*, Chapter 2 this technical paper .

Holzmann, R. & J∅rgensen, S. 2000., *Social risk management, a new conceptual framework for social protection and beyond.* Social Protection Discussion Paper Series No. 0006. Social Protection Unit, Human Development Network. The World Bank, Washington.

Hoogeveen, J., Tesliuc, E., Vakis, R. & Dercon, S. 2004. *A guide to the analysis of risk, vulnerability and vulnerable groups.* World Bank Policy Research Working Paper.

Kamanou, G. & Morduch, J. 2002. *Measuring vulnerability to poverty.* New York University. Wagner Working Paper No. WP1012.

Kanbur, R. 1987. *The standard of living: Uncertainty, inequality and opportunity. In* G. Hawtorn, (editor). The Standard of Living. New York, Cambridge University Press.

Kurosaki, T. 2006. *Vulnerability and poverty: Concept, measurement, and implications for poverty reduction policies in Asia*, paper presented at the ASAE 2005 Conference on "Community Development and Poverty Alleviation,", Zahedan, Iran, August 2005.

Larson D. & Plessman, F. 2002. *Do farmers choose to be inefficient? Evidence from Bicol Philippines*, Policy Research Working Paper No. 2787, The World Bank, Washington D.C.

Ligon, E. & Schechter, L. 2003. Measuring Vulnerability, *Economic Journal*, Vol. 113, No 486, C95-C102.

Lindgren, B.W. 1998. *Statistical Theory*. Fourth Edition, Chapman & Hall/CRC.

Morduch, J. 2002. *Consumption smoothing across space: Testing theories of risk sharing in the ICRISAT study region of South India.* WIDER discussion paper 2002/55/United Nations University. World Institute for Development Economics Research, Helsinki.

Pritchett, L., Suryahadi, A. & Sumarto, S. 2000. *Quantifying vulnerability to poverty: A proposed measure, applied to Indonesia*. Policy Research Working Paper No.2437. Washington, D.C.: World Bank.

Rapsomanikis, G. & Sarris, A. 2007. *The impact of domestic and international commodity price volatility on agricultural income instability in Ghana, Vietnam and Peru*, *In* B. Guha-Khasnobis, S.S. Acharya and B. Davis (editors) Food Security Indicators, Measurement and the Impact of Trade Openess. Oxford University Press..

Sango, D., Hoffmann, V. & Christiaensen, L. 2007. *Risk and Coping*, Chapter 3 this technical paper.

Sarris, A. 2002. *The demand for commodity insurance by developing country agricultural producers: Theory and an application to cocoa in Ghana*, World Bank, Policy Research Working Paper No. 2887.

Sarris, A., Karfakis, P. & Christiaensen, L. 2007. *The stated benefits from commodity price and weather insurance,* Chapter 6 this technical paper.

United Republic of Tanzania. 2004: *Vulnerability and resilience to poverty in Tanzania: Causes, consequences and policy implications. 2002/2003, Participatory Poverty Assessment (TzPPA): Main Report*, Mkuki na Nyota Publishers Limited, Dar-es-Salaam,Tanzania.

United Republic of Tanzania: National Bureau of Statistics. 2002. *Household Budget Survey 2000/01*, Dar-es-Salaam, Tanzania.

World Bank. 2001: *World Development Report 2000/2001*, Attacking Poverty, The International Bank for Reconstruction and Development, Oxford University Press, New York.

5. The Effects of Shocks on Welfare and Poverty

by Luc Christiaensen, Vivian Hoffmann and Alexander Sarris

5.1 Introduction

Commodity price declines, droughts and health shocks have been identified by agricultural households in Tanzania as their major risk factors both in terms of the frequency of their occurrence as well as the severity of their effects. While we also find that households actively mitigate the effect of these shocks *ex post* through self insurance and reliance on informal assistance, the net effects of these shocks for rural households' welfare and poverty in Tanzania remain unclear.

This chapter examines the immediate effects of commodity price declines, droughts and health shocks on household welfare in the context of rural Kilimanjaro and Ruvuma while accounting for households' coping capacity and differential effects across livelihoods. Three broad questions are addressed. First, the chapter explores the welfare effect of the health and drought shocks and reflects on the welfare effects of the more systemic commodity price shocks. Second, the chapter examines the effectiveness of different *ex post* coping and ex ante risk reducing strategies in mitigating the negative welfare effects associated with these risks. It will focus in particular on self and informal insurance schemes and irrigation respectively. Finally, the determinants of people's coping capacity are investigated.

The chapter proceeds by outlining the empirical methodology in Section 5.2. The empirical results regarding the effects of the different shocks on household welfare and poverty are presented in Section 5.3, including the correlates of households' coping capacity. Section 5.4 concludes.

5.2 Empirical methodology

Economic theory holds that, households prefer smooth to volatile consumption. Given access to well functioning credit or insurance markets, these preferences will generate stable consumption paths, even when shocks occur. If credit and insurance markets are imperfect, household consumption may be susceptible to shocks (Deaton, 1992; Besley, 1995). These theoretical insights provide a practical framework to empirically explore whether and to what extent shocks and households' coping capacity affect their consumption levels.

More formally, suppose households at time t maximize inter-temporal expected utility U_t. Let u (c_t) be instantaneous utility derived from consumption c_t (≥0) and u'(.)>0, u''(.)<0 such that:

$$U_t = E_t \sum_{\tau=t}^{T} (1+\delta)^{t-\tau} u(c_\tau) \tag{5.1}$$

with δ the rate of time preference and T the end of the life-cycle. Households face risky income yt and income can be used to obtain consumption at prices p_t. Define *r* as the rate of returns to savings between periods and A_{t+1} as the value of assets at the beginning of period *t+1*. Assets evolve from one period to the next according to:

$$A_{t+1} = (1+r)(A_t + y_t - p_t c_t) \tag{5.2}$$

Solving (5.1) and (5.2) using the envelope condition and assuming that households have full access to credit and/or (formal or informal) insurance yields:

$$\frac{u'(c_t)}{p_t} = \frac{(1+r)}{(1+\delta)} E_t \left[\frac{u'(c_{t+1})}{p_{t+1}} \right] \tag{5.3}$$

Discounted marginal utilities suitably corrected for relative price change will be equated. In the absence of uncertainty, with r equal to δ and prices constant over time, the optimal consumption path implies equal consumption over time. In the tradition of Hall (1978) and Morduch (1990) we assume constant relative risk aversion with instantaneous marginal utility defined at t as $c_t^{-\rho} e^{\theta_t}$ with ρ the coefficient of relative risk aversion and θt a general taste shifter to parametrize (5.3) and obtain an empirical specification. Taking logs, and introducing subscript i and j to denote households i in location j, (5.3) can be written as:

$$\ln \frac{c_{ijt+1}}{c_{ijt}} = \frac{1}{\rho} \left(\ln(1+r) - \ln(1+\delta) + \ln \frac{p_t}{p_{t+1}} + (\theta_{ijt+1} - \theta_{ijt}) \right) + e_{ijt+1} \tag{5.4}$$

with eijt+1 the expectation error which has mean zero and is orthogonal to all variables known at time t given rational expectations. According to equation (4) the path of consumption over time is only affected by taste shifters and price changes, as long as there are no binding liquidity constraints over time and provided the underlying factors determining wealth (or permanent income) are not changing. In other words, under the hypothesis of perfect consumption smoothing, the optimal consumption path is not affected by idiosyncratic and/or covariate (income) shocks S_{ijt+1} and introduction of these shocks overidentifies equation (5.4). This provides an empirical framework to explore the effects of shocks on welfare. We further allow differential ability across households to cope with shocks *ex post*, leading to the following linear empirical specification:

$$\ln \frac{c_{ijt+1}}{c_{jit}} = \alpha_0 + \alpha_1 Z_{ijt} + \alpha_2 S_{ijt+1} \otimes M_{ijt} + e_{ijt+1}` \tag{5.5}$$

with Z_{ijt} comprising price changes and taste shifters (such as changes in household composition) and Mijt a vector of variables such as initial wealth, social capital, access to credit, availability of safety net programmes, capturing the household's capacity to mitigate the effect of income shocks *ex post*. Differential ability to cope with shocks *ex post* is likely to condition the effect of income shocks on consumption.

Alternatively, assume X_{ijt} the comprehensive set of observable (and exogenous) household and location characteristics affecting preferences, permanent income and coping capacity (after shocks S_{ijt} have materialized)[1], such that $c_{ijt} = c(X_{ijt}, v_{ij}, \omega_j)$ with vij and ωj reflecting unobserved (time invariant) household and location heterogeneity respectively. Equation (5.5) can then also be written and estimated as:

[1] These include but are not limited to Z_{ijt} and $M_{ijt.}$

$$\ln c_{ijt+1} = \beta_0 + \beta_1 X_{ijt} + \beta_2 S_{ijt+1} \otimes X_{ijt} + v_{ij} + \omega_j + \varepsilon_{ijt+1} \qquad (5.6)$$

When panel data are available, equation (5.5) could be estimated (either as a difference or a fixed effects model) and unobserved household (and location) heterogeneity would be explicitly controlled for. Yet in practice, panel data are often not available, and when available, they tend to focus on a limited set of livelihoods/populations and usually span relatively short time periods. This poses a particular challenge when studying the effect of slow onset, systemic shocks such as broad economic crises or a decline in commodity prices. The period covered by the panel may be too short to fully encompass the period of the shock (e.g. precipitous commodity price decline) and the shock may affect all households in the sample leaving the researcher in effect without a control group. Estimates of the welfare effect of an economy wide shock based on welfare before and after the shock will be biased, if there are secular trends.

Furthermore, the availability of repeated observations on a household's consumption and income does not eliminate the need for explicit information on shocks to estimate the welfare effects of shocks. While changes in consumption are sometimes regressed on changes in income (Harrower and Hoddinott, 2005), attenuation bias due to oft observed measurement error in the latter, would lead us to underestimate the effect of an income shock. At the same time, imputation errors in valuing consumption from own food production in constructing the consumption and income variables may lead to a spurious positive correlation between total household consumption and income, biasing the income coefficient upwards (Deaton, 1997). Direct information on shocks usually provides the necessary instruments to address this problem. It also enables inference on the effect of shocks on income and consumption.

In the absence of panel data, but given cross sectional data on household consumption (C_{ijt+1}), explicit information on shocks experienced during t+1 (S_{ijt+1}) and comprehensive recall data on households' assets and their coping capacity (X_{ijt}) the differential effect of different shocks across households could be explored through estimation of equation (5.6), in effect using a retrospective panel approach and assuming $E(X_{ijt}v_{ij}) = E(S_{ijt}+_1v_{ij})=0$. In practice, an exhaustive description of the household characteristics (X_{ijt}) helps reduce the likelihood of potential bias due to unobserved household heterogeneity. Furthermore, potential endogeneity issues related to the shock variables can be avoided through the use of external shock information as opposed to self reported measures of shocks from the household questionnaire. The use of village fixed effects controls for bias due to correlation of X and S with unobserved village effects. Yet as this may cause an underestimate of the full effect of covariate shocks, it is useful to also explore models with an explicit comprehensive description of the location/village characteristics when available.

Given that slow onset commodity price shocks such as the systemic coffee and cashew price shocks only directly affect producers of these crops, the effect of these shocks could in principle be explored when the sample includes a sufficiently large control group of non-coffee or cashew crop growers with similar characteristics. The shock variable (Sijt) in this case becomes being a coffee (cashew) crop grower at t or not. Yet, caution is warranted in interpreting the empirical results. First, it is implicitly assumed that cash and non-cash crop growers are ceteris paribus equivalent (i.e. $E(S_{ijt}+_1\cdot v_{ij})=0$) such that the effect of being a cash crop grower only captures the effect of the systemic price shock. Second, if the overall economic activity in the region declines as a result of the price decline, the approach is likely to underestimate the direct negative effect as non-coffee growers are likely to have suffered as well, albeit indirectly. Bearing these caveats in mind and using a comprehensive specification to minimize potential bias due to unobserved differences between cash crop and non-cash crop growers, the proposed approach also sheds light on the effect of the cash crop price decline in Kilimanjaro and Ruvuma.

5.3 Data considerations

We take (the logarithm of) total household expenditures per adult equivalent excluding expenditures on health, education and functions (baptism, funerals) from the first survey round as our measure of welfare.[1] To capture differences in household preferences, their permanent income potential and their coping capacity we include age of the household head (a life cycle proxy), the dependency ratio, gender of headship and the years of formal education achieved by the household head (allowing for differential effects across primary, secondary and post secondary education). As cultivation of certain cash crops may be traditionally dominated by certain ethnicities (see below), we also control for the ethnic origins of the household head. This also helps control for people's social capital and thus their capacity to cope with shocks *ex post*. For example, the Chagga, which make up 74 percent of the total rural population in Kilimanjaro, are known to be highly mobile and well connected in Tanzania.

To proxy households' productive capacity and thus also their permanent income potential, we include the size of their landholdings owned, the numbers of their large (cattle, oxen, horses) and small (goat, sheep, pigs) livestock owned, and the value of their agricultural equipment and vehicles (all normalized by the number of adult equivalents) as well as their squared terms to capture non-linearities in their effects on consumption. A self reported measure of ease in obtaining seasonal credit for inputs is included to proxy access to production (as opposed to consumption) credit.

The effect of the fall in coffee prices is explored through inclusion of the number of coffee trees owned by the household in 2000 when the coffee price decline set in. Where the data allow it, we correspondingly also lag our asset variables to 2000 to be consistent. We furthermore divide the coffee growers in our sample in five quintiles based on their number of coffee trees in 2000 to allow for differential effects among smaller and larger coffee farmers. The omitted category is the non-coffee growers, which makes up about one third of the total sample in Kilimanjaro. A similar approach is followed in Ruvuma, though we also include quintile categories for cashew growers based on their number of cashew trees and a category for tobacco growers.[2] As our data in Ruvuma allowed us only go to two years back these were based on tree ownership in early 2002.[3]

Tables 5.1, 5.2 and 5.3 review differences among coffee growers in the different quintiles and non-coffee growers in Kilimanjaro and Ruvuma along a series of (observed) characteristics.

[1] See Appendix 3 for a detailed description of the construction of the expenditure variable. Comparison of health expenditures among households with and without an illness shock shows that households who experienced a health shock have on average two to three times more health expenses. However, we don't find that expenditures on functions are systematically larger among households who experienced a death over the past two years. Since we can't distinguish between health expenditures for preventive reasons, which may be an expression of larger household welfare, and health expenditures for curative reasons or between expenditures on functions for funerals and baptisms, we opt to exclude all expenditures on health and functions to avoid a downward bias in the estimated coefficient of the welfare effects of health shocks.

[2] Given that only 4 percent of the households in our Ruvuma sample were tobacco growers, we did not disaggregate the group of tobacco growers further.

[3] The first survey rounds for Kilimanjaro and Ruvuma were conducted in the fall of 2003 and the spring of 2004 respectively.

Consistent with the agro-ecological requirements of coffee production coffee growing households in Kilimanjaro live at higher altitudes. They are also more likely to be Chagga than Pare in Kilimanjaro and almost exclusively Matengo in Ruvuma, confirming the importance of controlling for ethnicity when exploring the effect of coffee price shocks through a retrospective panel approach. Cashew production is largely confined to the Yao. There is a large difference in the amount of coffee trees owned across the different quintiles with the amount of trees estimated at about 40 in the lowest quintile and more than doubling from quintile to quintile to about 1,325 trees in the highest quintile in Kilimanjaro. In Ruvuma, coffee growing households have on average three times as many trees than in Kilimanjaro with those in the highest quintile owning on average 5 times as many trees as those in the lowest quintile.

Coffee growers in the lowest quintile in Kilimanjaro tend to own less land, livestock and consumer durables compared with non-coffee growers while coffee growers in the largest quintile tend to have more land, have more valuable housing and receive more remittances compared with non-coffee growers. Further exploration does not show much difference across coffee and non-coffee growers in the likelihood of using one's savings or receiving aid from others when experiencing a shock (see Table 3.11). Coffee growers in higher quintiles in Ruvuma tend to own more livestock and have more valuable compounds. The larger cashew growers tend to have much more land, though they do not appear richer along other dimensions compared with other households in Ruvuma. They are however more likely to use savings when faced with shocks.

Households' coping capacity is approximated both directly through the inclusion of a dummy that is equal to one when the household reported coping through saving or receipt of aid in case of a health and drought shock, and indirectly through the value of household consumer durables (per adult equivalent) in the year preceding the survey. We also control for the proportion of time in non-farming activities and the amount of remittances (per adult equivalent) received as further indirect determinants of households' coping capacity. The amount of acres irrigated (per adult equivalent) indicates exposure to drought shocks. Similarly, the proportion of time spent on non-farming activities also indirectly captures exposure to drought shocks.

To mitigate potential endogeneity problems arising from the self reporting of drought shocks we use an index of a household's qualitative assessment of the rainfall amount across its plots as opposed to the self-reported occurrence of a drought shock from the directly administered shock module in the questionnaire.[1] According to the former measure, 21 percent of all households in Kilimanjaro experienced rainfall much below normal on their plots in 2003 and 42 percent rainfall below normal. Drought shocks are much less frequent in Ruvuma with four percent of all households experiencing rainfall much below normal in 2003 and 34 percent rainfall somewhat below normal. To better capture actual exposure to the rainfall shock, the rainfall shock indicator is multiplied by the household's cultivated land area per adult equivalent.

Our health shock variable includes both the occurrence of a death and/or an illness shock in the two years preceding the survey. While death shocks are arguably not infected by self-reporting bias, illness shocks may be. The literature on the accuracy of self-reported health

[1] In particular, households were asked for each plot whether the rainfall was much below normal, below normal, normal, above normal, much above normal. A plot size weighted average of these rainfall assessments was calculated and rounded off to the nearest digit to obtain a qualitative assessment for each household.

shocks (Foster, 1994; Groot, 2000; Gertler and Gruber, 2002; Baker, Stabile and Deri, 2004) suggests that the likelihood of reporting a health shock is associated with a household's reference group (the poor tending to report fewer health problems), the intensity of the problem (the more severe the illness, the more likely it is it will be reported), and the need for justification (for example to rationalize absenteeism from work). While the two latter motivations are less of a concern in the current context, the former might bias our results. Inclusion of the comprehensive vector of households' assets and consumer durables described above capturing household wealth will however substantially mitigate the potential bias from self-reporting illness shocks. We also provide robustness tests using non-self village means of self-reported illness incidence as an instrument. Being a coffee or cashew crop grower is treated as exogenous to the household's current living standards.

While we use village dummies in our base models to control for unobserved heterogeneity across locations, we also present a model unbundling the village effects. This will allow us to further explore whether our shock variables underestimate the welfare effects of shocks when they cannot fully capture the covariant nature albeit at the expense of potentially introducing endogeneity related to unobserved village effects. We measure in particular how connected a village is, proxy the quality of its infrastructure through the availability of electricity at the village level, and use the altitude at which the village is located to help define its agro-ecological characteristics and thus also its agricultural potential. To capture the connectivity of the village we use information on the presence of a tarmac road in the village, the availability of a public phone and a cell phone signal, the regular organization of a market, and the availability of a bus service to the village.

5.4 Determinants of welfare and welfare effects of shocks

Given the divergent nature of the economies in Kilimanjaro and Ruvuma, we ran separate consumption regressions for both regions. The results are in Tables 5.4 and 5.5. The baseline model in column (1) includes the shock variables and controls for location effects through village dummies. Models incorporating interaction terms of coping strategies (aid, use of own savings, and remittances) with the different shocks are in column (2). The differential effects of the different health shocks (death and illness of an adult member) are explored in column (3). A model explicitly identifying the location effects through inclusion of village proxies of connectivity, access to electricity and agro-ecological conditions is presented in column (4). The different specifications fit the data very well and explain almost half the variation in the observed (log) expenditures (R-squared between 0.45 and 0.50).

The coefficients on the household characteristics and assets are highly significant and largely consistent with predictions from theory. Households with higher dependency ratios tend to be poorer and households with better educated heads enjoy higher consumption. However, the latter effect only holds when the heads have secondary education in Kilimanjaro and only when heads have primary education in Ruvuma, possibly reflecting the fact that Kilimanjaro finds itself further on the path of structural transformation than Ruvuma. Surprisingly, household heads with post secondary education appear disadvantaged in Kilimanjaro though not in Ruvuma, which may reflect the current lack of remunerative employment opportunities for the well educated in Kilimanjaro. Once a household's possession of assets and education are controlled for, female headed households tend to be better off, though the results are only weakly significant.

Households with more asset variables (landholdings, livestock ownership, total value of productive assets) tend to be richer. These effects were found to be highly statistically significant and the marginal returns were often observed to be declining as asset possessions increase. Households with easy access to credit for modern inputs were on average estimated to be about ten percent richer in Kilimanjaro underscoring the importance of access to capital and the use of modern inputs. Surprisingly, the opposite appears to hold in Ruvuma, where those with easy access to seasonal credit appear worse off.

Consumption is also positively associated with possession of consumer durables albeit at a declining marginal rate. Access to irrigation substantially enriches households with consumption in Kilimanjaro estimated to increase on average by 19 percent per acre per adult equivalent irrigated. While irrigation also positively affect consumption in Ruvuma, it is not found to be statistically significant. This is likely related to the limited use of irrigation in Ruvuma, consistent with its more reliable rainfall pattern, and thus the limited variability in the sample. Only 2.1 percent of all households in Ruvuma irrigate (some of) their land, while 21 percent do so in Kilimanjaro. Income from remittances positively contributes to consumption both in Kilimanjaro and Ruvuma, though the effect is (again) somewhat less precisely estimated in the latter sample. Also, households with a larger proportion of productive time spent in non-agricultural activities tend to be richer.

Farmers in Kilimanjaro who have faced a drought shock over the past year (ie, those who reported receiving much below normal rainfall on their plots) experienced a reduction of consumption of 10 percent per acre cultivated per adult equivalent. While the corresponding reduction in gross total agricultural revenue was estimated to be much more severe at about 50 percent per acre (Sarris, Savastano and Christiaensen, 2006), households in Kilimanjaro clearly cannot fully protect their consumption from drought shocks.

The availability of (cash) savings may help offset the effect of the drought shocks, though its effect is imprecisely estimated (column 2). While access to irrigation is associated with larger overall consumption levels, it does not mitigate the effect of severe rainfall shocks. As most irrigation in Kilimanjaro is gravitation irrigation and when rainfall failure is relatively widespread as in 2003, this does not come as a surprise. More generally, rivers are reported to dry up which reduces their effectiveness in acting as an insurance device. The result should thus be seen in the particular context of Kilimanjaro and not as a statement on the ex ante risk mitigation capacity of irrigation more generally. Our results further suggest that the reception of aid may exacerbate the effect of a drought shock. While it is quite plausible that aid received is not sufficient to offset the negative effect of covariate shocks, the estimated negative relationship seems counterintuitive. It may reflect the fact that those getting aid from neighbours and relatives even in times of a covariate shock are actually the very poorest. About one fifth of all households in Kilimanjaro experienced a drought shock in 2003 with double this number reporting suffering from drought in 2004.

In contrast, households who experienced on average somewhat below normal rainfall on their plots did not see their consumption decline. The 35 percent estimated average reduction in households' gross total agricultural revenues associated with somewhat below normal rainfall on their plots (Sarris, Savastano and Christiaensen, 2006) does not translate into a reduction in households' consumption levels. Households in Kilimanjaro appear able to cope with milder rainfall shocks.

Household consumption in Ruvuma appears not to be negatively affected by drought shocks. The effect of the drought shock may however be imprecisely estimated due to the small number of households who experienced a drought shock in 2003 (less than 4 percent of the sample). Somewhat surprisingly those who experienced somewhat below rainfall were even found to be slightly better off, though this result was only statistically significant at the 10 percent level.

The results in column (1) of Tables 5.4 and 5.5 would suggest that household welfare is unaffected by death and/or illness shocks experienced over the past two years. Yet, when we also control for the household's coping behavior through the self reported use of savings and/or receipt of aid when faced with an illness or death of an adult member (column (2)), health shocks are found to have a strong negative effect on consumption. In particular, households in Kilimanjaro who were unable to cope with the shocks suffered a 16 percent loss in consumption. It furthermore appears that households who used savings (often cash) to cope with health shocks managed to almost completely offset the negative effects associated with the shock. Receipt of aid from others appeared less effective. Finally, and somewhat surprisingly, health shocks appear not to affect household welfare in Ruvuma, even after controlling for households' use of coping strategies.

Further decomposition of the health shock into illness and death shocks to explore whether illness and death have differential effects (results in column 3), suggest that households suffer especially from illness shocks, and less so from the death of an adult member. This is in line with the findings from Kagera, in northwest Tanzania by Beegle (2005) who reports that wage employment of adult men declines substantially in response to a future female or male adult death, but that past deaths are not associated with changes in either wage employment or non-farm self-employment. Similarly, she finds that coffee farming is reduced in households with a death within 6 months, but not for deaths after 6 months.

Welfare loss from health shocks comes about through 1) increased medical expenditures and 2) foregone opportunities through a loss in labour supply (and thus earnings) and/or a decrease in the return to labour (Gertler and Gruber, 2002). While we do not have directly comparable information on the opportunity cost related to changes in labour supply and returns to labour in both regions, the survey did record expenses related to illness and death shocks on two separate occasions in the questionnaire. First, it asked the expenses (medical and others) the household incurred in case of an illness or death shock of one of its members. Second, health expenditures (and expenditures on functions) during the last 30 days were recorded separately as part of the expenditure module. In both cases, expenditures in case of illness and death shocks are substantially larger in Kilimanjaro than in Ruvuma which might suggest larger immediate welfare losses in Kilimanjaro than in Ruvuma, in line with the results of the regression analysis (Table 5.6).

Moreover, regular (preventive) health expenditures (i.e. health expenditures when there is no illness shock) in Ruvuma (see second part Table 5.6) are only about half those in Kilimanjaro (when expressed in per adult equivalence)[1]. This is consistent with the much lower reported use of health providers in case of illness/injury.[2] While this might be because illnesses/injuries are generally less severe in Ruvuma, the larger average distance to a dispensary or health centre in rural Ruvuma (4.5 km) compared with rural Kilimanjaro (2 km) would suggest that lower accessibility of health care partly underpins this difference in

---

[1] Health expenditures during previous 30 days per adult equivalent are not reported in Table 5, but available from authors upon request.

[2] While about the same proportion of households reported an illness/injury over the past 4 weeks in Kilimanjaro and Ruvuma (23 and 24 percent respectively) during the 2000/01 HBS, 74 percent of all households (includes both rural and urban) in Kilimanjaro consulted a health provider, compared with 47 percent of all households in Ruvuma (National Bureau of Statistics, 2002, Table C16).

health spending.[1] In addition, lower overall welfare levels in Ruvuma might also have led to lower spending on health care. In other words, the absence of a significant result on the health shock in Ruvuma should not be taken to mean that there is no welfare loss associated with illness and/or dealth shocks in Ruvuma.

The estimated welfare loss from the regression analysis is also consistent with those emerging from the related directly reported expenditures. First, our regression results indicated that the welfare loss is much more pronounced when there is an illness shock. This is largely consistent with the results from the bi-variate analysis in Table 5.7 which shows that consumption among households who experienced a death shock is sometimes even larger than among those without a death shock. Second, we estimated an average welfare loss of 16 percent associated with a health and in particular an illness shock in Kilimanjaro or an average reduction of Tsh 38,800 per adult equivalent given the estimated average consumption per adult equivalent of Tsh 242,500 in Kilimanjaro 2003. The directly reported health expenditures during the first survey round in Kilimanjaro in case of an illness are around Tsh 31,000. This does not only provide confidence in the reported estimates, but also suggests that the welfare loss is largely due to medical expenses and less due to labour supply effects and income loss. The latter is also consistent with the low marginal productivity of labour (and labour surplus) reported by Sarris, Savastano and Christiaensen (2006) in Kilimanjaro. Labour seems even more abundant in Ruvuma, and when combined with the limited medical expenditures, the absence of a welfare loss in Ruvuma does no longer come as a surprise.

Finally, the overall absence of welfare loss in case of the death of an adult member, despite expenditures equivalent to those in case of an illness shock suggests that 1) households don't appear to suffer major labour supply or income losses as mentioned above and especially that 2) households manage to insure themselves from such shocks both through their savings and reliance on traditional/informal insurance schemes such as group based funeral insurance as illustrated in Dercon, *et al*. (2006).[2]

Kilimanjaro coffee growers in the lowest quintile category of tree ownership are on average ceteris paribus about 20 percent poorer than rural households not growing coffee, while those in the richest quintile tend to enjoy higher consumption levels. Households in the intermediate quintiles do not appear to differ from non-coffee growers in their consumption levels, though the signs of the coefficients are all negative. As in the case of health shocks, when we include interactions with the amount of remittances received (one of the coping strategies)[3], the negative effects are exacerbated, though still not statistically significant for the intermediate quintiles, and coffee growers in the richest quintile are no longer statistically significantly richer.

Given our comprehensive controls for differences in wealth among households at the time of the onset of the coffee price shocks, these result would suggest that while most coffee growers have managed to cope with the coffee price decline, or at least did not see their

---

[1] National Bureau of Statistics, 2002, Table C17.

[2] The reported amount of contributions to (other) funerals, at an average of Tsh 10,400 per household per year, and ranging up to Tsh 500,000, also suggests substantial solidarity in bearing the funeral costs. Rutherford (2001) has documented the existence of insurance mechanisms for funerals across the developing world and highlights funeral insurance as one of the most popular products offered by more formalized micro-finance institutions.

[3] Unlike for the health and rainfall shocks, no data has been collected on the particular strategy coffee growers used to cope with the systemic coffee price shock (e.g. use of savings and/or aid).

consumption levels fall below those of the non-coffee growers, for example through the use of remittances and cash savings, the smallest among them experienced a substantial decline in their consumption. Given several years of high prices preceding the collapse in coffee prices starting in 2000, it is indeed plausible that coffee growers largely managed to smooth their consumption, albeit at the expense of their (cash) savings. In sum, while it cannot be excluded that coffee growers' welfare declined, most of them appear not worse off nowadays compared with non-coffee growers, apart from the smaller coffee growers who clearly suffered substantially.

Similarly, coffee growers in Ruvuma appear not worse off than non-cash crop growers and the larger ones actually enjoy substantially higher consumption levels despite the decline in coffee prices since 2000.[1] Again, given that we control extensively for asset holdings, though not for cash savings, this may reflect the availability of large amounts of cash savings held by the larger coffee growers following windfall earnings from coffee production during the late 1990s. This hypothesis is further supported by the fact that the likelihood of using (cash) savings in case of a drought or health shock is largely unassociated with a household's asset holdings as discussed in Section 3.3

While cashew growers also appear better off than non-cash crop growers, this picture reverses when we replace the village dummies (column 2) by village characteristics (column 4). This follows from the fact that cashew growers live concentrated in one district in Ruvuma and that virtually all households in our sample villages have at least some cashew trees. The overall lower consumption levels among cashew crop growers are thus captured through the village dummies. As there are no reasons to believe that the cashew crop growing villages systematically differ from the non cash crop growing villages beyond the village characteristics included in the analysis, the results in column four suggest that the smaller cashew growers are substantially worse off than the non cash crop growers. This is consistent with the observed collapse in cashew prices since the late 1990s and the fact that the smaller cashew growers are likely to hold less cash savings to help smooth their consumption compared with the larger cashew farmers.

Finally, the models with the village dummies unbundled are presented in columns 4 of Tables 5.4 and 5.5. Especially noteworthy is the fact that households in villages with a tarmac road are on average about 16 percent richer in Kilimanjaro and about 33 percent richer in Ruvuma. While these effects may partly reflect placement effects, the effects are sufficiently large to underscore the critical importance for overall household welfare of being connected through all weather roads. As indicated above, village dummies may also capture some of the covariant effect of shocks. This is borne out by the slight reinforcement of the shock effects observed in the Kilimanjaro estimations when replacing the village dummies with the village characteristics. Yet, for all practical purposes the observed changes are negligible.

5.5 Welfare effects of shocks and the effectiveness of coping strategies

To gauge the overall effects of the shocks and coping on average welfare in our sample, we perform a series of simulations. As the evidence does not reveal a negative effect of health or drought shocks on household welfare in Ruvuma, we focus on the estimated results for Kilimanjaro. In particular we estimate by how much average consumption in our sample would have improved in the absence of shocks (and thus also coping) compared with the

[1] Given the limited number of observations receiving remittances in each of the coffee and cashew quintile categories, we did not interact these with the receipt of remittances.

currently observed situation and by how much it would have deteriorated if there hadn't been any coping in the face of the observed shocks. To do so, we use the village fixed effect model including interaction terms with households' coping strategies (column 2, Table 5.4). Given that our model is loglinear, we can examine the effects of the different shocks and coping strategies on log consumption directly by adding or subtracting the relevant terms $\hat{\beta}_{21} S_{ijt+1}$ and $\hat{\beta}_{22} S_{ijt+1} X_{ijt}$. We focus on the use of savings and receipt of aid from others when faced with a shock as coping strategies. When coping more than offsets the effect of the shock itself, the positive compensating effect of coping is set equal to the negative effect of the shock. The results of these simulations are presented in Table 5.8.

The gross total loss among Kilimanjaro households in 2003 due to health and drought shocks is estimated at about Tsh 11,100 per adult equivalent or about 6 percent of annual consumption on average. Put differently, households who experienced either one or both shocks lost on average Tsh 33,369 per adult equivalent gross or about 18 percent of their annual consumption. This amounts to a total gross loss of about Tsh 8.43 billion or US$ 8.43 million in 2003 among rural households in Kilimanjaro alone.[1] Clearly the gross costs of shocks to the economy can be substantial.

As about 12 percent of all rural households in Kilimanjaro experienced an illness or death of an adult member in the two years preceding the survey and almost twice as many households experienced a drought shock in 2003 (Table 5.9), drought shocks contributed more to the aggregate loss (Tsh 7,000 per adult equivalent) than health shocks (Tsh 4,100 per adult equivalent), even though the individual welfare loss associated with a health shock was estimated to be slightly larger than the estimated gross loss from a drought shock.[2] Put differently, the total gross loss in personal consumption among rural households in Kilimanjaro attributed to drought is estimated at Tsh 5.32 billion , while the loss associated with illness and death of adult household members is estimated at Tsh 3.11 billion.

Yet, some households managed to (partly) smooth their consumption in the face of these shocks. Consequently, the actual reduction in consumption experienced by the population was smaller than it would have been in the absence of coping. The difference between the observed average consumption in our sample and the average consumption in the absence of any (or the use of other) coping strategies[3] provides an estimate of the effectiveness of households' coping strategies. On average about 53 percent of the loss due to health and rainfall shocks was compensated for either through use of one's own savings or reliance on aid from family and neighbours or traditional funeral insurance schemes. This could also be taken as an upper bound estimate of the potential crowding out effect of private insurance, were public insurance to be introduced either through public health or rainfall based insurance. Furthermore, households were better able to cope with health shocks than with rainfall shocks. This follows from the fact that in the former case, which is more idiosyncratic

[1] From Table 5.8, it can be seen that 63,134 households experienced either a health or a drought shock in 2003, corresponding to 252,536 adult equivalents at an estimated average of 4 adult equivalents per household. Given an average loss of Tsh 36,707 this results in a total estimated gross loss of Tsh 8 billion 427 million or about US$ 8.43 million at an exchange rate of about Tsh 1,000 per US$ in 2003.

[2] The gross negative effect of the health and drought shock are estimated at 16 and 11 percent respectively (see column 2,Table 5.4).

[3] In the simulations we focus on the use of savings and aid from others as coping strategies. When coping more than offset the effect of the shock, only the effect of the shock is subtracted from the actual consumption.

in nature, households could rely on both their own savings as well as aid from others, while in the latter case their coping strategies were confined to use of their own savings only.

Finally, assuming the decline in welfare among the small coffee growers could be completely ascribed to the coffee price decline, we estimated that the coffee price decline resulted in a net average loss of about Tsh 3,900 per adult equivalent. Given that larger farmers may have used their (unobserved cash) savings to cope with the coffee price decline, this is likely to be an underestimate.

5.6 Correlates of households' *ex post* coping capacity

Rural households in Kilimanjaro and Ruvuma largely rely on self insurance (i.e. use of their own savings) and informal mutual insurance (i.e. receipt of aid from neighbours and family) to cope with shocks. From Tables 5.4 and 5.5 we see that the use of savings is more efficient in helping farmers cope with rainfall shocks while both savings and aid are used to mitigate the effect of health shocks. To explore who is more likely to be able to cope with shocks either through savings or through aid, we run probit models of having received aid or having used savings in case of a shock on the nature of the shock (drought versus illness or death), the household's demographic characteristics (educational attainment, gender of head, ethnicity), its possession of assets (small and large livestock, land, number of cash crop trees), and a series of village characteristics. This information is critical in targeting social protection interventions. The estimated results for Kilimanjaro and Ruvuma are in Tables 5.10 and 5.11 respectively.

Consistent with the covariate nature of rainfall shocks, households are more likely to use their own savings to cope with droughts, though savings are also used to cope with illness and death shocks. External formal assistance (e.g. food aid or formal social protection interventions) has been rare in our study areas. When faced with a health shock (especially when it concerns the death of an adult member) which is idiosyncratic in nature, a household is more likely to receive aid. Aid appears not responsive to drought shocks.

There appears no clear pattern of association between the amount of assets possessed by the household and its use of coping strategies. The Ruvuma results suggest that the more coffee trees a household had two years ago, the higher the likelihood was that it coped either through use of savings and the reception of aid. This is consistent with our earlier finding that coffee growing households in Ruvuma are not worse off than non-cash crop growers despite the decline in coffee price during the early 2000s. We do not find a positive association between the number of coffee trees owned in 2000 and the use of self-insurance or mutual insurance in Kilimanjaro, suggesting that overall their coping capacity is by now no different from the non-coffee grower. Yet, when we include the quintile categories of coffee trees owned (as opposed to the number of coffee trees and its squared term) (results not presented), we find that those in the highest quintile are more likely to use savings (though not aid), consistent with the results in Table 5.4 indicating that this group is still better able to cope and that it might still be better off than the non-coffee growers. Cashew tree growers were not found to be different in their coping capacity than the other non-cash crop growers.

While educational attainments do not affect households' coping capacity in Kilimanjaro, in Ruvuma secondary education of the head is associated with a lower probability of receiving assistance, and primary schooling negatively correlated with the use of either coping strategy. Female headed households in Kilimanjaro appear much more likely to receive aid, and much less likely to use savings to cope with shocks. A similar pattern was observed in Ruvuma, though the coefficients were imprecisely estimated. In Kilimanjaro, the probability of receiving aid decreases with the age of the household head up to 36 years, and becomes positively associated with age at 72 years. In Ruvuma, we see a corresponding increase in likelihood of using savings up to the age of 43.

The availability of bus service in a village positively affect households' likelihood of using savings in Ruvuma, while electrification and cell phone reception in the village, both indicators of general wealth levels, are positively associated with the use of savings in Kilimanjaro.[1]

5.7 Concluding remarks

This chapter has explored the immediate effects of drought and health shocks on welfare and poverty in Kilimanjaro and Ruvuma and reflected on the effect of the coffee and cashew price decline since 2000. About one third of the rural population in Kilimanjaro suffered either from drought or health shocks in the survey year and those households suffered on average a direct 18 percent gross loss in their annual consumption in 2003 as a consequence. Yet, through reliance on savings and aid from others they were able to partly smooth their consumption and reduce the immediate negative welfare effect of these shocks to 8 percent loss on average.

No immediate (negative) welfare effects were found from the drought and health shocks in Ruvuma. The former result is related to the generally more secure rainfall patterns and the low incidence of drought shocks in Ruvuma in 2003. The lower medical expenditures in case of illness due to limited use of health care providers which is in turn associated with lower access to health facilities, underpins the estimated absence of an immediate welfare loss in Ruvuma. This does not necessarily imply that households in Ruvuma suffer less from illness shocks, but rather that they spend less to deal with them.

In addition, the potential income loss either due to reduced labour supply or reduced return to labour following illness or death, appears sufficiently small to not change this picture for Ruvuma. Also in Kilimanjaro, appears the estimated welfare loss largely associated with the medical expenses and not due to substantive income loss. This is consistent with the relative abundance of labour in both Kilimanjaro and even more so in Ruvuma. Sarris, Savastano, and Christiaensen (2006) estimate for example that the ratio of the marginal product of labour in agriculture to the agricultural wage is only 0.22 in Ruvuma (compared to 0.32 in Kilimanjaro). Finally, while the direct reported expenses related to death shocks are on par with those related to illness shocks, death shocks have much smaller immediate welfare effects, likely related to the existence of effective group based funeral insurance schemes (Dercon *et al*., 2006). How such schemes evolve as HIV/AIDs puts increasing pressure on these mechanisms must be closely followed.

Ceteris paribus, coffee growers in Kilimanjaro appear no worse off than non-coffee growers in Kilimanjaro, apart from the smallest ones, whose consumption level is on average 20 percent lower. Similarly, coffee growers in Ruvuma enjoy *ceteris paribus* similar consumption levels on average as non-cash crop growers, with indications that the larger ones are actually even better off. This suggests that coffee growers (apart from the smallest) have managed to weather the effects of the coffee price decline, at least to the point of not falling below the welfare levels of the non-cash crop growers and most likely at the expense of a depletion of their (cash) savings. Indeed, the decline in coffee prices since 2000 came on the heels of an income windfall from coffee during the late 1990s. In addition, many coffee

[1] None of the villages in Ruvuma has electricity, and only one village has cell phone reception.

growers in Kilimanjaro, who have access to the market in Dar-es-Salaam, have also been able to switch into bananas as an alternative cash crop. Consistent with this hypothesis is the finding that even in 2003 coffee growers in Ruvuma (as well as the richer coffee growers in Kilimanjaro) tend to be more inclined to use their own savings in case of health or drought shocks compared with non-cash crop growers. Cashew crop growers on the other hand, especially the smaller ones, appear worse off than non-cash crop growers in Ruvuma. Consumption levels among the two bottom quintiles of cashew trees are 15 to 20 percent lower than those among non-cash crop growers. Several years of low cashew prices are beginning to take their toll.

While there are little formal insurance or assistance schemes available to help households smooth their consumption, households rely heavily on self insurance through a depletion of their cash savings (and to a lesser extent their assets) as well as informal mutual insurance schemes including group based funeral societies. Aid from others is frequently received in case of death shocks, and to a lesser extent in case of illness, though not in case of a drought shock. Own savings on the other hand are the more important recourse in case of drought shocks, though they are also relied upon to deal with health shocks, especially illness shocks. Somewhat surprisingly, physical asset ownership and educational attainment appear to be poor predictors of the use of savings, pointing to the importance of cash savings in rural Tanzania. Coffee farmers in Ruvuma (as well as the richer coffee farmers in Kilimanjaro) are still more inclined to use their savings to cope with drought or health shocks. Female headed households tend to rely more on aid and less on their own savings. Households in Kilimanjaro in electrified villages and villages with cell phone signals, both signs of wealth, also tend to be more likely to receive aid and use their own savings to cope with shocks.

While these coping strategies help households smooth consumption, not all households have equal coping capacity and as documented in the 2002/03 Tanzanian Participatory Poverty Assessment these strategies may come at the expense of future earnings. Moreover, given that this study has abstracted from estimating the long run effects of shocks on welfare, the *ex ante* behavioral effects (Binswanger and Rosenzweig, 1993; Dercon, 1996) as well as their effects on human development outcomes (Ainsworth, Beegle and Koda, 2005), it must be underscored that the results presented here are only a lower bound on the actual welfare losses associated with health, drought and price shocks.

In looking for effective vulnerability reducing interventions, public policies aimed at improving health conditions and reducing the effect of droughts emerge as important, especially in Kilimanjaro. This includes the need for continued efforts to combat the HIV/AIDS epidemic, especially as this expanding epidemic may put the traditional funeral societies under increasing pressure to effectively deal with death shocks, as well as concerted efforts to prevent malaria infections. The ability to control water levels for example through irrigation emerges as an important general instrument to help enhance household consumption even though it has lost its effectiveness as an insurance instrument in Kilimanjaro which largely depends on gravitation irrigation. There are substantial uninsured welfare losses due to drought, suggesting a role for weather based insurance schemes, an innovative approach to protect consumption from drought shocks currently piloted in a series of developing countries (Ethiopia, Morocco, India). Farmers also expressed substantial demand for market based coffee price insurance schemes to help them insure against coffee price declines. Access to non-agricultural employment and enterprise further helps raising overall welfare levels and reduces exposure to drought shocks. Finally, the importance of connectivity in raising overall income levels and thus also households' ability to cope with shocks cannot be sufficiently underscored. Consumption levels were found to be ceteris paribus 15 to 30 percent higher in villages with a tarmac road compared with those without a tarmac road.

References

Ainsworth, M., Beegle, K. & Koda, G. 2005. The Impact of Adult Mortality and Parental Deaths on Primary Schooling in North-Western Tanzania, *Journal of Development Studies*, 41-3, pp. 412-439.

Alderman, H., Hoddinott, J. & Kinsey, B. 2006. Long Term Consequences of Early Childhood Malnutrition, *Oxford Economics Papers*, 3-6: 450-74.

Baker, M., Stabile, M., & Deri, C. 2004. What Do Self-Reported, Objective Measures of Health Measure*? Journal of Human Resources*, 39-4: pp. 1067-1093.

Beegle, K. 2005. Labor Effects of Adult Mortality in Tanzanian Households*, Economic Development and Cultural Change*, 53-3: p. 655-683.

Besley, T. 1995. Savings, Credit and Insurance, Handbooks in Economics Vol 9, Vol 3A: pp. 2123-2207, *Elsevier Science*, North Holland: Amsterdam.

Datt, G., & Hoogeveen, H. 2003. El Nino or El Peso? Crisis, Poverty and Income Distribution in the Philippines, *World Development*, 31-7: pp. 1103-1124.

Deaton, A. 1992. *Understanding Consumption*, Oxford: Clarendon Press.

Deaton, A. 1997. *The Analysis of Household Surveys: A Microeconometric Approach to Development Policy*, John Hopkins University Press: Baltimore, MD.

Dercon, S. & Krishnan, P. 2000. Vulnerability, Seasonality and Poverty in Ethiopia, *Journal of Development Studies*, 36-6: pp. 25-53.

Dercon, S., Bold, T., De Weerdt, J. & Pankhurst, A. 2006. Group Based Funeral Insurance in Ethiopia and Tanzania, *World Development*, 34-4: 685-703.

Dercon, S., Hoddinott, J. & Woldehanna, T. 2005. Shocks and Consumption in 15 Ethiopian Villages, 1999-2004, *Journal of African Economies*, 14-4, pp. 559-85.

Foster, A. 1994. Poverty and Illness in Low-Income Rural Areas, *American Economic Review*, 84-2: pp. 216-220.

Gertler, P. & Gruber, J. 2002. Insuring Consumption Against Illness, *American Economic Review*, 92-1, pp. 51-70.

Groot, W. 2000. Adaptation and Scale of Reference Bias in Self-Assessments of Quality of Life, *Journal of Health Economics*, 19, p. 403-420.

Hall, R., 1978. Stochastic Implications of the Life Cycle-Permanent Income Hypothesis: Theory and Evidence, *Journal of Political Economy*, 86-6: pp. 971-87.

Harrower, S. & Hoddinott, J. 2005. Consumption Smoothing in the Zone Lacustre, Mali, *Journal of African Economies*, 14-4, pp. 489-519.

Morduch, J. 1991. *Risk and Welfare in Developing Countries.* Harvard University. (Ph.D. thesis)

National Bureau of Statistics Tanzania. 2002. *Household Budget Survey, 2000/01*, *Final Report*, National Bureau of Statistics, Tanzania: Dar-es-Salaam.

Research and Analysis Working Group. 2004. *Vulnerability and Resilience to Poverty in Tanzania: Causes, Consequences and Policy Implications – 2002/03 Tanzania Participatory Poverty Assessment (TZPPA)*: *Main Report*, Research and Analysis Working Group: Dar-es-Salaam, Tanzania.

Rutherford, S. 2001. *The Poor and Their Money*, Delhi: Oxford University Press for India.

Sarris, A., Savastano, S. & Christiaensen, L. 2006. *Agriculture and Poverty in Commodity Dependent African Countries: A Rural Household Perspective from the United Republic of Tanzania*, FAO Commodities and Trade Technical Paper 9: Rome.

Table 5.1: Comparison of socio-economic characteristics and past coping behaviour among quintile categories of coffee and non-coffee growers in Kilimanjaro

	No trees	Lowest quintile[1)]	2nd quintile	3rd quintile	4th quintile	Highest quintile	Total
Altitude (meters)	3578	4575**	4548**	4694**	4546**	4451**	4177
% Pare	36.2	9.4**	2.4**	8.7**	6.7**	3.4**	17.9
% Chagga	44.8	90.6**	9.7**	90.3**	92.4**	96.6**	74.3
Land (2000)	2.9	1.6**	2.2***	2.4	2.9	3.6***	2.7
Goats/sheep/pigs (2000)	2.8	1.1***	1.3	1.6	1.9	1.5	2.0
Cattle/horses/oxen (2000)	4.4	2.3	3.0	3.5	3.1	2.2	3.5
Value Consumer Durables Tsh 1000, (2002)	264	140**	248	233	234	315	246
Value of compound (2003)	2342	2194	4051***	3243**	4943***	7851***	3681
Remittance income (Tsh 1000) (2003)	24.4	25.4	38.9	42.4**	62.1**	44.1**	35.4
Coffee trees (2000)	0	39***	109***	235***	502***	1326***	269
Of those who faced a shock, % who received aid	47.2	44.4	43.6	63.1**	55.7	60.1	50.9
Of those who faced a shock, % who used own savings	67.4	78.3	69.1	81.4	68.0	67.4	78.3
Number of households	74,593	23,287	23,034	23,301	22,974	23,123	190,312

1) based on number of coffee trees owned in 2000
denotes significance at 1%, * at 5%, * at 10% when comparing characteristics to the non-coffee growers

Table 5.2: Comparison of socio-economic characteristics among quintile categories of coffee growers and non-coffee growers in Ruvuma

	No trees	Lowest quintile[1)]	2nd quintile	3rd quintile	4th quintile	Highest quintile	Total
Altitude (meters)	2658	4362***	4531***	4660***	4682***	4833***	3275
% Matengo	16.6	91.2***	96.5***	96.6***	100.0***	95.5***	41.6
% Ndendeule	8.8	1.8	1.9	0.0*	0.0*	2.1	6.4
% Ngoni	20.3	5.1*	0.0***	1.6**	0.0***	2.4**	14.5
% Yao	32.5	0.0***	0.0***	0.0***	0.0***	0.0***	22.3
% Nyasa	0.9	0.0	0.0	0.0	0.0	0.0	0.6
Land (2002)	9.76	9.76	9.29	8.94	8.63	9.26	9.57
Goats/sheep/pigs (2002)	2.87	4.14**	5.46***	5.24***	4.33**	4.30**	3.44
Cattle/horses/oxen (2003)	0.16	0.49***	1.04***	0.91***	0.75***	1.39***	0.40
Value Consumer Durables Tsh 1000, (2002)	139.4	109.9	137.4	141.5	125.7	192.4	139.9
Value of compound (2003)	433.3	399.4	931.1***	1196.8***	1168.3***	1024.6***	596.0
Remittance income Tsh (1000) (2003)	169.8	45.1	130.9	94.9	41.0	116.7	144.1
Coffee trees (2000)	0.0	432.5***	847.7***	1304.4***	1592.4***	2084.5***	393.9
Of those who faced a shock, % who received aid	45.2	43.3	41.7	59.1	56.1	58.5	47.0
Of those who faced a shock, % who used own savings	69.7	66.4	70.8	74.8	83.5	82.2	71.3
Number of households	119,022	11,089	10,899	11,159	11,024	10,728	173,921

1) based on number of coffee trees owned in 2002
denotes significance at 1%, * at 5%, * at 10% when comparing characteristics to the non-coffee growers

Table 5.3: Comparison of socio-economic characteristics among quintile categories of cashew growers and non-cashew growers in Ruvuma

	No trees	Lowest quintile[1)]	2nd quintile	3rd quintile	4th quintile	Highest quintile	Total
Altitude (meters)	3684	1997***	1864***	1991***	1994***	2054***	3275
% Matengo	53.9	13.3***	0.0***	0.0***	0.0***	0.0***	41.6
% Ndendeule	7.5	7.5	3.0	0.0*	1.6*	1.9	6.4
% Ngoni	16.9	5.8*	12.4***	10.1**	4.3***	1.7**	14.5
% Yao	9.6	36.5***	56.1***	62.6***	71.2***	86.3***	22.3
% Nyasa	0.5	0.0	1.8	0.0	1.7	1.6	0.6
Land (2002)	8.87	7.45*	7.48	9.83	13.74***	20.60***	9.57
Goats/sheep/pigs (2002)	3.81	2.31**	1.47***	2.17***	3.32**	2.11**	3.44
Cattle/horses/oxen (2003)	0.47	0.57***	0.00***	0.00***	0.18***	0.00***	0.40
Value Consumer Durables Tsh 1000, (2002)	147.8	139.7	72.4**	111.9	125.9	124.4	139.9
Value of compound (2003)	668.9	212.4	356.1***	317.9***	426.1***	539.9***	596.0
Remittance income (Tsh 1000) (2003)	158.6	142.0	27.2	57.6	46.5	83.3	144.1
Cashew trees (2000)	0.0	32.9***	92.4***	157.7***	336.1***	905.9***	72.9
Of those who faced a shock, % who received aid	45.4	50.6	54.3	38.7	60.6	56.9	47.0
Of those who faced a shock, % who used own savings	69.3	78.8	53.5***	87.9**	71.4	93.6**	71.3
Number of households	132,195	8,440	8,307	8,328	8,362	8,289	173,921

1) based on number of cashew trees owned in 2002
denotes significance at 1%, * at 5%, * at 10% when comparing characteristics to the non-coffee growers.

Table 5.4: Shocks, coping and consumption in Kilimanjaro

Log consumption per adult equivalent (ae) (exclusive of health and education expenditures, and expenditures on functions)	baseline	Shocks interacted with coping strategies	Health shocks unbundled	Village dummies unbundled
	(1)	(2)	(3)	(4)
Shocks, exposure and coping				
major illness or death of adult member	-0.020	-0.161		-0.205
	(0.47)	(1.82)***		(2.29)*
used savings to cope with major illness or death of adult member		0.148		0.202
		(1.55)		(2.19)*
received aid to cope with major illness or death of adult member		0.070		0.074
		(0.87)		(0.93)
death of adult member last 2 yrs			-0.150	
			(0.78)	
death of adult member last 2 yrs * received aid			0.025	
			(0.13)	
death of adult member last 2 yrs * used savings			0.271	
			(1.99)*	
major illness of adult member last 2 yrs			-0.170	
			(1.63)	
ill adult member last 2 yrs * received aid			0.068	
			(0.70)	
ill adult member last 2 yrs * used savings			0.101	
			(0.90)	
acres/adult equivalent * very low rainfall	-0.104	-0.112	-0.108	-0.116
	(2.82)**	(3.04)**	(2.94)**	(3.24)**
acres/adult equivalent * very low rainfall * got aid for drought		-0.243	-0.245	-0.253
		(2.02)*	(2.05)*	(2.07)*
acres/adult equivalent * very low rainfall * used savings for drought		0.131	0.131	0.137
		(1.21)	(1.20)	(1.25)
acres/adult equivalent * somewhat low rainfall	0.044	0.025	0.027	0.029
	(1.19)	(0.72)	(0.76)	(0.87)
acres/adult equivalent * somewhat low rainfall * got aid for drought		-0.214	-0.195	-0.136
		(1.35)	(1.18)	(0.87)
acres/adult equivalent * somewhat low rainfall * used savings for drought		0.166	0.165	0.158
		(2.93)**	(2.97)**	(2.70)**
lowest quintile coffee trees 2000	-0.205	-0.217	-0.210	-0.233
	(3.45)**	(3.59)**	(3.47)**	(3.85)**
lowest quintile coffee trees 2000 * remittance income Tsh 100,000/adult equivalent		-0.119	-0.124	-0.051
		(1.18)	(1.23)	(0.53)
second quintile coffee trees 2000	-0.065	-0.092	-0.093	-0.085
	(1.14)	(1.60)	(1.61)	(1.58)
second quintile coffee trees 2000 * remittance income Tsh 100,000/adult equivalent		0.150	0.148	0.163
		(1.08)	(1.07)	(1.22)
third quintile coffee trees 2000	-0.043	-0.065	-0.062	-0.071
	(0.72)	(1.03)	(1.00)	(1.27)
third quintile coffee trees 2000 * remittance income Tsh 100,000/adult equivalent		0.150	0.147	0.207
		(1.18)	(1.15)	(1.75)***
fourth quintile coffee trees 2000	-0.022	-0.051	-0.051	-0.044
	(0.38)	(0.86)	(0.86)	(0.85)
fourth quintile coffee trees 2000 * remittance income Tsh 100,000/adult equivalent		0.179	0.172	0.227
		(1.97)*	(1.89)***	(2.68)**
highest quintile coffee trees 2000	0.145	0.114	0.118	0.156
	(2.10)*	(1.56)	(1.63)	(2.48)*
highest quintile coffee trees 2000 * remittance income Tsh 100,000/adult equivalent		0.155	0.155	0.111
		(1.15)	(1.15)	(0.92)

Table 5.4 (continued): Shocks, coping and consumption in Kilimanjaro

Log consumption per adult equivalent (ae) (exclusive of health and education expenditures, and expenditures on functions)	baseline	Shocks interacted with coping strategies	Health shocks unbundled	Village dummies unbundled
	(1)	(2)	(3)	(4)
irrigated acres/adult equivalent * very low rainfall	0.039	0.060	0.053	0.099
	(0.42)	(0.66)	(0.58)	(1.10)
irrigated acres/adult equivalent * somewhat low rainfall	-0.265	-0.241	-0.245	-0.234
	(3.10)**	(2.92)**	(2.99)**	(2.90)**
irrigated acres cultivated 2003 per adult equivalent	0.188	0.188	0.188	0.195
	(2.89)**	(2.96)**	(3.07)**	(3.36)**
Remittance income, Tsh 100,000/adult equivalent	0.149	0.060	0.065	0.030
	(2.81)**	(0.68)	(0.74)	(0.37)
Demographic characteristics				
dependency ratio	-0.186	-0.181	-0.180	-0.178
	(3.00)**	(2.89)**	(2.88)**	(2.89)**
age of head	-0.028	-0.027	-0.027	-0.027
	(4.07)**	(4.00)**	(4.02)**	(4.14)**
age of head squared	0.000	0.000	0.000	0.000
	(3.83)**	(3.74)**	(3.77)**	(3.98)**
female-headed household	0.068	0.063	0.068	0.089
	(1.51)	(1.40)	(1.53)	(1.97)*
yrs primary education of head	0.006	0.005	0.006	0.008
	(0.89)	(0.74)	(0.83)	(1.21)
yrs secondary education of head	0.034	0.033	0.033	0.034
	(1.68)***	(1.65)***	(1.63)	(1.66)***
whether head has post-sec education	-0.206	-0.222	-0.219	-0.238
	(1.80)***	(1.95)***	(1.93)***	(2.09)*
head is Chagga	0.149	0.158	0.152	0.132
	(2.41)*	(2.52)*	(2.43)*	(2.40)*
head is Pare	0.125	0.125	0.112	0.036
	(1.82)***	(1.81)***	(1.64)	(0.59)
proportion of time in non-agricultural activities in 2002	0.185	0.203	0.205	0.212
	(2.80)**	(3.05)**	(3.09)**	(3.12)**
Productive assets and consumer durables				
land owned 3 years ago/adult equivalent	0.094	0.095	0.094	0.072
	(2.62)**	(2.64)**	(2.62)**	(2.21)*
land owned 3 years ago/adult equivalent sqr	-0.000	0.000	0.000	0.002
	(0.04)	(0.06)	(0.03)	(0.94)
value of productive assets in 2002, Tsh 100,000 per adult equivalent	0.043	0.042	0.042	0.040
	(3.17)**	(3.04)**	(3.03)**	(2.35)*
value of productive assets in 2002 squared, Tsh 100,000	-0.000	-0.000	-0.000	-0.000
	(3.37)**	(3.24)**	(3.23)**	(2.53)*
relatively easy to obtain seasonal credit for inputs	0.114	0.119	0.119	0.128
	(2.50)*	(2.54)*	(2.53)*	(2.71)**
head of cattle, oxen, horses 3 years ago/adult equivalent	0.088	0.091	0.091	0.105
	(4.54)**	(4.70)**	(4.79)**	(5.49)**
head of cattle, oxen, horses 3 years ago/adult equivalent sqr	-0.001	-0.001	-0.001	-0.001
	(2.58)*	(2.80)**	(2.85)**	(3.59)**
head of goat, sheep, pigs 3 years ago/adult equivalent	0.031	0.032	0.032	0.024
	(2.39)*	(2.48)*	(2.58)**	(1.93)***
head of goat, sheep, pigs 3 years ago/adult equivalent sqr	-0.001	-0.001	-0.001	-0.001
	(2.21)*	(2.34)*	(2.41)*	(1.97)*
value of consumer durables in 2002, Tsh 100,000 per adult equivalent	0.304	0.297	0.297	0.311
	(8.49)**	(8.53)**	(8.57)**	(9.35)**

Table 5.4 (continued): Shocks, coping and consumption in Kilimanjaro

Log consumption per adult equivalent (ae) (exclusive of health and education expenditures, and expenditures on functions)	baseline	Shocks interacted with coping strategies	Health shocks unbundled	Village dummies unbundled
	(1)	(2)	(3)	(4)
value of consumer durables in 2002 squared,Tsh 100,000	-0.027	-0.024	-0.024	-0.025
	(4.96)**	(4.72)**	(4.72)**	(5.01)**
Village connectivity, infrastructure and agro-ecological potential				
tarmac road reaches village				0.161
				(2.36)*
village has public phone				0.036
				(0.97)
village has cell phone signal				0.024
				(0.35)
bus service to village				0.010
				(0.25)
village has a market				0.040
				(1.13)
village has electricity				0.102
				(2.14)*
village has health center, dispensary, or hospital				-0.084
				(0.89)
Altitude of village, 1000 m				0.200
				(0.09)
Constant	5.268	5.268	5.260	5.136
	(22.61)**	(22.45)**	(22.53)**	(24.12)**
Observations	914	914	914	914
R-squared	0.49	0.50	0.50	0.47

Models (1)-(3) include village dummies which are not presented to save space. Absolute value of t statistics in parentheses; *** significant at 10%; * significant at 5%; ** significant at 1%

Table 5.5: Shocks, coping and consumption in Ruvuma

Log consumption per adult equivalent (ae) (exclusive of health and education expenditures, and expenditures on functions)	baseline	Shocks interacted with coping strategies	Health shocks unbundled	Village dummies unbundled
	(1)	(2)	(3)	(4)
Shocks, exposure and coping				
major illness or death of adult member	-0.005	0.030		0.067
	(0.11)	(0.42)		(0.99)
used savings to cope with major illness or death of adult member		-0.083		-0.074
		(1.06)		(0.94)
received aid to cope with major illness or death of adult member		-0.004		-0.024
		(0.05)		(0.29)
death of adult member last 2 yrs			0.075	
			(0.93)	
death of adult member last 2 yrs * received aid			-0.414	
			(2.72)**	
death of adult member last 2 yrs * used savings			0.164	
			(1.15)	
major illness of adult member last 2 yrs			0.003	
			(0.04)	
ill adult member last 2 yrs * received aid			0.057	
			(0.62)	
ill adult member last 2 yrs * used savings			-0.021	
			(0.20)	
acres/adult equivalent * very low rainfall	-0.018	-0.020	-0.019	-0.017
	(0.34)	(0.36)	(0.36)	(0.28)
acres/adult equivalent * very low rainfall * got aid for drought		-0.078	-0.078	0.014
		(0.69)	(0.69)	(0.19)
acres/adult equivalent * somewhat low rainfall	0.031	0.030	0.030	0.036
	(1.83)***	(1.73)***	(1.74)***	(2.11)*
acres/adult equivalent * somewhat low rainfall * got aid for drought		-0.326	-0.325	-0.328
		(1.52)	(1.51)	(1.61)
acres/adult equivalent * somewhat low rainfall * used savings for drought		0.004	0.006	-0.010
		(0.09)	(0.11)	(0.17)
lowest quintile coffee trees 2002	0.134	0.138	0.131	0.071
	(1.49)	(1.54)	(1.46)	(0.83)
second quintile coffee trees 2002	0.156	0.156	0.158	0.066
	(1.81)***	(1.81)***	(1.86)***	(0.80)
third quintile coffee trees 2002	0.079	0.083	0.075	0.003
	(0.94)	(0.97)	(0.89)	(0.04)
fourth quintile coffee trees 2002	0.336	0.338	0.345	0.243
	(3.87)**	(3.86)**	(3.94)**	(2.85)**
highest quintile coffee trees 2002	0.290	0.289	0.291	0.199
	(3.21)**	(3.17)**	(3.22)**	(2.16)*
lowest quintile cashew trees 2002	0.066	0.068	0.065	-0.148
	(0.79)	(0.81)	(0.77)	(2.01)*
second quintile cashew trees 2002	0.103	0.107	0.110	-0.234
	(0.99)	(1.02)	(1.05)	(3.12)**
third quintile cashew trees 2002	0.312	0.312	0.304	-0.034
	(2.67)**	(2.67)**	(2.60)**	(0.39)
fourth quintile cashew trees 2002	0.312	0.326	0.316	-0.042
	(2.76)**	(2.87)**	(2.79)**	(0.52)
highest quintile cashew trees 2002	0.394	0.401	0.393	0.025
	(3.27)**	(3.32)**	(3.24)**	(0.29)
irrigated acres/adult equivalent * somewhat low rainfall	0.039	0.036	0.052	0.037
	(0.16)	(0.15)	(0.22)	(0.16)
irrigated acres cultivated 2003 per adult equivalent	0.142	0.141	0.137	0.147
	(1.03)	(1.03)	(1.00)	(1.15)
cultivated tobacco in 2004	-0.160	-0.156	-0.150	-0.091
	(1.46)	(1.42)	(1.37)	(0.84)
remittance income,Tsh 100,000/adult equivalent	0.184	0.183	0.186	0.184
	(1.45)	(1.44)	(1.49)	(1.35)

Table 5.5 (continued): Shocks, coping and consumption in Ruvuma

Log consumption per adult equivalent (ae) (exclusive of health and education expenditures, and expenditures on functions)	baseline	Shocks interacted with coping strategies	Health shocks unbundled	Village dummies unbundled
	(1)	(2)	(3)	(4)
Demographic characteristics				
dependency ratio	-0.196	-0.195	-0.189	-0.162
	(2.44)*	(2.41)*	(2.34)*	(1.94)***
age of head	-0.046	-0.046	-0.046	-0.043
	(5.66)**	(5.67)**	(5.64)**	(5.15)**
age of head squared	0.000	0.000	0.000	0.000
	(4.88)**	(4.89)**	(4.83)**	(4.45)**
female headed household	0.105	0.107	0.110	0.101
	(1.75)***	(1.77)***	(1.83)***	(1.64)
yrs primary completed by head	0.024	0.024	0.024	0.024
	(2.70)**	(2.68)**	(2.72)**	(2.61)**
yrs secondary completed by head	0.015	0.013	0.015	0.007
	(0.61)	(0.55)	(0.60)	(0.29)
head has post-sec education	0.209	0.207	0.182	0.261
	(1.17)	(1.17)	(1.06)	(1.56)
head is Matengo	-0.063	-0.061	-0.057	-0.004
	(0.71)	(0.68)	(0.64)	(0.06)
head is Ndendeule	-0.009	-0.011	-0.009	0.116
	(0.09)	(0.10)	(0.09)	(1.27)
head is ngoni	-0.132	-0.134	-0.137	-0.025
	(1.64)	(1.65)***	(1.70)***	(0.32)
head is yao	-0.062	-0.065	-0.065	-0.056
	(0.78)	(0.80)	(0.79)	(0.85)
head is nyasa	0.010	0.007	0.019	0.024
	(0.07)	(0.05)	(0.13)	(0.17)
proportion of time in non-agricultural activities in 2003	0.218	0.212	0.217	0.286
	(2.39)*	(2.33)*	(2.39)*	(3.05)**
Productive assets and consumer durables				
land owned 1 year ago/adult equivalent	0.035	0.035	0.035	0.042
	(3.24)**	(3.19)**	(3.27)**	(3.87)**
land owned 1 year ago/adult equivalent sqr	-0.001	-0.001	-0.001	-0.001
	(2.56)*	(2.52)*	(2.57)*	(2.85)**
value of productive assets in 2003,Tsh 100,000 per adult equivalent	0.047	0.046	0.046	0.039
	(1.76)***	(1.73)***	(1.76)***	(1.47)
value of productive assets in 2003 squared, Tsh 100,000	-0.001	-0.001	-0.001	-0.001
	(2.12)*	(2.10)*	(2.10)*	(1.72)***
relatively easy to obtain seasonal credit for inputs	-0.070	-0.068	-0.072	-0.072
	(1.76)***	(1.72)***	(1.79)***	(1.84)***
head of cattle, oxen, horses one year ago per adult equivalent	0.389	0.385	0.401	0.353
	(4.43)**	(4.36)**	(4.55)**	(3.98)**
head of cattle, oxen, horses, one year ago squared per adult equivalent	-0.146	-0.143	-0.150	-0.146
	(3.68)**	(3.54)**	(3.88)**	(3.98)**
head of goat, sheep, one year ago per adult equivalent	0.080	0.082	0.081	0.101
	(2.88)**	(2.91)**	(2.91)**	(3.58)**
head of goat, sheep, one year ago squared per adult equivalent	-0.007	-0.007	-0.007	-0.009
	(1.53)	(1.61)	(1.57)	(1.94)***
value of consumer durables in 2003, Tsh100,000 per adult equivalent	0.470	0.470	0.465	0.466
	(5.91)**	(5.92)**	(5.89)**	(5.66)**
value of consumer durables in 2003, Tsh100,000 per adult equivalent, sqr	-0.004	-0.004	-0.004	-0.004
	(4.76)**	(4.72)**	(4.65)**	(4.70)**

Table 5.5 (continued): Shocks, coping and consumption in Ruvuma

Log consumption per adult equivalent (ae) (exclusive of health and education expenditures, and expenditures on functions)	baseline	Shocks interacted with coping strategies	Health shocks unbundled	Village dummies unbundled
	(1)	(2)	(3)	(4)
Village connectivity, infrastructure and agro-ecological potential				
tarmac road reaches village				0.331
				(3.02)**
village has cell phone signal				-0.059
				(0.75)
village has a market				-0.073
				(1.95)***
bus service to village				0.035
				(0.72)
Health facility in village				0.046
				(1.28)
altitude				0.154
				(0.06)
Constant	5.235	5.491	5.477	5.446
	(21.79)**	(23.75)**	(23.61)**	(24.61)**
Observations	878	878	878	878
R-squared	0.47	0.47	0.47	0.42

Models (1)-(3) include village dummies which are not presented to save space. Absolute value of t statistics in parentheses; *** significant at 10%; * significant at 5%; ** significant at 1%; rainfall very low * acres cultivated/adult equivalent * used savings to cope with drought, rainfall very low * irrigated acres/adult equivalent, village electricity, village public phone, are all dropped due to collinearity

Table 5.6: Expenses incurred as result of an illness or death shock, 1999-2004

Average expenses (Tsh 000) incurred per household in case of an illness or death shock over the past 5 years	Illness of adult member (15-64 yrs old)	Death of adult member (15-64 yrs old)
Kilimanjaro		
- Round 1 [a]	137	143
- Round 2	102	108
Ruvuma		
- Round 1 [a]	38	94
- Round 2	49	51

Health expenditures (Tsh 000) per household during 30 days preceding survey	Illness shock		Death shock	
	No	Yes	No	Yes
Kilimanjaro				
- Round 1 [a]	33	68	34	55
- Round 2	35	117	42	40
Ruvuma				
- Round 1 [a]	21	40	23	28
- Round 2	19	55	23	12

Source: Authors' calculations

a) While the reported expenses in case of a shock in round 1 are averaged across the 5 years preceding the survey given a shock, those in round 2 only to the year preceding the survey.

Table 5.7: Household welfare with and without illness or death shocks

Expenditures per adult equivalent (ae)[1)]	Illness or death	# obs	illness	# obs	death	# obs
Kilimanjaro						
Round 1						
no shock	192.5	832	193.7	881	190.7	893
shock	186.7	117	166.0	66	209.4	56
difference	*5.8*		*27.7*		*-18.7*	
Total	191.8	949	191.8	949	191.8	949
Round 2						
no shock	142.0	806	142.0	836	139.3	883
shock	118.2	109	108.2	79	141.0	32
difference	*23.7*		*33.8*		*-1.7*	
Total	139.4	915	139.4	915	139.4	915
Ruvuma						
Round 1						
no shock	158.4	789	160.1	824	157.5	855
shock	163.5	103	146.5	68	193.5	37
difference	*-5.1*		*13.6*		*-36.0*	
Total	159.0	892	159.0	892	159.0	892
Round 2						
no shock	156.1	723	156.2	751	156.0	810
shock	156.4	115	155.5	87	159.5	28
difference	*-0.3*		*0.7*		*-3.4*	
Total	156.1	838	156.1	838	156.1	838

1) Expenditures exclude expenditures on education, health and functions and have been deflated for comparison with HBS expenditures.

Table 5.8: Welfare and poverty effect of shocks and coping in Kilimanjaro[1)]

	Health & rainfall	Health only	Rainfall only	Coffee shock only
Consumption per adult equivalent (ae) (Tsh 000)[2)]				
no shock, no coping	197.0	192.9	195.8	195.7
shock and coping (=actual)	191.8	191.8	191.8	191.8
shock, no coping	185.9	189.0	188.6	191.8
Poverty incidence (%)				
no shock, no coping	14.4	14.8	14.5	14.3
shock and coping (=actual)	15.0	15.0	15.0	15.0
shock, no coping	16.7	16.0	15.8	15.0

1) The simulations were performed using the village fixed effect model including interaction terms with households' coping strategies (column 2, Table 3).
2) These consumption levels have been deflated for comparability with the 2000/01 HBS

Table 5.9: Incidence of rainfall and health shocks in Kilimanjaro and Ruvuma in 2002-2004

	Kilimanjaro		Ruvuma	
	Percent of households	Number of households	Percent of households	Number of households
Adult health shock last 2 years	12.2	23,336	11.9	20,706
Adult illness shock last 2 years	6.9	13,172	8.1	14,105
Adult death shock last 2 years	5.8	11,194	4.0	7,035
Very low rainfall this year	20.8	39,798	3.8	6,547
Somewhat low rainfall this year	41.9	80,234	33.8	58,822
Either very low rainfall or adult health shock	33.0	63,134	15.7	27.253

Table 5.10: Correlates of use of savings, aid and remittances in case of a shock in Kilimanjaro

	(1)	(2)	(3)
	received aid	used savings	received aid or used savings
Shocks			
shock was any death	1.896	0.559	1.891
	(8.89)**	(3.05)**	(6.01)**
shock was any illness	0.894	0.758	1.057
	(4.47)**	(3.77)**	(4.85)**
shock was drought	-0.053	0.852	0.741
	(0.29)	(4.98)**	(4.33)**
Productive assets			
head of cattle, oxen, horses one year ago per adult equivalent	0.365	-0.196	0.185
	(1.89)***	(1.35)	(0.99)
head of cattle, oxen, horses, one year ago squared per adult equivalent	-0.057	-0.000	-0.047
	(1.63)	(0.01)	(1.53)
head of goat, sheep, one year ago per adult equivalent	-0.134	0.022	-0.033
	(2.24)*	(0.41)	(0.55)
head of goat, sheep, one year ago squared per adult equivalent	0.005	0.001	0.002
	(2.27)*	(0.80)	(1.00)
land owned 3 years ago/adult equivalent	0.037	-0.119	0.024
	(0.26)	(0.91)	(0.17)
land owned 3 years ago/adult equivalent sqr	0.001	0.009	0.000
	(0.14)	(1.01)	(0.03)
coffee trees owned in 2000, hundreds per adult equivalent	0.013	0.115	0.054
	(0.16)	(1.05)	(0.52)
coffee trees owned in 2000 per adult equivalent squared, hundreds	-0.003	0.002	0.002
	(0.70)	(0.24)	(0.45)
Demographics			
dependency ratio	-0.205	-0.020	0.071

Table 5.10 (continued): Correlates of use of savings, aid and remittances in case of a shock in Kilimanjaro

	(1)	(2)	(3)
	received aid	**used savings**	**received aid or used savings**
	(0.68)	(0.07)	(0.21)
female-headed household	0.611	-0.432	0.120
	(3.00)**	(2.22)*	(0.54)
age of head	-0.072	0.028	-0.016
	(2.45)*	(1.19)	(0.63)
age of head squared	0.001	-0.000	0.000
	(2.89)**	(1.35)	(0.56)
yrs primary education of head	0.021	-0.006	-0.026
	(0.60)	(0.20)	(0.72)
yrs secondary education of head	0.058	0.021	0.022
	(0.56)	(0.23)	(0.22)
whether head has post-sec education	-0.424	0.170	-0.089
	(0.94)	(0.37)	(0.19)
head is Chagga	-0.505	-0.385	-0.279
	(1.90)***	(1.36)	(0.91)
head is Pare	-0.195	-0.355	-0.167
	(0.67)	(1.17)	(0.52)
Village connectivity, infrastructure and agro-ecological potential			
tarmac road reaches village	0.045	0.070	0.183
	(0.17)	(0.25)	(0.59)
village has public phone	-0.201	-0.248	-0.197
	(0.97)	(1.29)	(0.92)
village has cell phone signal	0.251	0.728	0.910
	(0.68)	(2.09)*	(2.67)**
village has a market	-0.113	-0.158	-0.150
	(0.60)	(0.87)	(0.73)
village has electricty	0.294	0.520	0.631
	(1.21)	(2.11)*	(2.30)*
bus service to village	0.076	0.192	0.046
	(0.38)	(1.02)	(0.22)
village has bank or other formal credit inst.	-0.336	-0.075	-0.181
	(1.52)	(0.31)	(0.70)
altitude	0.003	-0.002	-0.002
	(0.27)	(0.24)	(0.16)
Constant	0.500	-1.273	-0.318
	(0.49)	(1.44)	(0.34)
Observations	484	484	484
F stat	5.41	2.43	3.12
Prob > F	0.000	0.000	0.000
Pseudo R-squared [1)]	0.2873	. 1230	0.2249

Absolute value of t statistics in parentheses; *** significant at 10%; * significant at 5%; ** significant at 1%; results presented allow for different correlation structures within districts, except for pseudo R-squared statistics, which are taken from a model which does not.

Figure 5.1: Kernel distribution of consumption in Kilimanjaro

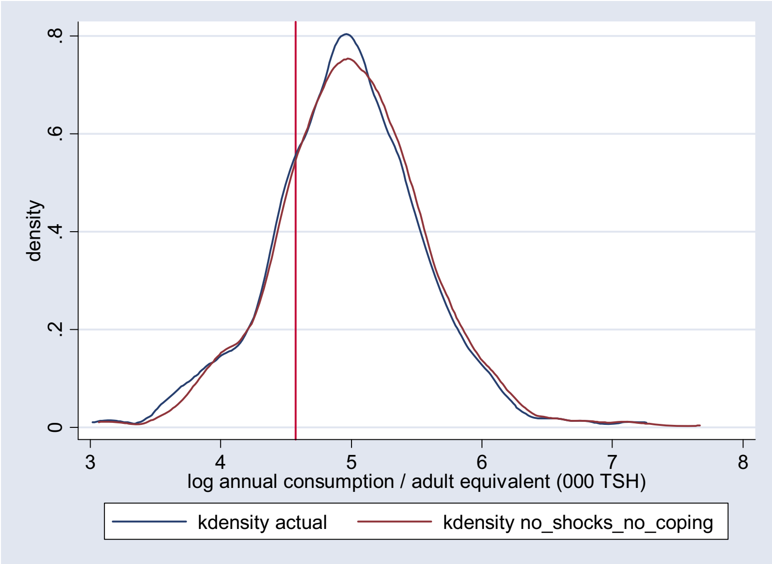

Figure 5.2: Kernel distribution of consumption in Ruvuma

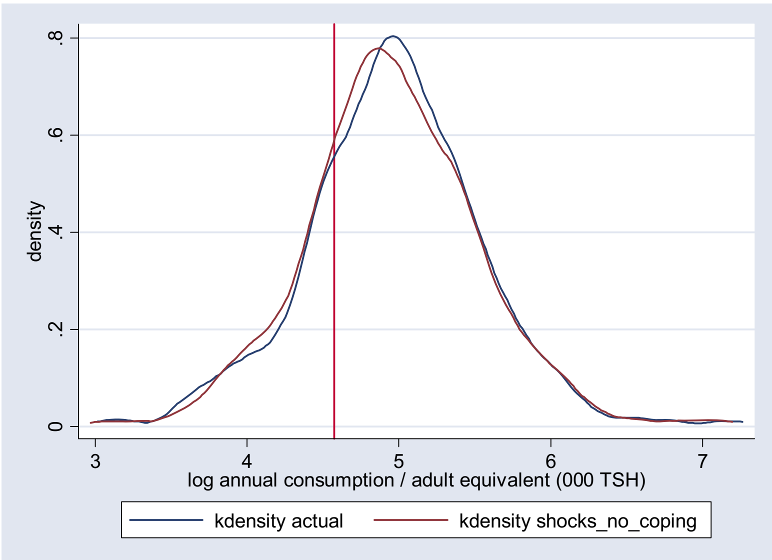

Table 5.11: Correlates of use of savings, aid and remittances in case of a shock in Ruvuma

	(1)	(2)	(3)
	receipt of aid	**use of savings**	**receipt of aid or use of savings**
Shocks			
shock was death	1.769	0.553	1.321
	(5.37)**	(1.88)***	(3.30)**
shock was illness	0.129	0.773	1.424
	(0.50)	(2.58)*	(3.23)**
shock was drought	-0.377	0.902	0.657
	(0.88)	(1.82)***	(1.31)
Productive assets			
head of cattle, oxen, horses one year ago per adult equivalent	-0.676	-0.560	-3.012
	(0.94)	(0.80)	(2.30)*
head of cattle, oxen, horses, one year ago squared per adult equivalent	0.485	0.036	1.333
	(1.67)***	(0.13)	(1.77)***
head of goat, sheep, one year ago per adult equivalent	0.374	-0.535	-0.322
	(1.53)	(2.16)*	(1.10)
head of goat, sheep, one year ago squared per adult equivalent	-0.095	0.075	0.014
	(1.78)***	(1.48)	(0.26)
land owned 1 year ago/adult equivalent	0.041	0.141	0.196
	(0.36)	(1.27)	(1.44)
land owned 1 year ago/adult equivalent sqr	-0.000	-0.006	-0.008
	(0.04)	(0.82)	(0.99)
coffee trees owned in 2002, hundreds per adult equivalent	0.331	0.339	0.902
	(1.29)	(1.29)	(2.81)**
coffee trees owned in 2002 per adult equivalent squared, hundreds	-0.056	-0.034	-0.146
	(1.08)	(0.73)	(2.63)**
hundreds of cashew trees owned in 2002 per adult equivalent	0.169	-0.770	-1.007
	(0.55)	(0.78)	(0.93)
hundreds of cashew trees owned in 2002 per adult equivalent, squared	-0.027	0.663	0.573
	(0.72)	(1.31)	(1.20)
whether produced tobacco this year	0.577	-0.168	-0.272
	(0.77)	(0.24)	(0.35)
Demographics			
dependency ratio	-0.279	0.442	-0.217
	(0.59)	(0.87)	(0.39)
head is female	0.466	-0.578	0.050
	(1.13)	(1.37)	(0.11)
age of head	-0.038	0.086	0.108
	(0.68)	(1.71)***	(1.82)***
age of head squared	0.000	-0.001	-0.001
	(0.53)	(1.99)*	(2.13)*
yrs primary completed by head	0.038	-0.031	-0.145
	(0.72)	(0.54)	(2.10)*
yrs secondary completed by head[2)]	-0.411	0.113	0.235
	(2.30)*	(0.82)	(1.63)
head is Matengo	-0.178	0.144	-0.285
	(0.45)	(0.37)	(0.64)
head is Ndendeule	-0.772	-0.379	-0.311
	(1.47)	(0.76)	(0.60)
head is Ngoni	0.265	-0.110	-0.088
	(0.59)	(0.26)	(0.19)
head is Yao	0.429	0.297	0.648
	(1.16)	(0.76)	(1.38)
head is Nyasa	-0.394		
	(0.57)		

Table 5.11 (continued): Correlates of use of savings, aid and remittances in case of a shock in Ruvuma

	(1)	(2)	(3)
	receipt of aid	**use of savings**	**receipt of aid or use of savings**
Village connectivity, infrastructure and agro-ecological potential			
tarmac road reaches village	-0.134	0.647	0.286
	(0.17)	(0.87)	(0.39)
village has cell phone signal	-0.470		
	(0.89)		
village has a market	0.302	-0.107	-0.099
	(1.14)	(0.39)	(0.30)
bus service to village	-0.007	0.709	0.689
	(0.03)	(2.16)*	(1.96)***
village has bank or other formal credit inst.	-0.020	-0.187	-0.577
	(0.05)	(0.44)	(1.12)
Constant	-1.087	-1.366	-0.373
	(0.53)	(0.69)	(0.16)
Observations	202	195	195
F stat	1.63	1.43	1.53
Prob > F	0.0289	0.0865	0.0550
Pseudo R-squared	0.2025	0.1686	0.2847

Absolute value of t statistics in parentheses; *** significant at 10%; * significant at 5%; ** significant at 1%; rainfall very low * acres cultivated/adult equivalent * used savings to cope with drought, rainfall very low * irrigated acres/adult equivalent, village electricity, village public phone, are all dropped due to collinearity; results presented allow for different correlation structures within districts, except for pseudo R-squared statistics, which are taken from a model which does not.; post-secondary education of head predicts use of savings and no receipt of aid perfectly; differing number of observations between regressions is due to the fact that observations are dropped when a variable is perfectly collinear with the dependent variable.

6 The Stated Benefits from Commodity Price and Weather Insurance

by Alexander Sarris, Panayotis Karfakis and Luc Christiaensen

6.1 Introduction

As illustrated in Chapter 3, global agricultural commodity markets for tropical products such as coffee, cashew, and others, are characterized by considerable price instability. Under the current prevailing marketing system in Tanzania, much of this price instability is transmitted to the producers, many of whom are smallholders. This induces considerable income risk, as reported in Chapter 3. Price interventions to help farmers deal with price instability usually focus on direct intervention in the product markets with the purpose of altering the price distribution either through price support policies, often backed by buffer stock policies, or through international commodity agreements. While most of the international commodity agreements have failed (Gilbert, 1996), there are still many national policies that attempt to control domestic agricultural commodity markets.

Since the 1980s a growing process of globalisation has witnessed the proliferation of markets for many financial instruments to manage risks, such as futures, options, swaps, etc. This development has also generated new ways to help farmers hedge against unforeseen price declines, based on the use of such market instruments, either directly by farmers, or via marketing and financial intermediaries.[1] Recently, these market based insurance schemes are also being piloted in developing countries. For instance, a recent initiative of the International Task Force (ITF) on Commodity Risk management, has proposed using market based derivative instruments to provide price insurance for internationally traded commodities (ITF, 1999), while other proposals have suggested using market based weather insurance to cover yield or crop income risks (Skees, Hazell and Miranda, 1999). Varangis, Larson and Anderson (2002) have suggested using combinations of the above instruments to manage agricultural market risks in developing countries.

The institution of any policy or instrument designed to insure producers against the risk of an unexpected price or yield decline must be evaluated based on a benefit cost analysis. While the costs can be estimated relatively easily, the benefits are often more difficult to ascertain, as the underlying demand for such policies by the affected groups must be assessed. Yet, this information is important to help governments decide on the usefulness and modalities of such market based price insurance schemes in helping smallholder farmers deal with commodity price and weather risks.

Moreover, given that agricultural commodity price and weather risks are only few of the many risks farmers face, the demand for agricultural price and weather based insurance, must be seen in the context of the farmer's overall exposure to a variety of shocks, as well as the already available options for the farmer to manage and cope with these risks and shocks through other means (Dercon, 2004b). As discussed in Chapter 5, while rural households manage to cope with some of the idiosyncratic and covariant shocks, rural agricultural households in Tanzania face substantial uninsured consumption risk and the currently used (self or informal group based) insurance schemes may also be costly. In other words,

[1] Harwood *et al*. (1999) survey the theoretical and empirical literature on applications of these ideas in developed countries.

estimates of the demand for price and especially weather based insurance do not only provide an estimate of the benefits from providing insurance against price and especially weather risk. They can also be seen as (lower bound) estimates of the implicit welfare cost of agricultural households' residual uninsured consumption.

This chapter helps shed light on the potential for market based insurance schemes in Tanzania by empirically exploring the demand for minimum price insurance for coffee and cashew among coffee and cashew growing farmers in Kilimanjaro and Ruvuma as well as the demand for weather based insurance among agricultural households in these two regions. We begin by describing our empirical methodology and its theoretical grounding in section 2. We then proceed by describing the cash crop marketing arrangements, the survey methodology and the estimated wtp and overall demand for coffee and cashew price insurance in Section 3. Section 4 reviews the same issues for weather based insurance. Section 5 concludes.

6.2 Empirical methodology and theoretical grounding

Assume that for a farm household time is measured in crop years, indexed by an integer T. Each crop year is divided into two, not necessarily equal, periods 1 and 2, indexed by j. The first period within each crop year is meant to represent the period after planting, but before the resolution of production and price uncertainty. The second period is meant to represent the resolution of production and price uncertainty, and the realization of annual crop income. In the first period the household income consists of sources other than agriculture, while all agricultural income is assumed to be realized in the second period (in addition to other possible sources of income). Time is indexed by an integer variable t=2T+j, where j=1 or 2. Hence, odd values of t denote the first part of any crop year, while even values the second part.

Denote the vector of consumed goods (it may include leisure) of the farm household in period t by C_t , the vector of quantities of assets in the beginning of period t by A_t , the vector of decision variables (such as inputs, land allocation, amount of insurance instruments to buy, savings and investment decisions, etc.) that are determined in period t by x_t , the information available to the decision maker at the beginning of period t by I_t (such as values of all realized economic variables as well as states of nature in previous years), and the state of nature that is revealed in the beginning of period t by S_t (this may include uncertainty about income affecting variables such as weather, prices, sickness, etc.). Also denote by p_{At} , p_{Ct} and p_t , the vectors of prices of assets, consumption goods, and income earning activities (including labour) respectively at time t. Denote by $U(C_t)$ the instantaneous household utility in period t.

The household is postulated to maximize the ex-ante expected value of the discounted sum of instantaneous utilities, over n crop years:

$$W = E\{\left[\sum_{t=1}^{2n} \delta^t U(C_t)\right] / I_1\} \tag{6.1}$$

where δ is an appropriate discount factor. The expectation in (6.1) is taken over all states of nature S_t (t=1,2,,.,2n), based on information at the beginning of the relevant horizon for the household. The maximization will be assumed to be over all sets of decision vectors x_t. The restrictions relating the various variables are the following.

$$p_{At}A_{t+1} = p_{At}A_t + p_t y_j(A_t, x_t, S_t) - p_{Ct}C_t \equiv R_t - p_{Ct}C_t \qquad (6.2)$$

$$x_t \in X_t \qquad (6.3)$$

Equation (6.2) defines the value of end of period assets at period t prices. The variable R_t denotes the value of resources available to the household at the beginning of period t, namely previous period assets valued at current period prices, plus current income from these assets. X_t is an appropriate constraint set for the decision variables, and y_j (.) denotes the vector of quantity of netput activities (positive if outputs, negative if inputs) affecting the income of the household in period t.[1] The subscript j in the income function denotes the possibility that income sources may be different in the two periods of each crop year. Notice that no restriction is placed on the sign of assets. Hence negative assets (namely liabilities such as borrowing) are allowed in this general formulation. If the household is liquidity constrained, then the restriction that some or all assets should be non-negative must be imposed (Deaton, 1991).

The nature of the solution to such a problem is theoretically well known, (e.g. Deaton, 1992a, Zeldes, 1989). In general the solution is not analytically tractable, and can be written as:

$$C_t = f(A_t, y_j(A_t, S_t), p_t, p_{At}, p_{Ct}) \qquad (6.4)$$

If an equation like (6.4) is the solution to the overall optimization problem (6.1)-(6.3), then the utility function in (6.1) can be rewritten as follows.

$$W = E\left\{ \{\sum_{T=0}^{n} \delta^{2T}\left[U(C_{2T+1}) + \delta E\left(C_{2T+2} \middle| I_{2T+1}\right)\right]\} \middle| I_0 \right\} \equiv E\left\{ \sum_{T=0}^{n} \delta_1^T V(C_{2T+1}, I_{2T+1}) \middle| I_0 \right\} \qquad (6.5)$$

In (6.5) $\delta_1 = \delta^2$, the consumption within the various parentheses and brackets has a form like (6.4), and the function V just defines the quantity inside the bracket in the left had side of (6.4). The expectation inside the brackets are taken conditional on information available in the first period of a given crop year T, while the unconditional expectations outside the brackets are taken with information available in the beginning of the planning horizon, namely year 0[2].

Consider the provision of an insurance contract to the farmer in the first period of the crop year, whose outcome depends on events of the second period. The contract considered could be in the form of an option to sell all or a portion of a produced crop at a minimum "strike" price.[3] Denote the amount of the crop that is insured as q (can be fixed or variable), and the return to the insurance contract per unit of the insured crop as r. Alternatively, the insurance contract could guarantee a minimum return per acre (r) in case of a weather/rainfall shock and q could be seen as the amount of acres insured.

---

[1] The returns to any financial assets, such as interest on deposits or loans, are included in the income terms. Similarly the depreciation of physical assets can also be considered as included in y in this general notation.

[2] If the two periods within the crop year are different in duration, the discount rate within the bracket in the left hand side of (5) will be different than the discount rate outside the same bracket.

[3] Commodity minimum price insurance for an agricultural producer functions like a put option, or a minimum price guarantee. In other words it guarantees for the amount of contracts purchased or quantity covered, and over a period stated in the contract, a minimum price (the strike price of the option like contract), but allows the producer to obtain a higher price.

If we assume that the nature of the function f in (6.4) is not affected by the provision of this contract, then we can define the benefit of this contract as the amount that must be subtracted from income of the first period in the crop year, so that the two-period utility with the contract is equal to the utility without it. Analytically we define the benefit in year T to be the solution B to the following implicit equation.

$$U(C_{2T+1}(y_1 - B)) + \delta E\left[U(C_{2T+2}(y_2 + rq)) \middle| I_{2T+1}\right] = U(C_{2T+1}(y_1)) + \delta E\left[U(C_{2T+2}(y_2)) \middle| I_{2T+1}\right] \tag{6.6}$$

The key assumption that allows the definition in (6.6) is that the nature of the income generating function $y_j(.)$, as well as the consumption function (6.4), are not altered by the provision of insurance. This, of course, is not strictly correct, as the household may adjust its long term exposure to risk as is implied by theory. Given that the nature of the changes in the income functions as well as the consumption function under insurance are quite intractable, the assumption can be considered as a first approximation, and one that can facilitate the estimation of the "minimum value" of WTP, for such insurance contracts. In other words, the estimated benefit, and WTP can be considered as the minimum demand for price insurance. Any changes in production structure, induced by the provision of the insurance, will provide an additional benefit, and will not be considered here.

The implicit function B that can be derived from (6.6) is generally impossible to solve analytically. Sarris (2002) derived one such function analytically from (6.6) by approximating the consumption by a linear function of current resources R_t, and making several other simplifying assumptions. He showed that this function depends on the degree of consumption smoothing, the degree of farmer risk aversion, the current level of resources of the household, the expected value and variability of the returns of the insurance contract, and on the correlation between the return of the insurance contract with the current level of resources.

His analysis, led to several conclusions compatible with intuition. For instance, the larger is the degree of risk aversion, and the smaller is the degree of consumption smoothing, the larger is the benefit of insurance. Second, the larger is the degree of (unpredictable) deviation of current resources from normal/average (positive or negative), the larger is the WTP for insurance. Third, the larger is the variance of the return of the insurance contract, the lower the WTP for it. Finally the WTP for an insurance contract is larger with a more negative correlation between the return to insurance and the second period resource uncertainty. These are all variables that should enter in an estimation of the WTP for insurance.

There are direct and indirect ways to estimate the willingness of households to pay (WTP) to avoid adverse price or weather related agricultural income shocks. One method involves utilizing household surveys, coupled with exogenous time series information on shocks of variables such as prices and yields (for an application of this method see Sarris, 2002). The weakness of these indirect methods lies in the fact that the surveys utilized are not designed for the purpose of exploring issues of vulnerability and insurance. Direct methods on the other hand involve household surveys designed specifically to elicit the estimates of vulnerability and demand for insurance by households. There are very few such studies, a recent example being McCarthy (2003). This paper follows the direct approach.

The direct or "contingent valuation" (CV) methods are based on direct questioning of agents (producers, households, etc.) on how much they are willing to pay for avoiding an undesirable event, or for having available a possibly welfare improving instrument such as a given amount of an insurance contract. The major problems with this approach have largely to do with the specification of the "scenario" or the "benchmark" against which the agent is supposed to compare the current situation, and express a monetary value for what it is worth to him/her to move to the new situation, or avoid a bad one. It is not always easy to specify this scenario well, especially if it involves a rather improbable event, and this lies at the heart of most criticisms of this approach (see e.g. the papers in Hausman (1993)). However, in the case of well specified risks, such as price or yield variations, it is likely that farm households are familiar not only with their normal values, but also with their variability over time, and hence the above criticism may not be valid.

The basic theory of the CV approach has been known for some time, and a comprehensive survey can be found in Hanemann and Kanninen (1998) (herein HK). The idea favoured by current CV practice is to ask each respondent a closed form question, namely whether they would accept to pay a given amount to obtain a given change in their status quo. Hence the answers obtained are of the "Yes" or "No" type, necessitating a theory of how to translate these discrete responses into meaningful WTP estimates. Following HK, suppose that a respondent is asked to consider the change from the status quo q^0 to q^1, where q^1 refers to the value of an as yet non-existent good, such as an insurance contract, and presumably the latter choice is preferable to the former. Denote the indirect utility of the respondent as v(p,q,y,s,ε), where p is a vector of prices for all the market goods currently available, y is the respondent's income, s is a vector of respondent characteristics, and ε is the stochastic component of utility. This utility, for the problem at hand corresponds to the indirect utility defined in (6.5). Then if the respondent is asked whether he would be willing to pay an amount A to obtain q^1, his answer would be "Yes" if the following condition holds (where Pr denotes the probability):

$$\Pr\{response \quad is\text{"}Yes\text{"}\} = \Pr\{v(p,q^1,y-A,s,\varepsilon) \geq v(p,q^0,y,s,\varepsilon)\} \tag{6.7}$$

If we denote by B the maximum WTP for the change from q^0 to q^1, corresponding to what was defined in (6.6), then B is defined implicitly by the condition:

$$v(p,q^1,y-B,s,\varepsilon) = v(p,q^0,y,s,\varepsilon)\,. \tag{6.8}$$

This implies that B is a function of all the same variables that enter the function v(.). Hence condition (6.7) can be written equivalently as:

$$\Pr\{response \quad is\text{"}Yes\text{"}\} = \Pr\{B(p,q^0,y,s,\varepsilon) \geq A\}\,. \tag{6.9}$$

As B is a random variable, let $G_B(.)$ be the cumulative distribution function (cdf) of B. Then (3) translates into the following:

$$\Pr\{response \quad is\text{"}Yes\text{"}\} = 1 - G_B(A)\,. \tag{6.10}$$

When G=Φ, namely the standard normal cdf, and when B has mean equal to μ and variance equal to σ2 then one has a probit model:

$$\Pr\{response \quad is\text{"}Yes\text{"}\} = \Phi(\frac{\mu - A}{\sigma})\,. \tag{6.11}$$

Hence if we estimate a probit model of the type:

$$\Pr\{response \quad is\text{"}Yes\text{"}\} = \Phi(\sum_{i=1}^{n} \beta_i X_i - \gamma A)\,. \tag{6.12}$$

The no stochastic part of the WTP can be derived by the simple formula:

$$B = \frac{\sum_{i=1}^{n} \beta_i X_i}{\gamma} \tag{6.13}$$

The same formula is derived if the assumed cdf of B is logistic, giving rise to a logit model. As B is specified to be stochastic, the assumed distribution of the error term entering B, gives rise to estimable equations identical to (6.10). Under the assumption that the utility function is linear (the most common assumption), and that the error term is normal, the same probit model as in (6.12) arises. In this paper we utilize the probit approach, and hence formula (6.13) for the estimation of the WTP.

6.3 The demand for coffee and cashew price insurance

6.3.1 Cash crop marketing and price variability

Despite the fact that cash crops constitute significant shares of cash income, especially in Ruvuma, the amounts produced and marketed by each household are quite modest. In Kilimanjaro the average amount of coffee produced per household is only 50-60 kg, while in Ruvuma it is around 250-350 kg. This is in line with the larger shares of cash income derived from coffee in Ruvuma, as indicated in Chapter 2. Cashew nut producers sell on average 200-300 kg per year, while tobacco producers sell on average 300-350 kg.[1]

The majority of those selling coffee sell their coffee to primary cooperative societies. Only about 15-20 percent of coffee producers in both regions sell to private buyers highlighting the continuing importance of cooperatives. There are only very few who sell to both primary societies as well as private buyers. Cashew producers sell largely to private buyers, while tobacco is largely sold either on contract to tobacco companies, or to private buyers for these companies.

The average prices received, including both initial and subsequent payments, appear similar among those selling to primary societies and those selling to private buyers. However, there is considerable variation in the prices received by producers in the same year (Figures 6.1 and 6.2). While the distribution or prices received by producers from primary societies has lower variance than the distribution of prices received by private buyers, in both cases the dispersion of the distributions are substantial, indicating that prices received are influenced by a variety of factors other than the price in the main auction market. Figure 6.3 illustrates the prices received in Ruvuma by cashew producers (selling mostly to private buyers) in 2003 and 2004. Again, apart from the large difference in the average prices received in 2003 and 2004 (Tsh 441/kg in 2003 versus Tsh 624/kg in 2004), there is considerable dispersion of prices received within the same period. Tobacco producers constitute only a small portion of the total sample and the prices they receive seem to be more uniform.

Figures 6.4 and 6.5 illustrate a statistic designed to capture the degree of coffee price variability to producers. The survey asked about the maximum and minimum prices received by farmers over the past ten years. It also asked about the average prices (from all types of buyers) received in the season of the survey, as well as the two previous seasons. We

[1]These figures are based on a small sample of tobacco growers in Ruvuma. As very few among them indicated an interest in insurance, we did not estimate their demand for insurance.

calculate the ratio of the difference between the maximum and minimum reported total price during the last decade and the average total weighted (from all buyers) coffee price received over the last three years and plot its distribution for coffee in Kilimanjaro (Figure 6,4) and cashew nuts in Ruvuma (Figure 6.5).

Again, there is a wide spread in this statistic. While part of this variability for coffee is due to the secular decline of coffee prices over the past 10 years, it nevertheless implies that there has been very high variability in the price received for coffee and cashew nuts by producers in the last ten years. More importantly the degree of price variability varies considerably among various producers. The variability faced by tobacco producers is much smaller than that of coffee producers (about 25-30 percent of that experienced by coffee producers, as derived by comparing the mean values of the type of statistic indicated in figures 6.4 and 6.5). This may be due to the fact that most tobacco is produced under contract.

6.3.2 Interest in and demand for minimum price insurance

The survey asked a variety of questions related to coffee and cashew price insurance. All these questions immediately followed a series of questions about the prices coffee farmers received during the past decade. Their memories about the distribution of coffee prices and their evolution were thus refreshed. The insurance module first asked whether farmers were familiar with the functioning of an insurance contract works. Subsequently, a detailed description was given of how the minimum price contract that resembles a put option on price would work. After this description they were asked whether such a contract would interest them. If the answer was positive, the questionnaire proceeded to ask whether farmers would be willing to pay various amounts for given minimum price contracts.

In particular, coffee farmers were asked about their WTP for a contract paying a minimum of Tsh 400 per kg, or one paying a minimum of Tsh 600 per kg or one paying Tsh 800 per kg for coffee marketed in 4-5 months time from the period of the survey. The 4-5 month advance period over which the hypothetical contracts were structured relate to the time of the survey relative to the time of the new crop harvested in the next marketing year. For cashew nuts the contracts were for Tsh 300, 450 and 600 per kg, and the advance period was 6-10 months.

Each farmer was asked whether he/she would be willing to pay a certain amount for each of these contracts, and the answer was yes or no. For each contract five different bid values (namely prices to pay) were selected. For instance, for the coffee contract that stipulated a minimum price of Tsh 400 the bid values were Tsh 5, 10, 20, 50 and 100. Each farmer was randomly assigned to answer whether he/she would be willing to pay one of these bid values. In other words each farmer was asked about only one bid value for each contract.

In particular, in each village, the sample was randomly assigned in 5 groups and each group was presented with a bid. The first group was asked whether they are willing to pay Tsh 5 for the contract with minimum price Tsh 400, Tsh 10 for the contract with minimum price Tsh 600, and Tsh 20 for a contract with minimum price Tsh 800. The second group was asked whether they were willing to pay Tsh 10, 20 and 50 for each of the above three contracts respectively. The third was asked whether they were willing to pay Tsh 20, 50 and 100 for each of the above three contracts, the fourth was asked whether they were willing to pay Tsh 50,100 and 200 for each of the above three contracts, and the fifth group was asked whether they were willing to pay Tsh 100,150 and 300 for each of the above three contracts.

Tables 6.1 and 6.2 indicate the expressed interest of farmers in minimum price insurance for coffee and cashew nuts, after it was explained to them how it would work. It can be seen that this interest shifts over time. About a third of the heads of coffee producing households who indicated that they were interested in minimum price insurance in the first round, indicated that they were not interested in the second. However, about half of those who in the first round indicated that they were not interested in minimum price insurance, changed their mind in the second round. Similar results obtain for cashew nut producers in Ruvuma. These changes maybe related to the experiences of producers in each year, and highlight the fact that demand for insurance is state dependent. It may also be that while the households sampled were the same the respondents were different.

The WTP questions were administered only to those household heads who declared that they were interested in price insurance. This procedure could have introduced a sample selection bias in the estimations below, and for this reason we examine the determinants of those more likely to be interested in participating in price insurance.

Tables 6.3 and 6.4 indicate the probit selection equation among coffee producers in Kilimanjaro and Ruvuma respectively, while Table 6.5 reports the same equation for the cashew nut producers in Ruvuma. The selection equations fit relatively well, despite the low pseudo-R squared. The percentage of correct predictions (based on probability fitted values from the regressions of larger or not than 0.5) is more than 70 percent in most cases.

In general the following types of variables are utilized. First, we use household characteristic variables, such as education. Second, we use income structure and level variables such as per capita income, wealth, shares of cash to total income, share of coffee in total income, whether cash income from coffee is important, a banana production dummy, the share of coffee input costs in total coffee production value, easy access to seasonal credit, and the Herfindhal index of cash income concentration. Third, we use variable designed to proxy for recent conditions, such as the level recent prices received. Fourth, we use variables designed to indicate the level of instability faced, such as the range or prices received in the last ten years (already discussed), the number of years in the last 10 years when coffee cash income or total income fell below 50 percent of normal, or whether the household perceives cash crop income as very unreliable. Finally, we use variables designed to capture the importance of different coping mechanisms to shocks affecting livelihoods. The four mechanisms we capture with respective dummies are whether in response to a shock in the past (the shocks can be any of a variety of inquired shocks, such as an illness, death, drought, theft, loss of crops or livestock, etc.) the household used its own savings or other own resources, assistance from other non-household family, assistance from non-family (including friends, neighbours, NGOs, government, etc), or whether it ought to find new ways to generate income. In all empirical regressions village level effects were included, but are not reported.

These groups of variables are designed to proxy for the types of variables suggested by the theory. For instance the degree of risk aversion can be related to the level of wealth and income, while the degree of consumption smoothing to the dummies discussed above. The degree of deviation of current resources from normal/average is proxied by the variables relating to income instability and price instability, the conditional variance of the return of the insurance contract by the recent price coupled with the price variability variables. Finally the correlation between the return to insurance and the second period resource uncertainty can be proxied by the structural variables relating to the importance of coffee to the overall income.

There are not many variables that appear to affect the desirability of insurance by farmers. Concerning coffee producers in Kilimanjaro it is only the price received and variability dummies that are significant. These dummies are designed to control for households that did not report a price for coffee sales, and there are several of those. They are equal to 1 if the household, despite the fact of being a coffee producer has not made any sales this year, and hence does not report a price. The same holds for the price variability. In round 1 it is only the dummy for price received that is significant, while in the second round the total number of coffee trees is significant and positive, and the dummy which is equal to 1 if the family uses family assistance as a shock mitigating strategy is significant.

For coffee producers in Ruvuma, round 1 indicates that the interest in insurance increases with the variability of coffee income, when coffee income is important for the household, and decreases when own savings and resources are used as coping mechanisms. All these are consistent with intuition. In the second round the same variables are significant with the same signs, except for the savings coping variable, which now is insignificant, while the coping mechanism relating to new ways of earning income is significant and positive.

Concerning cashew nut producers in Ruvuma, in round 1 only the variable denoting that cashew nut sales are important in the household is significant and positive, while in round 2 wealth is negatively significant, the unreliability of cashew income is negatively significant the easy access to credit is positively significant, and three of the four coping mechanisms are significant, of which one (coping with own savings) is negative, while the other two (use family assistance, and seek new ways to earn income are positive).

The above results suggest that there does not seem to be clear differentiation between those that are interested in insurance and those that are not, at least not as far as the main income variables are concerned. Any differentiation seems to be mostly with respect to the income instability variables and the household coping mechanisms, something that is reasonable.

Tables 6.6 and 6.7 exhibit the results of the WTP probit regression (akin to equation (6.11) earlier) for coffee in Kilimanjaro and Ruvuma respectively from round 1, while Table 6.8 indicates the results for cashew nuts in Ruvuma from round 1. Each column in these tables presents the results concerning one of the three hypothetical administered contracts. The first notable observation is that in all regressions the coefficient of the bid value is negative and significant as expected. In Kilimanjaro income and the number of coffee trees affect negatively the WTP, while the total value of wealth affects it positively. Income structure variables, such as whether cash income from coffee is important, as well as instability variables, and exposure variables such as the Herfindhal index, are positive, while coping mechanism variables, as well as easy access to credit affect the WTP negatively, as expected. The predictive power is quite high, with more than 70 percent correct predictions.

The results for coffee in Ruvuma in Table 6.7 are a bit weaker in the sense that not as many variables are significant, though with more than 80 percent of the answers correctly predicted, the share of correctly predicted values is very good. Income, the importance of coffee in income, easy access to seasonal credit, affect the demand for insurance positively, while the share of cash to total income, the number of coffee trees, past price variability, and the coping mechanism involving the use of new ways to earn income, affect it negatively.

The results for cashew nuts in Ruvuma in Table 6.8 are similar to those for coffee. Income, the number of cashew trees, the importance of cashew income, and whether cashew income declined in the recent past, affect the WTP positively, while the ease of access to seasonal credit, and the coping mechanism relating to use of new ways to earn income affect it negatively.

Tables 6.9 and 6.10 for coffee in Kilimanjaro and Ruvuma respectively, and Table 6.11 for cashew nuts in Ruvuma indicate the summary statistics of the individual WTP values computed for each household. These values were computed for each household as indicated earlier in equation (6.13), utilizing the directly estimated values of the coefficients, and the household specific values for its characteristics, and averaging the results. The estimated WTP values for some households were negative. For such households this result can be interpreted as indicating low or no interest in insurance, and for them the individual WTP was set at zero in estimating the averages. Such households accounted for about 17-19 percent of households for the lowest priced contract, but for much lower shares for the middle priced contract (2-7 percent), and for less than one percent for the higher prices contract.

The results indicate that in Kilimanjaro coffee producing households that are interested in minimum price insurance, are willing to pay on average 23-29 percent of the underlying contract value as premium for the insurance. In Ruvuma, a poorer region, coffee producers that are interested in minimum price insurance are willing to pay on average between 13 and 30 percent of the underlying contract value. For Ruvuma, cashew nut producers the WTP averages also between 12 and 20 percent. These are considerable values, given the generally low incomes of producers.

The round 2 results are not as robust as the ones of round 1. For the Tsh 400 and 600 coffee contracts in Kilimanjaro, the coefficients of the bid value are positive and significant, which is counterintuitive. For Ruvuma coffee producers, the bid value coefficients are all negative, as expected, but the ones for the two lowest prices are not significant. For cashew nuts in Ruvuma, the bid value coefficients are negative, and only the first one is non-significant. The reason for these results may be that the average price of coffee as well as cashew nuts increased considerably between the first and the second rounds, while the contract values were not adjusted in the second round survey. In Kilimanjaro the average price received by producers went from Tsh 481/kg in the first round to Tsh 619 in the second, and in Ruvuma from Tsh 385 to 619/kg. For cashew nuts the average prices increased from Tsh 437 to 633 per kg. This may have affected the perception of producers concerning several variables in the desirability of minimum price insurance, as well as the amounts producers are willing to pay for it. Nevertheless, the variables affecting households' willingness to pay in the second round regressions are quite similar to those in the first round.

Table 6.12 indicates the summary statistics for the WTP for the cases where the probit regressions in the second round result in a significant and negative coefficient for the bid value. The average WTP for minimum price insurance in round 2 for the third coffee contract is higher in Kilimanjaro than the one estimated in round 1 (338 versus 233). The opposite holds for Ruvuma coffee producers, for the two contracts exhibited, and with much higher differences between the two rounds (for instance for the Tsh 600 minimum price contract the second round average WTP for insurance is Tsh 27.7 versus 110.7 in round 1). For cashew nuts the results are similar, with the average WTP for the first of the two exhibited contracts much lower in the second round (Tsh 36.56 versus 59.7 in round 1).

The results reported thus far have been based on estimations only among those who declared that they were interested in insurance. This may create problems of selection bias. For this reason, we also tried re-estimating the WTP probit regressions correcting for selection bias.

In all cases, however, the selection coefficient turned out to be not significantly different than zero, and this implies that there is no selection bias in our estimates.

6.3.3 The societal benefits from providing minimum price insurance

Given that the results suggest that there is considerable demand for minimum price insurance, it is interesting to ascertain the overall demand curve for such type of insurance. To do this we first rank all estimates of WTP for the households in descending order. For each point estimate, we compute the value of the cash crop that has been produced by the respective household. As the questions asked in the survey implied that any price insurance would involve all produced quantity, we assume that the farmer, when answering "yes" to a WTP question he/she implies that all quantity produced would be insured. The quantity produced by each household was then multiplied by the sampling weight corresponding to the household. For each new value of the WTP, the quantity desired is equal to the quantity desired at the immediately larger value plus the quantity desired for the specified value.

Figures 6.6, 6.7, and 6.8 indicate the scatter plots so derived for the three hypothetical contracts administered in Kilimanjaro in round 1, along with the best quadratic fits. Figure 6.9, 6.10, and 6.11 repeat this for coffee producers in Ruvuma, while Figures 6.12, 6.13, and 6.14 do the same for cashew nut producers in Ruvuma. All plots clearly show a relatively smooth downward pattern (which of course was by design, but could have been much less smooth than indicated). The quadratic fits are very good, with R squared in all cases larger than 0.88. The figures indicate, as expected, that for a given premium (namely value for the WTP) the demand increases as the insured price increases.

Given the demand curves, it is simple to compute the total consumer surplus, namely the area above a given WTP and below the demand curve, for any given contract. Tables 6.13, 6.14, and 6.15 present these estimates for a range of hypothetical premiums, along with the estimates of the amount of coffee that would be insured, the number of producers affected, and the total cost and consumer surplus (welfare) of the insurance. The premiums for which the computations have been carried out are the average WTP, the same average plus one standard deviation, and the average minus one and two standard deviations. In some cases the average WTP minus 2 standard deviations was less than zero, and in this case the surplus was not computed.

The results indicate that the majority of coffee producers, as well as production in both regions of Kilimanjaro and Ruvuma, would be benefit substantially from the provision of insurance. The welfare benefit, net of cost, as proxied by the consumer surplus, increases considerably with decreases in the premium, and reaches more than 50 percent of total coffee sales for some contracts and for very low values of the premium.

6.4 The stated demand for and societal benefits from weather based insurance

6.4.1 Perceptions concerning rainfall

In order to elicit households' demand for weather based insurance it is important to have an idea of how households perceive the incidence of drought. While a rainfall based insurance contract could be based on an objective rainfall index, such an index is certainly not available at the village level, and the farmers are not aware of it, and hence one has to rely on perceptions of rainfall. In this study the responses are based on questions that are anchored around various levels of rainfall, as perceived by the farmers.

Table 6.16 gives a first indication of this. Households were asked to report in how many years out of the last ten the rainfall in their farms was much below normal, somewhat below normal, normal, somewhat above normal and much above normal. The table reports the percentage of households in each rainfall category that report a given number of years in the given class. For instance in Kilimanjaro, 32 percent of households report that in 2 out of the last 10 years rainfall on their farms was much below normal. Similarly 81.1 percent of households reported that there was only 1 out of the past 10 years when rainfall was much above normal. From Chapter 2 we know that the incidence of drought (or rain much below normal) was much higher in Kilimanjaro than in Ruvuma. Table 16 corroborates this. There is much higher incidence of reporting of 2-4 years out of 10 of rainfall much below normal in Kilimanjaro compared to Ruvuma.

The survey asked not only household perceptions of rainfall in their farms, but also the perceptions of village officials for the village as a whole. Table 6.17 reports the average number of years perceived by households in the various rainfall classes, and compares them with those of the village chairmen or other officials interviewed for the village questionnaires (the sum of the entries across columns is equal to 10). While as far as the two extreme rainfall ranges (much below normal and much above normal) the average responses of households and village chairmen are quite similar, this is not the case with the responses in the next range (somewhat below and above normal). It appears that there are differing perceptions about what constitutes somewhat below and somewhat above normal rainfall, while much less disagreement as to what constitutes major rainfall shortages and excesses.

In this context it is interesting to explore the similarity of responses of farmers. This is interesting not only to elicit perceptions, but also to gauge whether rainfall patterns are similar for all farmers within a village. In Tanzania, farms within villages are quite dispersed, with distances between farms within the same administrative village sometimes or more than 10 kilometres. Hence it is important to understand the uniformity of rainfall patterns, at least as perceived by farmers. Tables 6.18 and 6.19 illustrate with two different indices the similarity between the responses of farmers to the questions of the types of rainfall experienced. Both indices manifest the same pattern. This is that in Kilimanjaro there seems to be considerable similarity in farmers' perceptions of rainfall in the various ranges, while in Ruvuma there is more disagreement in perceptions of farmers about what constitutes rainfall much below and much above normal, as well as in the other ranges.

Another issue concerns the relation between the subjective perception of rainfall, as falling in one of the various classes and the actual rainfall, again as perceived by farmers. Table 20 illustrates the responses of households concerning how they would classify rainfall when objectively the rain in a given year is a certain amount below normal. It can be seen that for small negative rainfall deviations ($^1/_{10}$ and ¼ below normal) the households have differences in perceptions (especially between classifying as rain being somewhat and much below normal). However, when it comes to rainfall below $^1/_3$ or ½ of normal, then there are uniform perceptions, namely that in such cases rainfall is much below normal. The reason for which these figures are important, is because the estimates on the basis of which the contracts specified for the questionnaire, as well as the amounts of income shortfall estimated are based on such perceptions.

6.4.2 Interest in and WTP for rainfall insurance

The survey subsequently asked a variety of questions related to rainfall based income insurance. At first the concept of rainfall insurance was explained and farmers were asked whether they were interested in such insurance. After this question, the questionnaire proceeded to ask whether farmers would be willing to pay various amounts for given rainfall based contracts. It is of considerable importance to design rainfall based contracts that are relevant to the farmers' income, as well as perceptions of rainfall. This is a difficult technical issue in itself, and is explained in detail in Appendix A to this chapter. The main point to highlight here is that the first round survey was utilized to design the contracts, namely the indemnity values, as well as the appropriate thresholds of rain for the different contracts. It is furthermore underscored that the questions discussed in the previous section preceded the WTP questions to implicitly help people refresh their memory about the concepts of probability and distribution of rainfall.

Table 6.21 indicates the reasons for which some households declared that they were not interested in the rainfall based insurance contracts. The interest in rainfall insurance is much higher in Kilimanjaro (47 percent of households), compared to Ruvuma (34 percent of households), but overall the interest is not universal. This reflects the fact that rainfall is much more reliable in Ruvuma, as already discussed. The major reason for lack of interest in Kilimanjaro was lack of funds to pay for it at any price. In other words, in the absence of liquidity constraints, interest in Kilimanjaro would be even higher. In Ruvuma, a large share declared that droughts were infrequent, and when occurring would not hurt them too much.

Each farmer was offered two different types of rainfall based contract. The first type involved a hypothetical rainfall reduction of 10 percent below normal rainfall, and the second a hypothetical rainfall reduction of 33 percent ($^1/_3$) below normal. For each hypothetical scenario three contracts were designed, offering a progressively higher indemnity under the given rainfall shortfall, for a correspondingly higher premium. This was done, in order to capture all the different income classes within the sample, and as it was impossible a-priori to know the income class of the farmer interviewed. Hence each farmer was offered six different hypothetical contracts. For each one of these there were five different options for the premium, structured around what was estimated (see Appendix A) as the actuarially fair premium for that type of contract. Farmers were split randomly in five even groups in each village and within each group each farmer was given a different unique choice among the five premiums.

Apart from the results of Table 6.21, we explored the desirability of drought insurance via a probit regression. Table 6.22 exhibits the results. Significant variables are education of head (positive but in Ruvuma only), per capita income (positive but in Kilimanjaro only), easy access to short term credit (positive in Ruvuma only), and a cashew production dummy. These results suggest that the more educated and the higher income a household head has, the more likely it is that he/she will understand and appreciate income insurance.

Irrespective of their answers to the desirability question all farmers were asked about their willingness to pay specific amounts for rainfall insurance. Tables 23 and 24 indicate the probit regressions concerning Kilimanjaro and Ruvuma, for the hypothetical contracts that stipulated 10 percent rainfall decline. Tables 6.25 and 6.26 repeat this for the contracts that stipulated $^1/_3$ below normal rainfall decline. In general the following types of variables are utilized. First we use household characteristic variables, such as education of head and household size. Then we use wealth variables such as per capita income and wealth, cultivated land size, number of trees and animals owned, and size of cultivated land. Thirdly we use diversification variables, such as the Herfindhal index of total gross income diversification and the share of cash in total gross income. Fourth we use variables designed to proxy for recent conditions, such as whether the household experienced recent drought. Fifth we use variables designed to indicate the level of instability faced, such as the number of years in last 10 when income was much below normal or cash crop income was much below normal. Sixth we use variables designed to indicate how households deal with adverse income shocks, such as dummies indicating what type of coping mechanism was used when faced with shocks. Finally we use specific crop production dummies, to capture attributes related to production of specific crops.

These groups of variables are designed to proxy for the types of variables that the theory mentioned earlier points to. For instance the degree of risk aversion can be related to the level of wealth, while the degree of consumption smoothing to the dummies discussed above. The degree of deviation of current resources from normal can be proxied by the variables relating to income instability, and the correlation between the return to insurance and the second period resource uncertainty can be proxied by the structural variables relating to the production of specific crops, or the share of cash in total income.

The coefficients of the bid values are everywhere negative as expected, and significant in all cases in Kilimanjaro but only in few cases in Ruvuma. In Kilimanjaro other significant variables appear to be the size of household (positive), per capita income (positive), the share of cash in total income (positive), and two coping variables, the one indicating that the household uses own savings when facing a shock (positive), and the one indicating that the household used family assistance when in shock (negative). These results suggest that higher income and exposure to the market make households more sensitive to income instability, and thus more open to paying for additional income insurance. It is likely also related to the liquidity constraint, as households with larger incomes are likely to be less liquidity constrained to pay the premium and buy the insurance. Also it appears that the type of coping mechanism makes a difference in their desire for weather insurance. If they use mostly own savings, namely if they self insure, they seem to be more open to external insurance. If, on the contrary they use family assistance, they seem to consider this enough of a safety net, and they are less open to paying for additional drought insurance. Alternatively, the cost of self insurance may be much larger than the cost of mutual insurance.

In Ruvuma, while all the coefficients of the bid values are negative, only one is significant. Other variables that appear significant are the level of education of the household head (positive), and the same types of coping mechanism dummies as in Kilimanjaro. The lack of significance of the bid values indicates much less interest in drought insurance in Ruvuma, a conclusion that is consistent with earlier results that indicated both less interest in drought insurance in Ruvuma as a result of more stable rainfall patterns, but also with the lower general incomes in Ruvuma. Despite the non-significance of most variables, however, and the low pseudo R-squared values, the proportion of correct predictions (on the basis of a probability larger than 50 percent is larger than 70 percent in all cases.

Tables 6.27 and 6.28 for Kilimanjaro and Ruvuma respectively indicate the summary statistics of the individual WTP values computed for each household. These values were computed for each household as indicated earlier in equation (13), utilizing the directly estimated values of the coefficients, and the household specific values for its characteristics, and averaging the results. The estimated WTP values for some households were negative. For such households this result can be interpreted as indicating low or no interest in insurance, and for them the individual WTP was set at zero in estimating the averages. Such households accounted for about 30-40 percent of households in Kilimanjaro and more than 50 percent of households in Ruvuma, consistent with the indicated interest in a weather based insurance contract.

The results indicate that in Kilimanjaro households who are willing to pay some amount for rainfall insurance, are willing to pay on average 12-23 percent of the underlying indemnity value as premium for insurance against a 10 percent rainfall decline. They are willing to pay considerably less, between 10-14 percent for insurance against the more improbable, but more detrimental event of 30 percent rainfall decline. In Ruvuma, a poorer region, and a more reliable one from a rainfall perspective, producers are much less interested in rainfall insurance, but those exhibiting a positive WTP for rainfall insurance, are willing to pay on average 18-40 percent of the underlying indemnity value for insurance against a 10 percent rainfall decline. They are willing to pay considerably less, 0.7-1.2 percent for insurance against the more improbable event of 30 percent rainfall decline. These results suggest that it is mainly in Kilimanjaro where rainfall insurance appears viable, while in Ruvuma, there is a small group of households (fewer than 20 percent) willing to pay considerable amounts for rainfall insurance against a rather frequent event, namely rainfall declines of 10 percent.

6.4.3 The demand curve for rainfall weather insurance and the welfare benefit for providing it

Given that the results suggest that there is considerable demand for weather insurance, at least in Kilimanjaro, it is interesting to ascertain the overall demand curve for such type of insurance. To do this we utilize the following method. We first rank all estimates of WTP for the households in descending order. For each point estimate, we have independent estimates from the questionnaire concerning the number of acres, households would be willing to insure at each contract. The area each household is willing to insure was then multiplied by the sampling weight corresponding to the household. For each new value of the WTP, the quantity desired is equal to the quantity desired at the immediately larger value plus the quantity desired for the specified value.

Figure 6.15 indicates the scatter plots so derived for the three hypothetical contracts administered in Kilimanjaro for the 10 percent rainfall reduction scenario. Figure 16 does the same for the 30 percent rainfall reduction scenario, Figures 6.17 and 6.18 repeat the same for Ruvuma. All plots clearly show a relatively smooth downward pattern (which of course was by design, but could have been much less smooth than indicated). The quadratic fits are very good in Kilimanjaro, with R squared in all cases larger than 0.9, and larger than 0.8 in Ruvuma. The figures indicate, as expected, that for a given premium (namely value for the WTP) the demand increases as the insured price increases. For Ruvuma, as already discussed the demand is much less, and the corresponding quadratic fits much weaker.

Given the demand curves, it is straightforward to compute the total consumer surplus, namely the area above a given WTP and below the demand curve, for any given contract. Tables 6.29 and 6.30 present these estimates for Kilimanjaro for a range of hypothetical premiums, along with the estimates of the number of acres that would be insured, the number of producers affected, and the total cost and consumer surplus (welfare) of the insurance. The premiums for which the computations have been carried out are the average WTP, and the same average plus one standard deviation (we would have liked to include also estimates for the average WTP minus one or two standard deviations, but as seen in Tables 6.27 and 6.28, the standard deviations of the WTP are in most cases larger than the mean, so this was not possible).

The results indicate that in Kilimanjaro for the 10 percent rainfall shortfall case, about 18-25 percent of households would purchase the insurance at the average WTP, insuring between 42-49 percent of their total acres cultivated. The premium paid would constitute 2.8-11 percent of total crop sales, and consumer surplus would be between 3.5-12.4 percent of total crop sales. For the case of insurance against a $^1/_3$ rainfall shortfall, participation would be between 10-14 percent of households, the cost would amount to 2.3-9 percent of total crop sales, and they would insure 46-57 percent of their cultivated acres. Consumer surplus in this case would amount to 4.2-11 percent of total crop sales.

For Ruvuma and for the case of 10 percent rainfall shortfall, the participation would be of only 5-7 percent of households, insuring about 16-26 percent of their total area cultivated. The cost of the insurance would constitute 0.3-2 percent of their crop sales, and the total consumer surplus would amount to 2.8-4 of total crop sales. For the case of insurance against $^1/_3$ rainfall reduction, only between 3-3.4 percent of households would insure, and they would insure 18-30 percent of their total cultivated area. The premiums would amount to 0.1-1 of total crop sales, and the total consumer surplus would amount to 1.6-3.7 of total crop sales.

6.5 Summary and conclusions

In this chapter we examined in more depth the cash crop price fluctuations and the erratic nature of rainfall patterns underpinning volatility in agricultural income, (and household consumption), and analyzed the effect of this volatility on household welfare using the stated preference approach or contingent valuation of willingness to pay to complement the immediate welfare loss estimates related to the experience of shocks obtained in Chapter 5. The strength of the stated preference methodology lies in the fact that it can estimate both the uninsured residual risks and the "latent demand" for insurance (price or weather based), given that the households already cope with shocks through self and mutual insurance mechanisms. The underlying assumption is that the way the households have adjusted to the recurring weather risks is by diversifying, as well as adopting different production patterns than what would be dictated through simple expected income calculations. As such, the empirical estimates involve the long run or steady state production pattern of the farm household, given the household's perceptions of crop price and drought risks.

The results confirm our earlier findings that commodity price and weather fluctuations in addition to health shocks pose an important challenge to agricultural producers, often resulting in substantial welfare loss. Households don't only face unexpected cyclical and downward trending commodity prices, even within the same year and area there appears a wide range in the actual prices households receive for their produce, even when these prices are low. Consistent with our analysis of rainfall patterns in Kilimanjaro and Ruvuma based on recorded rainfall, analysis of people's subjective perceptions of weather shocks indicates that weather shocks pose a substantial challenge in the Kilimanjaro Region. They are less of a problem for households in Ruvuma.

The demand for cash crop price and weather insurance insurance appears substantial. In case of coffee price insurance, households are on average willing to pay between 13 and 30 percent of the option value they will receive as a premium depending on the option value. This compares favourable with the actual costs of such option contracts in the New York stock exchange, where three-month put options trade for about 5-10 percent of the strike price, and more for six-month put options.. Setting the premium at the average wtp, about 25,000 to 30,000 households in Kilimanjaro (or about one quarter of all coffee growing households) would buy coffee price insurance insuring a total of about 1,200-1,700 tonnes or

20-30 percent of the total coffee production in Kilimanjaro. Were the premium to equal average wtp in Ruvuma, about one third of all coffee growing households (i.e. about 20,000 households) would buy the insurance, insuring about 7,000 ton of coffee or about 45 percent of Ruvuma's total production. Similarly, about one third of the cashew growers would buy cashew price insurance insuring about 4,000 tonnes or about 45 percent of Ruvuma's total cashew nut production. Were the coffee and cashew price contracts offered at a premium equal to households' average willingness to pay, the societal benefit (consumer surplus) would total between Tsh 78 and 700 million (between 3 and 25 percent of total respective cash crop sales depending on the contract). Clearly, the cost of uninsured consumption is large and the societal benefits from insurance substantial.

Given that agricultural income constitutes on average 57 and 71 percent of total income in Kilimanjaro and Ruvuma respectively, a more comprehensive measure of the cost of uninsured residual consumption risk is provided by our estimates of the wtp and consumer surplus related to weather based insurance. Households were more interested in Kilimanjaro, which is more exposed to rainfall, and they rather wanted more than less protection, i.e. a larger interest in contracts which paid out the indemnity when rainfall falls below 10 percent below normal as opposed to 30 percent below normal). This is reflected in a larger willingness to pay for the more secure contracts. For example, average WTP for the 10 percent below normal contracts was between 12 and 23 percent of the payout in Kilimanjaro compared with between 10 and 14 percent for contracts which pay out only when the rain drops 30 percent below normal. In Ruvuma, the average wtp was estimated between 18 and 40 percent and 0.7 and 1.2 percent respectively, though these results were estimated with imprecision. In Kilimanjaro the average WTP constitutes about 30-55 percent of the actuarially fair value of the contract, depending on the contract. In Ruvuma the average WTP is only 5-18 percent of the actuarially fair premium, in line with the lower WTP in that region.

Were the premium to be set at the average wtp, about one quarter of all households in Kilimanjaro would insure about 60000-77000 acres (about 18-24 percent of total land cultivated) resulting in a consumer surplus or benefit to society of about Tsh 1 billion or US$ 1 million. This is substantial and underscores the welfare loss associated with uninsured risks. About half of all households in Kilimanjaro and about one third of all households in Ruvuma indicated an interest in weather based insurance. More importantly, liquidity constraints were mentioned as the main reason for not being interested in such a scheme, at least in Kilimanjaro. Also the type of coping mechanism seems to affect the demand for rainfall insurance, with those that use own savings more interested and more willing to pay, compared with those that use other safety mechanisms, especially family based ones. This may be related both to differential liquidity constraints and different costs related to these coping strategies.

In sum, while households extensively use self and mutual insurance to cope with these price and weather induced income shocks, our findings indicate that there is substantial demand for both commodity price and weather based insurance, indicating both substantial uninsured risks as well as "latent demand" due to the costs of current ways of coping with shocks or the opportunities insurance opens up. Liquidity constraints at the household emerge as an important constraint to translate this stated demand into actual demand. Thus, while the demand and societal benefits are sizeable, great care will have to go into the design and institutional delivery mechanisms of market based insurance. The establishment of interlinked markets such as input, credit and insurance packages deserves special attention in this regard.