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Abstract

This paper investigates the importance of consumption seasonal fluctuations for the measurement of aggregate poverty and the understanding of factors related to poverty in agricultural LDCs.

Using panel data from Rwanda for four quarters, we estimate transient and chronic poverty measures. We find that a very substantial share of annual poverty can be attributed to consumption fluctuations. The importance of seasonal poverty is confirmed by household transitions across quantiles of the living standard distribution. The results are robust to various definitions, specifications and measurement problems that are controlled by using recent and novel methods. In particular, a new method for intertemporal welfare analysis under limited information is proposed. The results suggest that the actual poverty differences either between developing and industrial countries or between rural and urban areas in LDCs, are likely to be much larger than what is shown by poverty measures based on annual data. They also imply that implementing income stabilisation policy is relatively efficient. However, we show that policies fighting transient poverty only, do not have much of an affect on the poorest of the poor.

Finally, we estimate two-stage censored quantile regressions for household chronic and transient poverty measures. The agricultural decisions of peasants are found to be differently related to the two components of annual poverty. This allows differentiated policies addressing each poverty component and invite to design policies in harmony with household strategies against poverty risks.

Codes JEL: I32, O15, D31. Keyword: Poverty Analysis; Seasonal Consumption

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Résumé

Nous examinons dans ce papier l'importance dans les PVDs agricoles de la saisonnalité de la consommation pour le mesurement de la pauvreté agrégée et la compréhension des facteurs reliés à la pauvreté.

A partir de données de panel du Rwanda pour quatre trimtestres, nous estimons des mesures de pauvretés transitoires et chroniques. Nous trouvons qu'une part considérable de la pauvreté peut être attribué aux fluctuations de la consommation. L'importance de la pauvreté saisonnière transitoire est confirmé par les transitions de ménages à travers les quintiles de la distribution des niveaux de vie. Les résultats sont robustes á divers problèmes de définition, de spécification et de mesure qui sont controlés à l'aide de méthodes récentes et nouvelles. En particulier, une nouvelle méthode pour l'analyse intertemporelle de bien-être en information limitée est proposé. Les résultats suggèrent que les véritables différences de pauvreté entre pays en développement ou industriels ou entre zones rurales et urbaines dans les PVD,sont probablement bien pires que ce que montrent les mesures de pauvreté basées sur données annuelle. Ils impliquent aussi que la mise en oeuvre d'une politique de stabilisation des revenus est relativement efficace. Cependant, nous montrons que les politiques luttant seulement contre la pauvreté transitoire n'affedtent pas beaucoup les plus pauvres des pauvres.

Nous estimons des régressions-quantile censurées en deux étapes pour les indices de pauvretés chroniques et transitoire des ménages. Les choix agricoles des paysans sont différemment relié aux deux composantes de la pauvreté annuelle. Ceci permet des politiques différenciées s'adressant à chaque composante de la pauvreté et invite à concevoir des politiques en harmonie avec les stratégies des ménages contre le risque de pauvreté.

1. Introduction

Poverty analysis is central to development economics. The fact that most of the World poverty corresponds to peasants in rural areas of developing countries (The World Bank (1990)), invites analysts to pay special attention to the determinants of the income flows of poor agricultural households. Because the bulk of these households' income stems from their agricultural output, climatic fluctuations as well as the main agricultural inputs should play a crucial role in determining poverty and inequality (Nugent and Walther (1981)). Indeed, aggregate data of LDCs show clearly that the agricultural output patterns are closely related to climatic fluctuations. At the household level, because of the high seasonal variability of agricultural production and the existence of liquidity constraints, peasant living standards may substantially vary across seasons. This explains why the analysis of seasonal rural poverty in LDCs has attracted considerable interest both recently[1] and historically[2].

As yet, no robust and axiomatically sound measurement of seasonal poverty seems to be available in the literature, let alone estimation of its correlates. Neither the extent of poverty arising from seasonal fluctuations, nor the validity of the annual chronic poverty indicators used in the vast majority of poverty studies is known. Moreover, even when the widespread occurrence of seasonal poverty is acknowledged, poverty policies cannot cope with it efficiently, because of a shortage of statistical analyses. Indeed, the statistical relationship between poverty, socio-demographic and environment characteristics, and agricultural decisions of peasants is poorly understood. Numerous regression results exist for chronic poverty indices using annual consumption at household level (see section 5). However, there is no reason why factors estimated as related to chronic components of poverty should also be correlated with transient

1 Chambers, Longhurst and Pacey (1981); Chambers (1982); Fortman (1985); FAO (1986); Gill (1991); Lipton and Ravallion (1993); Paxson (1993), Reardon and Taylor (1996).
2 Chayanov (1864); Duby (1962).

components and vice versa. Differences in the correlates for the two components of poverty would guide the design of component-specific policies.

Can consumption seasonal fluctuations be neglected for the measurement of annual poverty? Does the decomposition of annual poverty into transient and chronic components add something to our understanding of the economic mechanisms associated with poverty and our ability to design efficient policies against poverty? The aim of this article is to answer these questions. We present the data in section 2. We conduct, in section 3, a seasonal poverty analysis based on aggregate poverty indicators, and a transition probability analysis follows in section 4. In section 5, we study the factors separately related to transient and chronic components of poverty at the household level. For this purpose, we estimate equations of transient and chronic poverty using two-stage censored quantile regressions, a novel method, and incorporating agricultural decision variables. Finally, section 6 concludes.

A good starting point to deal with these problems is the literature on poverty dynamics. As Baulch (1996) and Ravallion (1996) stress, few studies are yet available. Most existing studies focus on poverty incidence and do not account for poverty severity. Bane and Ellwood (1986), Ruggles and Williams (1989) and Stevens (1995) estimate the exit rates out of poverty and the duration of poverty spells for US households, without explicitly distinguishing between transient and chronic poverty. Accounting for poverty severity and using Indian data, Ravallion (1988) separates chronic poverty and transient poverty across years. Rodgers and Rodgers (1993) provide a thorough applied analysis of transient and chronic poverty with annual data for the US. Grootaert and Kanbur (1995) suggest that, in the Ivory Coast, the mobility of the poor in the living standard distribution across four years is large. Finally, using Indian data, Ravallion (1988); using Chinese data, Jalan and Ravallion (1996, 1998); and using Pakistani data, McCulloch and Baulch (1999) find substantial transient poverty coming from annual consumption fluctuations. Despite their high quality, most of studies consider a unique poverty line and a unique equivalence scale. Furthermore, corrections for price dispersion and the sampling frame are often absent or quite rough. Finally, no sensitivity analysis in terms of measurement errors has been undertaken. The latter point is essential since excellent data in terms of measurement errors are needed to avoid mixing pure stochastic effects caused by data contamination with living standard dispersion and time variation. We use very high quality data that satisfy this requirement and we apply novel methods to test the robustness of our main results.

An especially worrying element that has not been addressed in the past is the robustness of results to the specification of living standard and poverty indicators. We treat this concern as follows. First, we use 3 equivalence scales, 7 poverty indicators, 6 poverty lines; we deflate for price variability; we account for the sampling scheme, we isolate food consumption. Second, we develop a new method for intertemporal welfare analysis under limited information, incorporating inertia and imperfect intertemporal substitution effects of past consumptions. Third, we use complementary statistical tools: kernel density estimation; autocorrelation analysis; stochastic dominance; aggregate poverty estimation; transition analysis; and estimation of poverty equations at the household level. Four, we control for measurement errors by using appropriate data and new techniques.

2. The Data

Rwanda is a small African country with an estimated population of 5.7 million in 1983. In this year, a more peaceful situation than that of the recent civil war, per capita GNP was US$ 270, making Rwanda one of the poorest countries in the World. More than 95 percent of the population lived in rural areas (Bureau National du Recensement (1984)) and agriculture represented 38 percent of GNP. Climatic seasonal fluctuations are known to be substantial (Bulletin Climatique du Rwanda (1982, 83, 84)), although they are much less so than in most of

Sub-Saharan Africa, or in many other rural developing areas (Chambers, Longhurst, Pacey (1981)).

We took the data for the estimation from the 1983 Rwandan national budget-consumption survey of 270 households that was conducted from November 1982 to December 1983 [3]. 265 households only were included in the analysed sample because of non-responses. Households were quarterly surveyed on their demographic characteristics, their budget and their consumption. We have calculated quarterly consumption indicators that are of very high quality. Indeed, we obtain for most household close estimations of consumption and income levels, while in most studies income is very significantly underestimated with respect to consumption (e.g. Paxson (1992)). For our surveyed households, the ratios (income-consumption)/consumption are on average 0.16, with a median of 0.078, a first quartile of –0.13 and a third quartile of 0.36.

The quality of consumption indicators results from very intensive collection and treatment. The volume of all present containers and the traditional measurement units were measured for every household in order to obtain accurate records of quantities. Every household was visited at least once a day during two weeks for every quarter. Daily interviews covering these two weeks and retrospective interviews covering the quarter were carried out. The food was weighted for every meal during daily interviews. Every household registered the transaction information in a diary during and between the survey rounds. The surveyed topics were extensive and much information has been repetitiously treated by different collection methods. This allowed a high quality of the collection as well as a thorough data cleaning implemented under the supervision of the author. We designed sophisticated verification algorithms using the redundancies present in the data. Finally, the calculus of consumption indicators is based on algorithms deliberately aimed at reducing measurement errors from the combination of several information sources. Notably, we use optimal combinations of questionnaires for calculating seasonal consumption,

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[3] The survey was conducted by the government of Rwanda and the French Cooperation and Development Ministry in the rural part of the country (Ministère du Plan (1986)). The main part of the survey was designed by INSEE (French statistical national institute). The author was involved in this project until the last stage of the analysis as a principal adviser from the French Cooperation and Development Ministry.

accounting for the quality of the observation for each product or transaction in each questionnaire and for the frequency of transactions and consumptions of each product (see Muller (1998)).

Table 1 shows the descriptive statistics of the main variables for the sample of households. In 1983, the average exchange rate was 100.17 Frw for one 1983 US $, i.e. 60.16 Frw for one 1999 US $ (sources: IMF, Penn Tables).

3. Aggregate Poverty Analysis

The aggregate poverty analysis is organised as follows. We first discuss the living standard and poverty indicators and estimators. At this stage we conduct kernel estimates of living standard densities as well as auto-correlation coefficients for consumption and production across quarters. Then, we present the estimates of poverty measures, distinguishing results based on food consumption only. We pursue by discussing the collection design and corrections for measurement errors. Finally, we present results based on new indicators incorporating inertia and imperfect substitution effects of past consumptions.

3.1. Indicators and Estimators

The measure of living standards in this paper is based on the value of consumption. To control for differences in household composition, living standard indicators corresponding to three equivalence scales have been calculated. The first scale corresponds to per capita consumption (i.e. no equivalising) and to the results shown in this paper for reason of space. Results with other scales are in agreement and available in Muller (1997).

To account for geographical and seasonal price dispersions, we deflate individual welfare indicators using individual Laspeyres price indices based on local market prices[4]. Because of market imperfections and high own-consumption rates, production and consumption decisions

4 We updated a previous version of this paper by using here local price indices instead of regional price indices and

of most agricultural households are likely to be non-separable. For this reason, shadow prices corresponding to the separating budget constraint[5] would be more appropriate for the calculus of price indices. However, these shadow prices are unobserved and their estimation from a complete agricultural household model would produce noisy estimates, in contradiction with our robust approach. Muller (1999a) discusses price indices and representative price samples that avoid quality and endogeneity biases. In these price samples, observed market prices from a specific price questionnaire that was filled at market locations have been shown to be a reasonable approximation of shadow prices. When local quarterly market prices from the price questionnaire were not available for specific good, cluster and quarter, we have substituted them by the closest available price statistics, generally the average unit-value calculated from all observed consumption values and consumption quantities in the same cluster at the same quarter. Removing the specific household consumption observations from this average, so as to avoid possible endogeneity problems, does not significantly change price indicators.

The *quarterly living standard* indicator for household i at quarter t is defined as $y_{it} = c_{it}/(es_i\ I_{it})$ where c_{it} is the value of quarterly consumption of household i at quarter t; es_i is the adult-equivalent scale associated with household i and I_{it} is the price index for household i and quarter t. From now we focus on per capita consumption and es_i is the household size.

We start the empirical analysis by directly examining the quarterly fluctuations of agricultural output and consumption in Rwanda. Household consumption and production were observed during the four agricultural quarters of 1983, denoted successively as A, B, C, D. Their dates are the following: Round A: 01/11/1982 until 16/01/1983. Round B: 29/01/1983 until 01/05/1983. Round C: 08/05/1983 until 07/08/1983. Round D: 14/08/1983 until 13/11/1983. It is clear from table 1 that aggregate values of production, consumption and living standards differ across quarters. However, much seasonal variability may be hidden by aggregate statistics. Kernel

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a national annual price basis instead of a quarterly one. Qualitatively, the results are quite similar.

5 Singh, Squire and Strauss (1986), de Janvry, Fafchamps, Sadoulet (1991).

density estimates of quarterly and annual real per capita consumption distributions using Epanechnikov method are shown in figures 1a and 1b, with the two vertical lines representing our lower and higher poverty lines (see below). Clearly, the shape of living standard distribution varies a lot across quarters. Quarter D (after the dry season) is characterised by a higher peak centered at a lower value, which shows a higher incidence of poverty at this period. The other quarters cannot be obviously ordered in terms of poverty by merely examining their living standard density estimates.

Table 2 shows the autocorrelation coefficients of the deflated values at successive quarters for total consumption, per capita consumption, total production[6]. The autocorrelation coefficients of production are small. Because of the climatic seasonality, the agricultural output in one quarter is only weakly linked to the output in the next quarter. The autocorrelation coefficients of consumption or of per capita consumption are larger, although substantial variability remains. This limited link of consumptions at successive quarters justifies to proceed with the analysis of chronic and transient components of poverty. If per capita consumption were stable across quarters at the household level, a poverty measure based on annual consumption would give sufficient information.

The poverty analysis is based on the following elements: the poverty line, the poverty measures, the estimators of these measures, the estimators of sampling standard errors for these estimators. We have calculated three poverty lines (z_A, z_B, z_C) for severe poverty and three poverty lines for moderate poverty (z_D, z_E, z_F), expressed in terms of Rwandan Francs (Frw) per year and based on the first and second quintiles of quarterly and annual living standard distributions[7]. We denote as “the very poor” the population whose living standards indicators are

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6 The autocorrelation coefficients of a variable v at quarter t is the correlation coefficient of the vector of the $v_{i,t}$ ‘s with the vector of the $v_{i,t-1}$’s, (i = 1,…,n), where i is the index of the household. The standard deviations in table 1 enable the reader to calculate autocovariances if wished.

7 The values of the poverty lines are shown in Muller (1997). We want to obtain reasonable poverty lines,

below the poverty lines calculated from the first quintile. Those whose living standards indicators are below the poverty lines calculated from the second quintile are denoted “the poor", that is, the sum of “the very poor” and the “moderately” poor.

We simultaneously use the most popular applied poverty measures: the Watts’ measure (Watts (1968)), denoted W; the FGT(a) measures (where a = 0, 1, 2, 3 is a poverty aversion parameter), which have been introduced by Foster, Greer, Thorbecke (1984), the CHUC(c) measures (where c = 1, ½, 1/3) that have been proposed by Clark, Hemming and Ulph (1981) and Chakravarty (1983). We estimate poverty at quarter t by using ratios of Horwitz-Thompson estimators:

$$\hat{P}_t = \frac{\sum_{s=1}^{n} \frac{f(y_{st}, z) 1_{[y_{st} < z]}}{\pi_{st}}}{\sum_{s=1}^{n} \frac{1}{\pi_{st}}} \qquad (1)$$

where π_{st} is the sample inclusion probability of household s at date t (s = 1,...,n; t = 1,…,4), f is the kernel function associated with the poverty index, and $1[y_{st} < z]$ is the dummy variable for identifying the poor[8]. $f(y, z) = (1-y/z)^a$ for FGT(a). $f(y, z) = 1-(y/z)^c$ for CHUC(c).

f(y, z) = -ln(y/z) for W. The sampling standard errors of the poverty indicators are less easy to estimate, because of the complexity of the actual sampling scheme described in Roy (1984). We use an estimator inspired from the method of balanced repeated replications (Krewski and Rao

located in relevant parts of the distribution. z_A is four times the minimum of the first quintiles of quarterly living standards. z_B is the sum of the first quintiles of quarterly living standards. z_C is the first quintile of annual living standards. z_D, z_E, z_F, have respectively the same definitions calculated from second quintiles. These definitions correspond to “annual poverty lines”. The “quarterly poverty lines” are the annual poverty lines divided by four.

8 Alternatively, if one considers that the proper level to conduct poverty analysis is the individual one instead of the household one, this formula is to be modified by weighting the expression at the numerator and denominator by the household size of household s at date t. This approach has been criticised on the ground that it corresponds to equal

(1981)) that is presented in appendix 1.

We now discuss notions of seasonal, chronic and transient poverty. In section 3.2, we shall use simple definitions providing practical analytical tools. Then, we shall propose extensions of these definitions in section 3.3, 3.4 and 3.5, so as to treat various specification and measurement problems. We start with the living standards indicators. The *annual living standard* is the sum of the four quarterly living standards. The mean living standard of household i over the studied agricultural year is denoted *chronic living standard,* although it is not here the permanent income corresponding to the entire lifetime of the household. Moreover, because of the short length of our observation period we omit discount factors between the quarters.

The notions for poverty measures share similar names, whereas they are of different nature since they are directly extracted from the literature on poverty studies[9]. P_t is the poverty measure calculated in quarter t using the quarterly poverty line and the observations y_{it} for all households. It is denoted *quarterly poverty* or *poverty at quarter t*. A natural notion of annual poverty is a central tendency of its observations across time. We denote *annual poverty* the arithmetic average of quarterly poverty measures: $AP = (P_1 + P_2 + P_3 + P_4)/4$.

The *chronic poverty*, denoted CP, is defined as the poverty measure formula applied to the *chronic living standard.* It is the poverty indicator that one may want to measure if people could have smoothed consumption if they had wanted to. It corresponds to the usual poverty indicators of the literature. The term chronic refers here to the use of the *chronic living standard* in the calculus. The same poverty line is used in calculating each one of the quarterly poverty measures, P_t, and the chronic poverty index, CP.

The *transient poverty* over the year is defined as the residual of the annual poverty once the chronic poverty has been accounted for: $TP = AP – CP$. TP is the poverty increase that can be attributed to the variability of living standards during the year. To stress the fact that this

members' shares of household living standard. In any case, it does not change the qualitative results of this paper.

9 Ravallion (1988), Rodgers and Rodgers (1993), Jalan and Ravallion (1996).

component of the measured annual poverty comes from the seasonal fluctuations of living standards, we denote it *transient-seasonal poverty* [10]. The share of annual poverty caused by seasonal fluctuations is the ratio F = (AP – CP)/AP.

In the 'stationary case' where the quarterly living standard distribution is identical at all quarters, AP is identical to any quarterly poverty indicator P_t. However, even in this case, the transient poverty is not null. Indeed, even when distributions are stable, the living standards of individual households may fluctuate substantially across seasons and may cross the poverty line.

We now turn to several conceptual difficulties occurring when dealing with intertemporal poverty. **A) First,** if there is no consumption smoothing opportunities, the mean of living standards over the quarters reflects both permanent and transitory income in the sense of consumer theory. In the presence of borrowing constraints, the expected income, which is conditional on household resources and information at the beginning of the period (Paxson (1992), Deaton (1993)), is not necessarily equal to the consumption mean over the set of observed periods[11]. Besides, perfect smoothing is unlikely for poor peasants with little insurance and limited access to credit. However, an absence of perfect smoothing could indicate that either credit constraints prevent households from smoothing consumption or that cautious households decide not to fully smooth consumption because of different income dispersion at different seasons. If much of the consumption fluctuations comes from preferences changes, then chronic and transient poverty measures incorporate desired rather than constrained consumption. Though, this may be unlikely to happen with the empirical case that we study in the next sections because most households in our sample are extremely poor (in contrast with Thai households in Paxson (1992, 1993)). Then, and this is corroborated by our own interviews of Rwandan peasants, we

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10 Other names than chronic and transient poverty could have been chosen to avoid confusion with permanent income theories or spectral analysis of time series. However, they are now traditional in poverty analysis and we follow this use. A notion of *transient poverty at quarter t* can also be defined as the difference between the annual poverty and P_t . Thus, TP is the average of the transient poverty at all quarters. If we had seasonal data for several years, we could define seasonal poverty from residuals of moving averages of living standards calculated over a large span of time, rather than observations of poverty at four quarters. This would also allow the separation of the trend and random shocks from the seasonal component, which is not possible here.

11 An approach proposed by Paxson (1992) is to explicitly model transient and permanent components of income,

do not believe that an important part of consumption fluctuations in Rwanda derives from seasonal changes in tastes. This approach is as well supported by other elements. Firstly, we are reluctant to consider that very poor households, close to the subsistence minimum, voluntarily and substantially reduce their food consumption across the year. Then, we shall provide additional results based on food consumption only. Secondly, autocorrelation analyses have shown us that very rich households, who are likely to meet less stringent liquidity constraints, substantially stabilise their per capita consumption, while other categories, except the extremely poor, have more unstable living standards. This is consistent with the assumption that poor or potentially poor households may not sufficiently smooth their consumption due to liquidity constraints, except when they are constrained by subsistence barriers. Finally, in all cases, CP is the indicator calculated in the literature, which is based on total annual consumption only. In this sense, it is the relevant comparison point when one wants to assess the importance of using consumption observations at every quarter.

B) Second, a poverty measure that is both intertemporally and interpersonnally additive is a simplified specification that involves the aggregation of households and the aggregation of periods for specific households. The first aggregation process may be related to the poverty aversion of the public planner and to the risk-aversion of households. The second aggregation process is associated with intertemporal substitution. It is unclear how to specify these aggregations. Blackorby, Bossert and Donaldson (1995) show that in an intertemporal framework, any axiomatically valid social evaluation function satisfying the Pareto principle and the independence from unconcerned individuals must be an additive function of the lifetime utilities of individuals. This specification is consistent with the interpersonnally additive specifications of subgroup-consistent poverty indices (Foster and Shorrocks (1991)) and we retain it.

The intertemporal aggregation for households (or individuals) is more delicate. As noted

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using identifying explanatory variables such as rainfall for the transient component.

by Deaton (1992), intertemporally additive preferences imply an inverse link between the intertemporal elasticities and the risk-aversion. Attempts to model simultaneously risk aversion and intertemporal substitution exist in the consumer literature[12], although the choice of the relevant specification for welfare analysis is still an open problem. Unfortunately, direct additive specifications as well as recursive utilities imply that several aspects of dynamic poverty cannot be incorporated. Indeed, the requirements for a well-behaved intertemporal poverty measure are not limited to substitution and risk considerations. Because there is a perfect symmetry in the formula of the annual poverty between households and periods, the same household observed in two different periods is considered as two different households in the same period. Thus, the persistence of the harm caused by a poverty spell beyond one season is neglected in usual specifications. We shall estimate transition matrices and poverty measures incorporating inertia and imperfect substitution effects in order to account for dimensions of poverty that are not captured by the usual aggregate poverty measures.

C) Third, the specification of unobserved household expectations matters for the definition of the poverty measure. In particular, to be poor as a young or to be poor as an old person may need to be considered as radically different because of different expectations in the length of lifespan. Constraints and information conditional on which expectations are to be calculated would be important elements of this specification. In this optic, a complete model of the welfare fluctuations would involve the estimation of the consumer choices of their consumption flows, the heterogeneity of liquidity constraints across households, the risk protection behaviour and the expectations of households. Since we do not observe most of these elements, we shall not pursue this research line herein. However, strategies of protection against risks arising from climatic fluctuations are discussed and incorporated in estimations in section 5.

12 Kreps and Porteus (1978), Epstein and Hynes (1983), Epstein and Zin (1989) propose classes of recursive, but not necessarily expected utility describing preferences over intertemporal consumption lotteries.

D) Fourth, it may be that high frequency variations of living standards do not matter much in practice. On a very short interval of time, as between two meals, large variations of consumption are not very relevant to individual welfare. The variations merely describe the subjacent consumption “technology”. This phenomenon, which is blatant for food and daily intervals, may be less easy to capture for other goods, such as clothing and housing, for which intervals between purchases are much longer. Then, quarterly fluctuations in consumption expenditure of durable goods might have little impact on welfare. Although such considerations cannot be totally discarded – or controlled since we do not observe when households are constrained in their consumption choices – the case of Rwanda in 1983 is particularly advantageous if one wants to avoid a too large contribution of consumption fluctuations of durable goods. Indeed, in rural Rwanda food makes up 83% of the value of the consumption (plus 3 % of very short-term consumption of firewood for cooking)[13]. As for the food, quarterly fluctuations seem to be adequate to measure individual welfare fluctuations since first it is difficult to imagine households choosing to starve during such a long period. Second, the observed households do not have any adequate food storage facility. As a matter of fact, a low consumption of food during a whole week may already have severe consequences in terms of individual welfare depletion. The poverty estimates that are presented in the following sections 3.2 through 3.5 are an attempt to account for the above discussion of section 3.1.

3.2. Estimates of poverty measures

A stochastic dominance analysis of poverty curves delivers a partial ordering on distributions that is consistent with any poverty indicator based on concave kernel functions (Atkinson (1987), Foster and Shorrocks (1988)). Figure 2 shows the poverty curves for the four quarters and per capita consumption. The Y-axis corresponds to the average living standards of the poor for the considered quarter, when the poverty line goes from zero to a maximum level that

13 respectively 85 % and 5 % for households whose consumption expenditure is below the median (Muller (1992)).

does not exceed the median of the distribution of living standards. The proportion of the poor is measured on the X-axis. All these numbers account for the sampling scheme. Quarter D is dominated by the three other quarters, showing the poverty crisis at the end of the year. In contrast, the living standards of the poor are unambiguously higher at quarter B.The ordering of the other quarters depends on the poverty line and the importance attached to poverty in various parts of the distribution. Estimating poverty indicators will show the quantitative influence of fluctuations in the annual poverty, which is not possible with poverty curves. Muller (1997) presents curves and tables for other equivalence scales with results in agreement with the present paper.

Tables 3 and 4 present the means over the six poverty lines of the estimates of poverty measures[14]. Per capita consumption is the living standard indicator. The qualitative results are robust to the choices of: the poverty line; the poverty indicator; the equivalence scale. We begin by comparing the poverty levels at the different quarters. The worst period for both the very poor and the poor is the last agricultural quarter D, just after the dry season, when the stocks have not yet been reconstituted before the next important harvest (notably the beans harvest at end-December/ beginning-January). By contrast with what is shown by the means of living standards, the best period for the poor is the quarter B. The second worst quarter for the poor is quarter A or C, depending on the chosen indicator or poverty line. For all poverty indicators and all poverty lines, the increase in the number of the poor between the first and the last quarter is dramatic. Moreover, the shock at quarter D is more damaging for the very poor than for the moderately poor. This result is strengthened by the fact that the last quarter is a period of hard agricultural work including ploughing, weeding and cropping after the less intensive dry season.

Using chronic poverty measures only based on annual consumption makes the picture of the situation of the poor less dramatic. The incidence of chronic poverty is notably lower than the incidence of annual poverty. The difference is even stronger when using axiomatically sound

14 Results for each of the six lines are available under request.

poverty indicators. Clearly, measuring chronic poverty instead of annual poverty strongly underestimates the seriousness of the welfare situation, and all the more so that the poverty aversion parameter is large.

Let us now focus on our main interest: the share of annual poverty caused by seasonal consumption fluctuations. The influence of consumption fluctuations is non-negligible for the incidence of poverty. Moreover, the moderate sensitivity of the number of the poor to consumption fluctuations contrasts with results when using more axiomatically sound indicators for which the fluctuations have a much larger impact. The dramatic importance of seasonal-transient poverty is not the consequence of a "bad year" or of "adverse seasonal shocks" since 1982-83 is considered a normal agricultural year. The observed "bad state" in quarter D of 1983 can be considered as a normal event at this season. In Rwanda, the transient-seasonal component constitutes the larger part of annual poverty.

The means over the six poverty lines of the standard errors of poverty measures are shown in parentheses in tables 3 and 4. The standard errors of the differences in quarterly poverty measures have also shown us that poverty changes significantly across the year, whatever the used poverty indicator or poverty line. The transient-seasonal poverty is significant for all poverty indicators and lines and cannot be neglected.

It is a concern that only one year is observed. Because we observe only four seasons, it is not possible to separate the trend and the seasonal component of living standards. However, the trend component is likely to be small compared to the seasonal fluctuations. Indeed, the main economic shocks for peasants in 1983 were seasonal climatic shocks. Agricultural households in Rwanda are very isolated from modern economic mechanisms and the international economic conjuncture does not substantially modify their living standards in the short term. For instance, coffee, which is the main export of Rwanda, represents on average only 3% of the value of peasant output. In 1983, the demographic growth contributed only 3.5% of the decrease in per capita consumption. Moreover, migrations that were controlled by the government could not be a major factor of living standard variations in 1983. The quality of the land diminishes because of its intensive use, although the rate of decline is limited. Exceptional events could also add to the transient component of poverty in Rwanda, although 1982-83 is considered as a fairly normal agricultural year. On the whole, the variation of poverty during the year is likely to be mostly explained by seasonal fluctuations rather than by economic trends or by other events. In any case, the existence of a substantial trend would change the interpretation of the transient component, but not its size.

Several elements have been learned from the experiment with 6 lines, 7 poverty indices, 3 equivalence scales. First, the main qualitative results do not depend on the particular specification of the poverty indicator. In almost all cases, the transient-seasonal poverty contributes massively to the annual poverty. Second, using axiomatically valid poverty measures, accounting for the severity of poverty (FGT(2), FGT(3), CHUC(1/2), CHUC(1/3), W) delivers qualitatively similar results, by contrast with results based on the head count index, which underestimate the transient-seasonal component. Third, the influence of the poverty line reveals two different regimes respectively for the moderately poor and the very poor. A stronger share of transient-seasonal poverty is obtained in the case of the very poor and decreases when the line augments, perhaps because the influence of extremely poor households, stuck at the subsistence threshold, diminishes. Fourth, using different equivalence scales confirms the main qualitative results, and show that using the per capita consumption underestimates the share of the transient-seasonal poverty, as opposed to scales giving a smaller importance to children. Let us now investigate the robustness of these results to changes in the scope of consumption, to data contamination and to the definition of annual poverty.

3.3. Results with food poverty measures

We have estimated food poverty measures using the same methodology. This enables us first to assess the importance of durable and non-food consumptions in results revealing a large transient poverty, second to avoid considering high frequency variations of consumption that would be deliberately chosen or directly related to household welfare. Table 5 shows the share of the transient-seasonal component in the annual food poverty. Here, the consumption is replaced in the calculus of living standards by the food consumption, and the poverty lines are accordingly recalculated. As above, we find that, except sometimes for the head-count index, a very substantial share of the annual poverty comes from the transient-seasonal component. As a matter of fact, eliminating the non-food consumption generally leads to overestimate the amount of transient-seasonal poverty, perhaps because the food consumption, which is largely own-produced, is more sensitive to seasonal climatic fluctuations associated with seasonal crops.

3.4. Collection design and measurement error

Household consumption information has been recorded using daily and quarterly interviews. This has several consequences. First, the measurement errors are specific to each questionnaire. Then, omissions are likely to be more important for non-poor households whose consumption measure rely more on quarterly recording. On the other hand, sampling noise caused by the selection of surveyed days (two weeks at each quarter) is likely to affect more the measured consumption (mostly food and frequent purchases) of the poor, more recorded from the daily interviews. Second, the mixture of quarterly and daily information has consequences for the correction for price dispersion. The price index corresponds to price observations that are contemporary to daily observations, while retrospective records correspond to the previous remaining of the quarter. Then, stationary inflation would lead to slightly overestimate the consumption recorded using retrospective interviews, and therefore to overestimate relatively more the consumption of the rich than that of the poor. Seasonal and geographical price variations as well as measurement error on prices have more complex effects difficult to extrapolate from the questionnaire design. Fortunately, a very large share of the consumption of all households has been measured using daily records and the inflation at this period is low (around 10 percent). Then, the distortions brought by quarterly records should be very small. Moreover, using local and seasonal price indices for the deflation is much more accurate than the present general practice. The remaining distortion in deflation caused by the questionnaire design should be of limited size in comparison with errors that would have been introduced by using regional or annual prices (see Muller (1999a)).

Another difficulty stems from the fact that the information recorded from daily interviews actually measures expenditure in two weeks at each quarter rather than the whole quarterly expenditures. This information comes from daily recall *and* daily diary records. It is very accurate for the two weeks of the enumerator's investigation, but is missing for the rest of the quarter. Quarterly consumption indicators are therefore a complex combination of direct quarterly information (both recall and diary records) and of the extrapolation to the whole quarter of the daily records during two weeks. This bears consequences on the interpretation of results in that measurement errors are introduced by extrapolating the two weeks information to the whole quarter. Several points deserve to be noted. First, it has been unanimously acknowledged, by enumerators as well as by survey supervisors, that the quality of observations from daily interviews is much better than the quality of quarterly interviews. As a matter of fact, the quarterly extrapolated measures are generally preferable to the direct quarterly records (except in rare cases that are dealt with the combination of the two information sources). Then, relying on quarterly records so as to reduce measurement errors woul probably be noxious. Second, the collection design may bias upward or downward the measures of the extent of consumption fluctuations. Indeed, on the one hand, the extrapolated quarterly consumption measure may be more irregular than the true consumption if weekly consumption fluctuates more than quarterly consumption. On the other hand, the noise caused by the extrapolation may also contribute to smooth some extreme variations of quarterly consumptions.

To investigate the sensitivity of our main results to data contamination caused by the questionnaire design as well as by other sources of measurement errors, we use a recent method proposed by Chesher and Schluter (1999), who propose formulae of corrected poverty estimators that are shown in appendix. The assumed extent of measurement errors depends on a parameter σ that can be chosen to investigate a variety of situations. The values that we use for our estimation correspond to very low up to very high levels of measurement errors. Table 6 shows the share of annual poverty caused by the consumption fluctuations, with and without measurement error for poverty lines Z_C and Z_F, and six values of σ. Only values for FGT(a), a = 0, 1, 2 are shown. It is remarkable that whatever the size of the measurement error, the corrected share of annual poverty caused by consumption fluctuations, is considerable for all lines. As previously, the impact of consumption fluctuations strongly increases with the poverty severity parameter. If anything, noisy consumption data contributes to raise the measure of the impact of quarterly fluctuations. Indeed, axiomatically sound poverty indicators correspond to concave kernel functions (conditionnally to the stability of the population of the poor, which we assume to be approximatively satisfied). In that case, AP is the mean of quarterly poverty indices, while CP is the poverty calculated using the mean of quarterly living standards. Therefore, Jensen's inequality implies that for centered measurement error distributions, $\Delta AP < \Delta CP$ where Δ expresses the variation of measures caused by data contamination. Then, since F = 1-AP/CP, one expects that when AP and CP have the same order of magnitude, F is increasing with measurement errors. The results presented in this subsection have shown that the high contribution of seasonal consumption fluctuations for poverty measurement is not likely to be caused by measurement errors only.

3.5. Inertia and imperfect substitution effects of consumption

We now investigate the robustness of results to the incorporation of inertia and imperfect intertemporal substitution effects of past consumptions. This will deal with some concerns evoked in section 3.1. We still decompose an indicator of annual poverty, denoted AP', into two additive components, the chronic poverty defined as above based on the sole annual consumption, and a residual, denoted TP', that shows the contribution of consumption fluctuations to annual poverty when compared to chronic poverty CP. However, we now consider lagged effects of consumption on living standards. These effects can be interpreted as mere perception phenomema such as memory effects on household preferences, or as actual biological consequences of past consumption, for example through health and nutritional status. Their incorporation can also be considered as a robustness check with respect to the specification of the annual poverty indicator and therefore of the transient poverty indicator. We begin with the following intertemporal living standard model at the household level.

$$W = \frac{1}{T}\sum_{t=1}^{T} \beta^{t} u\left(\left[C_t^{\alpha} + \left(\rho C_{t-1}\right)^{\alpha} + \ldots + \left(\rho^{P} C_{t-P}\right)^{\alpha}\right]^{1/\alpha}\right) \qquad (2)$$

where T is the number of quarters to consider, P the number of lags associated with the effects of past consumption, ρ is the parameter describing the strength of the inertia link over one quarter, α is an intertemporal substitution parameter for the living standard variable defined at each quarter, β is a subjective actualisation parameter, u is an utility function accounting for static household tastes. When α is equal to 1, this representation corresponds to a truncated accumulation of living standards through consumption with a depreciation parameter equals to ρ. When α is different from 1, the new living standard at quarter t is defined as a CES function (with coefficients summing to P) of present and past depreciated consumptions. Consistently with the absence of observations of household expectations, we do not include future consumptions in the utility function, although that may be important in practice.

Since we observe only four quarters, eq. (2) can only describe a latent model and missing observations for some consumptions play the role of errors terms inside the utilities. To make the problem tractable, we make four restrictive hypotheses. Firstly, we neglect the contributions to welfare of unobserved past and future utilities to focus on the four observed quarters. Secondly, we consider lagged effects of consumption limited to three quarters. Although, these two assumptions are restrictive, there would be little to gain to speculate about unknown effects coming from totally unobserved periods. Thirdly, we specify the utility function as a power function, $u(x) = x^c$ where c is a parameter. Fourthly, we consider that the quarterly household consumption at a given quarter can be approximated by the household consumption at the same quarter of the previous or following year. This is clearly a strong requirement. However, it will enable us to account better for household heterogeneity than to assume a given value or an average value over all households for the unobserved consumption. Moreover, it is consistent with our approach that is to focus on seasonal consumption fluctuations, rather than on unobserved yearly fluctuations. In a sense, the observed quarterly consumptions are the only possible basis for estimating the seasonality structure of consumption. Finally, this approach should deliver a lower bound of the role of consumption fluctuations at the household level instead of introducing excessive predictions errors that would exaggerate these imputed fluctuations if a model for unobserved consumption were used. These lower bounds can be obtained for freely chosen values of parameters c, α, β and ρ.

To simplify the exposition, we focus on the CHUC poverty measures, which can be expressed as poverty indicators using a kernel function 1- u(y/z) where u is a power function. Here, as it is usual, the total value of consumption is normalised by a poverty line and by the household size. The utility function u is then replaced by the welfare function W of eq. (2) to define the kernel of the new annual poverty measures. Appropriate dummy variables for the poor at each quarter are incorporated to complete the definitions. Finally, the integration is carried out over the population of households. Parameter c is here identical to the parameter of the CHUC measure. Note that the quarterly poverty line must be updated to account for the modification of quarterly living standard indicators. Let z be the initial poverty line. Consider the situation where the household per capita consumption is identical to z at every quarter. Then, referring to the the argument of function u in eq. (2), it is easy to see that the quarterly poverty line associated with the new quarterly living standard indicator is $zq = z\,(1 + \rho^{\alpha} + \rho^{2\alpha} + \rho^{3\alpha})^{1/\alpha}$. The updated poverty line is used in the utility function and in the dummy variable defining the quarterly poor. Then, the annual poverty indicator AP' for a given household can be written as follows

$$AP' = \frac{1}{4}\{ \left[1 - LS1^{c}\right] 1_{[iLS1<zq]} + \beta.\left[1 - LS2^{c}\right] 1_{[LS2<zq]} + \beta^{2}.\left[1 - LS3^{c}\right] 1_{[LS3<zq]} + \beta^{3}.\left[1 - LS4^{c}\right] 1_{[LS4<zq]} \} \tag{3}$$

$$where\ LS1 = \left(C_1^{\alpha} + (\rho C_4)^{\alpha} + (\rho^{2} C_3)^{\alpha} + (\rho^{3} C_2)^{\alpha}\right)^{1/\alpha}$$

$$LS2 = \left(C_2^{\alpha} + (\rho C_1)^{\alpha} + (\rho^{2} C_4)^{\alpha} + (\rho^{3} C_3)^{\alpha}\right)^{1/\alpha}$$

$$LS3 = \left(C_3^{\alpha} + (\rho C_2)^{\alpha} + (\rho^{2} C_1)^{\alpha} + (\rho^{3} C_4)^{\alpha}\right)^{1/\alpha}$$

$$LS4 = \left(C_4^{\alpha} + (\rho C_3)^{\alpha} + (\rho^{2} C_2)^{\alpha} + (\rho^{3} C_1)^{\alpha}\right)^{1/\alpha}$$

where the dummy variables define the poor at each quarter by using the CES compound for this quarter. If α, β and ρ are all equal to one, AP' = CP and TP' = 0 by definition. The case of sections 3.2 corresponds to $\alpha = 1$, $\beta = 1$ and $\rho = 0$.

The estimates shown in table 7 demonstrate that, except of course in the case ($\alpha = 1$, β

=1, ρ =1), the share of annual poverty that is caused by accounting for quarterly consumptions is never negligible. Remind first as indicated above that what we get for F is probably a lower bound of the impact of consumption fluctuations since the stationary seasonality structure has been used in place of the unobserved one that is likely to be noisier. F without inertia effects is generally larger than when it incorporates these effects. It is nonetheless rare with the chosen values of parameters that F be small. It is always higher than 30 percent for $\rho < 0.3$. The smallest values are obtained for high value of the inertia parameter, ρ, at least 0.5, which may be unrealistic. In general F diminishes when ρ increases, while the effect of α depends on the value of ρ. In that sense, α is a modifier of inertia effects. F is also increasing with β, i.e. decreasing with the subjective household interest rate.

Note that our comment of this section is based on the conviction that small values of ρ (0.1 or 0.2) are the more plausible. However, there is no empirical basis to support this opinion. Therefore, an alternative reading of this section results could be that if inertia effects are very strong, the importance attributed to seasonal consumption fluctuations may be much exaggerated by the use of the simple poverty statistics.

We have therefore robustly established that most of the severity of poverty comes from the transient-seasonal component of annual poverty. This result has several consequences for policy. On the one hand, since climatic seasonal variations in Rwanda is moderate, the actual differences in poverty between developing countries and industrial countries (or between rural and urban areas in LDCs) may be much worse than it is shown by chronic annual poverty indices or even by the seasonal incidence of poverty. International actions to reduce welfare differences between nations, such as debt relief programmes, need therefore more emphasis. On the other hand, the extent of TP makes more difficult targeting against poverty in general. With seasonal fluctuations, the cost of eliminating poverty can be much greater because of imperfect targeting.

4. Results from Transition Matrices and Cumulative Analysis

Despite the strength of section 3 results, the picture shown by aggregate poverty indicators may be misleading because it does not always account for changes in the composition of the population of the poor across seasons. It makes a difference whether the transient poverty results mostly from aggregate fluctuations with general upward and downward movements of living standards, or if many households exchange their position as poor and non poor across seasons. Indeed, a macroeconomic intervention may be better adapted to the first case, while more precise policies, directed towards target groups at each season would be necessary in the second case. To clarify these points we now study the transition probabilities across quarterly distributions of living standards. This will also enable us to investigate the situations of households in different classes of living standards and to distinguish flows into and out of these classes.

The transition probability numbers from quintile h to quintile k (h = 1,…,5; k = 1,…,5) of the living standard distribution summarise the information included in the transition probability. Only three transitions are observed. The transition probability from state j at quarter t to state k at quarter t+1 (the states are here the quintiles at the beginning and the end of a specific quarter t) is denoted $P^i_{jk}(t+1) = P_{jk}(t+1)$ for all households i at quarter t. Under a Markovian framework, the likelihood function conditional on a starting situation can then be written as

$$L = \prod_{t=1}^{3} \prod_{k} \prod_{j} P_{jk}^{n_{jk}^{t+1}} (t+1) \qquad (4)$$

where n_{jl}^{t+1} is the number of households in state l at t+1 given that they are in state j at date t. The MLE of the probability numbers associated with a first-order homogeneous and seasonal-stationary Markov chain model (Amemiya (1985)) are $P'_{jk}(t+1) = n_{jk}^{t+1}/\Sigma_l\, n_{jl}^{t+1}$. Using sampling weights enables us to substitute the n_{jk}^{t+1} by consistent estimators of the number of households in each cell[15].

15 This interpretation of the transition matrices shows well that a restrictive assumption of absence of link between

Table 8 shows the estimates of the transition matrices across quintiles of per capita real consumption. Although using other equivalence scales sometimes delivers different quantitative results, they remain qualitatively similar. In transition AB, the situation of the very poor (first quintile) improves a lot, while the situation is more ambiguous for the moderately poor (second quintile). By contrast, changes in AB are not favourable for the average households, the rich and the very rich (respectively third, fourth and fifth quintiles). Transition BC benefits less to the very poor, who more rarely escape from poverty, while it is more favourable than transition AB for the moderately poor who often improve their status. This transition is still not positive for the average households and the very rich. Transition CD is the worst for the very poor and the moderately poor. This period is as well very harmful for the rich and the very rich, leading to a steady increase in the number of very poor coming from all classes of society and a rise of the number of moderately poor. The poverty crisis at transition CD does not result so much from a greater difficulty in escaping from poverty and severe poverty, as from a large number of households falling in poverty or severe poverty. A temporary "safety net" policy at this period would be an appropriate response by the government to this crisis.

Mobility is very strong in every transition. Many households escape or fall into poverty at every quarter. Unfortunately, the most stable population in Rwanda is the very poor who can escape poverty only with difficulty all along the year. Indeed, a very large proportion of them remains poor at every transition (56 percent, 68 percent, 88 percent respectively for the successive transitions). This is also much the case for the moderately poor with proportion staying poor of respectively 66 percent, 51 percent, 77 percent. The annual increase in the number of very poor is of 48 percent to 50 percent (depending on the equivalence scale), and the increase in the number of moderately poor across the year is of 32 percent to 38 percent. Since transition DA is missing the recovery caused by the harvests of the first agricultural quarter remains unobserved.

Note that the fact that immobility ratios are generally much larger for the first quintile than

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two successive tables is imposed. For simplicity and because of the small sample size, we stick to this common practice, although this assumption should be relaxed with richer data. For the same reasons, no attempt of modelling for the other quintiles suggests that measurement errors on living standards are small. Indeed, it is typical in household consumption surveys (Biemer et al. (1991)) that measurement errors on consumption indicators are more concentrated and larger at the lower tail of the distribution of living standards. This is first caused by the fact that the main source of error is the omission of transactions of consumption records, showing some households much poorer that they are in reality. Moreover, larger measurement errors among the very poor are possible because of the larger share of consumption from own production, which is more difficult to observe and value than monetary consumption expenditures. Then, if this type of measurement error were very important, one should observe that the very poor transit out of their category much more often than other household classes. The observation of the opposite result suggests that not only consumption records are of exceptional quality, reinforcing the results of section 3.4, but also that the very poor are excessively trapped into extreme poverty across seasons.

The transition analysis confirms that poverty in Rwanda is characterised by chronic features (households staying in the same quintile during some transitions) and transient ones (a substantial mobility across quintiles). Both aggregate movements of living standards, especially at the last transition, and exchanges in household positions, are important characteristics of poverty across seasons.

The importance of transient-seasonal poverty suggests that governments should implement income stabilisation policies. However, a careful analysis shows that this type of policy affects mostly the less poor amongst the poor. Figure 3 shows the cumulative curve of the transient poverty using indicator FGT(2) with line z_C. This curve reveals in a cumulative fashion the contribution to TP of different household populations ordered by their chronic living standards. The ordinate of a point of the curve is the ratio of the transient poverty of the population under a given level of annual living standard, over the transient poverty of the whole

household heterogeneity has been undertaken.

population. The abscissa of a point of the curve is the chronic living standard in logarithm. The poverty line z_C is indicated by a vertical line. It is easy to see that the share of TP that corresponds to the chronically poorest households is very small. Then, the contribution to TP from households with annual living standard under a given value sharply rises as the limiting value increases, until the poverty line is reached. Most of aggregate TP corresponds to households near the poverty line. This type of profile has also been found in Jalan and Ravallion (1996) for transient poverty from annual data. They argue that, because of the proximity to the subsistence level, poorest households cannot afford a large variability of income. Another reason of the small contribution of the extremely poor to TP is that these households are poor at all seasons. Therefore, their contribution only comes from the quantitative variability of their living standards, and not from discrete changes that would occur if they crossed the poverty line at some quarters during the year. The general conclusions from this curve analysis are robust to the choice of different poverty lines, axiomatically sound poverty measures, equivalence scales and price indices.

The fact that an income stabilisation policy cannot strongly affect the poorest of the chronically poor, invites us to investigate policies addressing separately the chronic poverty and the transient-seasonal poverty. How to define the target groups for each of these policies? Which instrument can be used to implement these policies? The next section is a first step towards the answer to these questions, based on estimations of equations for transient-seasonal poverty and chronic poverty, at the household level.

5. Equations of transient-seasonal and chronic poverty

5.1. The model

We investigate in this section the correlates of the two components of poverty using households as the basic statistical unit, in order to inform separate decentralised policies addressing CP and TP. The understanding of factors related to poverty has attracted substantial interest in the recent literature. Tables composed of poverty measures for different populations (poverty profiles) have been made possible by using decomposable poverty indices (Foster and Shorrocks (1984, 1991))[16]. Econometric analyses of household poverty indices are also common[17]. Notably, Jalan and Ravallion (1996) estimate censored quantile regressions of chronic and annual transient poverty measures.

None of these studies examine the causality and endogeneity of correlates. Even here, estimating a structural model of living standard generation for agricultural households with multi-output production is not our objective. We only investigate correlates of poverty measures and not pure causality relationships. However, we shall correct for the main endogeneity problems. An approach to these difficulties could be to estimate a model of expenditure dynamics across quarters, similar to Paxson (1992, 1993), from which we could derive implications concerning the effects of exogenous variables on alternative measures of welfare. Unfortunately, we would need to observe quarterly income data, local weather information and several years of consumption. Since this information is not available, and because there is only four observations by household,

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16 Shari (1979), Glewwe (1987) and Slesnick (1993) present tables of poverty incidence. Rodgers and Rodgers (1992), Alwang et al. (1996) show as well tables of other poverty indices.

17 Lanjouw and Stern (1991), Dercon and Krishnan (1994), Rodriguez and Smith (1994) and Mason (1996) estimate simple logit and probit models for incidence of poverty. Coulombe and McKay (1994) conduct a probit estimation of the incidence of poverty, and show OLS estimates for the depth of poverty (P_1/P_0). Appleton (1994) accounts for the quantitative dimension of poverty and for censorship by estimating Tobit models. McCulloch and Baulch (1999) estimate logit models of chronical poverty and annual transitory poverty.

our data is not well suited for this task. Besides, because our major concern is the study of poverty, we prefer to focus on the population of the poor and directly study the correlates of household transient and chronic poverty indices. Indeed, estimating an income model for the whole population may be excessively influenced by the characteristics of the rich (as shown in Yitzhaki (1996))[18]. The estimated model is the following. Two dependent variables are considered:

TP_i : the transient poverty measure of household i;

CP_i : the chronic poverty measure of household i.

TP_i and CP_i are null for a large set of observed households and strictly positive for others. For the estimation, household TP and CP indicators are calculated using FGT(2) measures based on deflated per capita consumption distributions and the defined poverty line z_F. We define two latent variables, "the latent transient poverty-welfare" and "the latent chronic poverty-welfare", respectively equal to $-TP_i^*$ and $-CP_i^*$, so as to interpret the null values of TP_i and CP_i as resulting from censorship. Then, we specify equations for the two latent welfare variables.

$$-TP_i^* = X_i'\beta + u_i \quad \text{and} \quad -CP_i^* = X_i'\gamma + v_i \qquad (5)$$

where X_i is a vector of independent variables for household i, β and γ are parameters, u_i and v_i are error terms. The link between latent and observed variables are specified as follows.

$TP_i = TP_i^*$ if $TP_i^* > 0$; $TP_i = 0$ otherwise.

$CP_i = CP_i^*$ if $CP_i^* > 0$; $CP_i = 0$ otherwise.

Eqs. (5) and the above links are the basis of separate estimations of censored regressions. Normality and homoscedasticity hypotheses are rejected for IV-Tobit estimates when using

18 The household chronic and transient contributions to the household annual poverty are defined from aggregate poverty measures TP and CP with the aggregation made over one household only. As a matter of fact, national poverty measures generally result from aggregating individual poverty measures (Atkinson (1987).

Pagan-Vella's tests (Pagan and Vella (1989)). This suggests estimating censored quantile-regression estimates that are robust to heteroscedasticity and non-normality. These estimators have been studied by Powell (1983, 1986). The confidence intervals of censored quantile-regressions are estimated using the bootstrap method (Hahn (1995)) with 1000 bootstrap iterations. The choice of the quantile in censored quantile-regressions is driven by the following arguments. Firstly, we want to focus on the poverty problem, specifically looking at the poor and at the extremely poor. This corresponds to quantiles close to 1 in the regressions of the latent welfare indices[19]. Secondly, as both the censorship and the robustness of estimation methods are associated with a loss of accuracy, we prefer to base the estimation on quantiles close to 1, so as to dispose of most of the quantitative information from poverty indicators in the maximised objective. Quantiles 0.975 are estimated for transient poverty, and 0.90 for chronic poverty[20]. As described in Buchinski (1994, 1995), the estimation is obtained by a combination of a linear programming algorithm and selection of a sub-sample at every iteration of the optimisation.

To solve possible endogeneity problems for some independent variables, we use a novel econometric technique that has yet not been applied. The possibly endogenous agricultural decisions, which are likely to convey the worst short-term endogeneity problems, are replaced by predictions based on a set of IV variables and then the censored quantile-regression is performed as usual. The consistency and the asymptotic normality of two-stage quantile-regressions for the slope coefficients are proven in Kim and Muller (1999) under mild conditions. It is also shown that the intercept coefficient is generally biased. The shares of products and the own-consumption ratio are predicted using Arcsine models[21], while the diversification indices are predicted using ordered probit models. The main identifying instrumental variables are local quarterly prices for the first three quarters and seven products, and various socio-demographic variables. This yields

19 Indeed, with the usual weak level of the goodness-of-fit statistics in poverty equations, conditional and unconditional quantiles are very close.

20 0.975 could be interpreted as if we focus on the 2.5 % poorest. However, considerations of robustness and information are also essential in the choice of quantiles close to 1, as in Jalan and Ravallion (1996).

21 We regress the agricultural decisions that are described in term of shares after transforming them by Arcsine function to avoid dependent variables that would be restricted between 0 and 1. Arcsine function is sometimes used

reasonable goodness-of-fit in the productive equations. The use of two-stage censored quantile regressions (2CQREG) is well suited to the problem at hand because it simultaneously treats our concerns for censorship, robustness, endogeneity and focus problems. Unfortunately, no quantile-regression method for simultaneous equations is presently available. This, the absence of strong structural priors about income generating processes and data limitations explain why we have separate estimations for TP_i and CP_i.

5.2. The correlates

The choice of correlates that we now discuss is guided by the consideration of the descriptive model as a preliminary step towards a causal model. Three distinct explanatory lines can be found in the empirical poverty literature. First, some authors focus on the direct origins of household income from economic activities. Second, earnings functions can be specified, or be derived from human capital or life cycle theories (Willis (1986)). Third, a similar approach consists of directly including the main production factors. All these arguments lead to the incorporation of the following explanatory variables: land, number of active household members, physical capital and assets, members' age and human capital, access to markets, and existence of employment opportunities off the farm.

A second set of independent variables, generally household composition and head's characteristics, is associated with the specification of indicators and the control of econometric misspecifications. These variables play at least three roles. They help to control for imperfect adult-equivalent scales, unobserved heterogeneity of households and omitted demographic changes correlated with poverty status (such as fertility). They may also embody additional information on the household's internal decision process. Finally, they may hint at segregation restricting the access to certain resources. Regional dummy variables sometimes play similar roles,

to transform probabilities for this purpose (e.g. Gouriéroux (1989)).

while also controlling for environment heterogeneity.

It is remarkable that agricultural decisions are generally not included whereas they can often be rapidly modified and could hint at potential policy instruments. We try to fill this gap. The production structure is important here because Rwandan households are characterised by multi-output production. Some cultures may be characterised by higher production returns than others. The poor may also be constrained in some cultures by lack of endowments or by their fields' characteristics. Producer theory indicates that the restricted profit function depends on input levels as well as on different output prices. However, when included in our estimates, prices were generally insignificant. Alternatively, output composition can be incorporated, since, if we assume a common multi-output production function for all households and no information problem, the aggregate production level is completely determined by input levels and product shares in the total output value.

Since agricultural contexts are characterised by major risks associated with output levels and prices, and food shortages, we need to consider household responses to these random elements. These responses are not specific to Rwanda but common to all the African Great Lakes countries (Sindayizeruka (1993)), and perhaps to most LDCs. Undertaking safe activities is an obvious protection strategy (e.g. Peemans (1993) in the very similar context of Burundi), whereas seasonal crops are more likely to be associated with high levels of seasonal poverty. In contrast, salaried labour activities are often efficient protections against crop income shocks (Kochar (1995)).

Moreover, the theory of decision under uncertainty (e.g. Demange and Rochet (1992)) shows that the composition of an efficient financial portfolio depends on both the vector of return expectations and the covariance matrix of returns, rather than only on levels and variances of returns. Of course, return functions for agricultural technologies, in contrast to those in financial markets, often involve decreasing returns to scale. However, correlations between returns from different crops still matter and an output diversification strategy can be appropriate. We include the output shares of the main products, and diversification indices (number of main cultivated products) for each quarter, in the set of independent variables.

Finally, preferring own-consumption to output commercialisation is another protection strategy against price shocks and food shortage risk. We account for this by including the "own-consumption rate" (percentage of non-purchased consumption). A high own-consumption rate may as well be determined by high transaction costs and other market imperfections, such as large differences between consumer and producer prices (de Janvry, Fafchamps and Sadoulet (1991)). These market imperfections contribute to the welfare loss caused by the impossibility of households extracting optimal exchange gains from the market. To separate risk strategy information included in the own-consumption rate from market imperfection information, we use the distance to the closest market as a measure of these imperfections. Even here reverse causality is possible, since the degree of market insertion may be the consequence of costly local migration[22].

"Agricultural decisions" denotes the product shares in the total output value, the diversification indices and the own-consumption rate. One expects that agricultural decisions vary for poor and rich households. Indeed, assets and risk aversion levels as well as risks faced, are likely to be different for these two categories of households. Let us now turn to the estimation results.

5.3. Estimation results

Table 9 presents the estimates from 2CQREG using poverty lines z_D and z_F. Estimates

22 Other risk protection strategies are also relevant, although no information is here available. For example, exchanges of gifts, helpful neighbours or extended family are traditional institutions, which assist the diversification of risks and smoothing of consumption (Townsend (1994)).

without agricultural decisions, which are not shown here to save place can be found in in Muller (1999b). We discuss the effects of correlates mostly by referring to their potential explanation, although the above-mentioned precautions about feed-back effects apply. The results are sensitive to the choice of the poverty line, although the signs of coefficients are generally stable when they are significant (at 5 % and 10 % levels). Highly insignificant variables (P-value over 0.5) have been excluded from regressions to save on degrees of freedom. Despite many similarities, different correlation structures correspond to severe poverty (low poverty line z_D) and moderate poverty (high poverty line z_F), whether chronic or seasonal. Some variables are never significant and we shall not discuss them further: number of adolescents, the dummy for regions except North-West and Centre-South, the share of non-food, the diversification indices at quarters C and D, and the own-consumption rate. Several significant coefficients are consistent with the positive impact of the main inputs on living standards. Land area is associated with lower CP, although it becomes insignificant when agricultural decisions are included. The number of young adult members, who constitute a large part of the labour force, is generally associated with lower TP. The education level of the household head is correlated with lower TP.

By contrast, the number of young children (and weakly the number of babies) is positively associated with chronic poverty-welfare, which may be explained by the burden that these members constitute for the household. This effect may also stem from inaccurate adult-equivalent scales. Female heads (and perhaps old heads) are associated with higher CP. This may be caused by lower productivity in these households frequently led by an old widow with limited access to economic opportunities. Living far from the neighbouring market reduces TP. Costly access to market makes the household less vulnerable to seasonal price shocks or seasonal shortage shocks, which helps to stabilise its living standard.

We now examine the effects of agricultural decisions. A higher share of beans makes TP less severe. Since this product is largely commercialised, an adverse effect of seasonal cropping pattern (von Braun et al. (1991)) may be offset by the stabilising financial capacity brought by this crop. The share of other fruit and vegetables negatively influences TP. This product is mostly composed of plantain bananas (excluding varieties of banana used specifically for beers). It helps households to smooth their consumption, since plantain bananas can be gathered most of the year.

The share of sweet potatoes is positively related to CP. This product is a staple food in Rwanda, intensively consumed by the poor. Sweet potatoes are mostly own-consumed and do not allow large gains from exchange because of their low value by kg, implying high transport costs. Their production is characterised by low returns to labour compared to other crops including cassava and banana (Peemans (1993)). The negative effect of the share of sweet potatoes on living standards may also come from unobserved poor quality for land and/or labour, restricting the cultivation of other products. The share of other tubers, mainly cassava and some potatoes, has a negative effect on TP. This is consistent with the use of cassava against famines and adverse climatic shocks, since it can be kept in the ground most of the year (Cochet (1993)). The output share of traditional beers (sorghum beer and banana wine) has a negative (but weakly significant) effect on TP and a weak positive effect on CP (with z_F). Because one third of this output is commercialised and one third is given and received in gifts, it enables the peasants to alleviate their liquidity constraint. Banana trees are one of the main forms of capital accumulation in the African Great Lakes (Cochet (1993)), generating precautionary savings.

The diversification index at quarter A negatively affects CP and TP. This is consistent with better management of agricultural risks and better plot allocation. Indeed, because Rwanda is a mountainous country, the agronomic properties of plots vary with land quality, altitude, slope and orientation. However, the diversification index at quarter B affects CP negatively but TP positively. At some seasons, the diversification strategy may be beneficial in the medium term but not necessarily in the short run.

The results provide useful hints about what makes some households poor. It seems that household actions themselves matter. Households not employing some low risk strategies appear to have a higher level of poverty. In particular, the absence of activity diversification in the beginning of the observation period is very significantly related to higher TP and CP. Successful policies are likely to be ones that account for these existing strategies and encourage them rather than ignoring them and imposing ready-made recipes.

Because different significant correlates are found for TP and CP equations, specific policies addressing each component of poverty are possible. Diversification indices in quarters A and B affect both CP and TP, but in different directions at quarter B. Specialisation in production of beans, banana, cassava and crop diversification in the first quarter, are all related to lower TP. Sweet potatoes constituting a small output share and crop diversification in the first and second quarter are associated with lower CP. Target groups based on these correlates can be different when fighting transient-seasonal or chronic poverty. Land, distance to market and crop specialisations are attractive sorting criteria because they can be easily observed.

Moreover, policies might be based on public incentives or constraints to develop crops that are associated with low levels of CP or TP. However, in that case further investigations are necessary first to validate the direction and strength of causality links, secondly to incorporate household responses to incentive and thirdly to investigate by-effects and macroeconomic links implied by policies. To some extent, these concerns apply also to target-group policies, especially when households can develop expectations about these policies.

6. Conclusion

We investigate in this paper the importance of seasonal consumption fluctuations for measuring aggregate annual poverty and the understanding the factors related to poverty. We robustly show that in Rwanda, a substantial share of annual poverty can be attributed to seasonal consumption fluctuations. This is confirmed by the large extent of household mobility across quintiles in all seasons. The poverty crisis after the dry season, when many peasants fall into poverty, is a critical hardship period for most households.

Several policy consequences can be derived. First, since climatic seasonality is rather moderate in this country, actual differences in poverty between LDCs and industrial countries or between rural and urban areas of LDCs are likely to substantially exceed that shown by most available poverty statistics. This calls for a revision of international policies in the direction of a greater emphasis on aid to poor agricultural countries. Second, temporary "safety net" policies targeted to the poor and the non-poor at crucial periods would be appropriate. Third, living standard stabilisation across the year would be a very efficient way to reduce the aggregate amount of annual poverty. However, this policy may not reach the extremely poor, as is the case in Rwanda.

What is needed is a combination of decentralised policies addressing separately seasonal-transient and chronic poverty at the household level. Estimated equations of chronic and transient poverty for Rwandan households show that differentiated policies can be anchored on different correlates, particularly when agricultural specialisation or diversification and market insertion are accounted for. The effects of these variables are consistent with suggestive explanations often related to risk protection strategies. This implies firstly, that it is possible to design specific policies that address the different components of annual poverty, or structural interventions based on household endowments by defining target groups specific to each component of poverty. This latter approach also entails that these interventions be designed in harmony with existing household strategies to cope with seasonal and annual agricultural risks.

Appendix 1: Sampling standard-error estimators

The poverty indicator of a sub-population is estimated by a ratio of the type

$$\overline{y'}_x = \frac{z'}{x'}$$

where ' denotes the Horwitz-Thompson estimator for a total (sum of values for the variable of interest weighted by the inverse of inclusion probability). z is the sum of the poverty in the sub-population and x is the size of the sub-population. The variance associated with the sampling error is then approximated by:

$$V(\overline{y'}_x) = [V(z') - 2\,\overline{y'}_x\, Cov(z',x') + (\overline{y'}_x)^2 V(x')] \,/\, (x')^2$$

obtained from a Taylor expansion at the first order from function Y = f(Z/X) around (E y', Ex') and because E z' ≠ 0 and x' does not cancel, where the appropriate expectancies are estimated by x' and $\overline{y'}_x$.

We divide the sample of communes (first actual stage of the sampling since all the prefectures are drawn) in five super-strata (α = 1 to 5) so as to group together the communes sharing similar characteristics, and to reduce a priori the variance intra-strata. Several sectors are assumed to have been drawn in each strata. This allows the estimation of the variance intra-strata, while the calculation of the variance intra-commune was impossible, since in fact only one sector had been drawn in each commune. Then, the Horwitz-Thompson formula for superstrata α is:

$$z'_\alpha = \sum_h \frac{M_h}{m_{h\alpha}} \sum_{i=1}^{m_{h\alpha}} \frac{N_{hi}}{n_{hi}} \sum_{j=1}^{n_{hi}} \frac{Q_{hij}}{q_{hij}} \sum_{k=1}^{q_{hij}} z_{hijk}$$

and

$$x'_\alpha = \sum_h \frac{M_h}{m_{h\alpha}} \sum_{i=1}^{m_{h\alpha}} \frac{N_{hi}}{n_{hi}} \sum_{j=1}^{n_{hi}} \frac{Q_{hij}}{q_{hij}} \sum_{k=1}^{q_{hij}} x_{hijk}$$

where M_h is the number of communes in prefecture h; $m_{h\alpha}$ is the number of communes in prefecture h and drawn in superstrata α; N_{hi} is the number of sectors in commune i of prefecture h and superstrata α; n_{hi} is the number of sectors drawn in commune i of prefecture h and superstrata α; Q_{hij} is the number of households in sector j of commune i of prefecture h; q_{hij} is the number of households drawn in sector j of commune i of prefecture h and superstrata α. A similar formula can also be used to account for the intermediary drawing of several districts in every sector.

Cov(z',x') is estimated by:

$$\hat{C}ov(z',x') = \frac{1}{20} \sum_{\alpha=1}^{5} (z'_\alpha - z').(x'_\alpha - x')$$

and similar formulae for V(x) and V(z) are obtained by making x = z.

Estimates of the sampling standard errors of CP, TP and differences of seasonal indices have also been calculated. Because the same sample of households has been surveyed at each quarter and because all these poverty statistics are linear functions of individual poverty statistics, the same type of Horwitz-Thompson estimators can be used to represent them. Therefore, the same method can be applied for the calculation of their sampling errors (implicitly calculating the covariance of different poverty indices).

Appendix 2: Correction terms for data contamination in poverty measures

The correction terms are derived from Taylor expansions applied to a convolution product incorporating a measurement error term. Let Z be the contaminated distribution of living standard, and let X be the error-free distribution. They are assumed related by the relation $Z = X V$ where $V = \exp(-\sigma^2/2) U^{\sigma}$ is a multiplicative measurement error component such that lnU has mean zero and variance one, and σ^2 is a parameter describing the extent of the measurement error. The application of results from Chesher and Schluter (1999) yields the following correction terms for FGT(a) indices, a = 0, 1, 2 with poverty line z.

$$FGT_Z(0) \approx FGT_X(0) + \sigma^2/2(z^2 f'_Z (z) + 2 z f_Z(z))$$

$$FGT_Z(1) \approx FGT_X(1) + \sigma^2/2 z f_Z(z)$$

$$FGT_Z(2) \approx FGT_X(2) + \sigma^2/2 \ (FGT_Z(2) - 2 FGT_Z(1) + FGT_Z(0))$$

where f_Z is the p.d.f. of Z.

The p.d.f. and its derivative are estimated using kernel density estimation with Epanechnikov method.
Parameter σ^2 is such that $Var(lnZ)/Var(lnX) = 1 + \sigma^2 /Var(lnX)$. The chosen values of σ^2 correspond to values of Var(lnZ)/Var(lnX) ranging from 100.1 % to 155 %.

We need to assume that there is no seasonal variation in measurement errors to be able to identify TP with and without data contamination. In that case, the same value of σ^2 can be used for all periods.

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Table 1: Descriptive Statistics

Variable	Mean	Standard Deviation
Total Consumption (Frw)	51176	24985
Total Production (Frw)	57158	38207
Per Capita Total Consumption (Frw)	10613	5428
Female head	0.20	0.40
Average age of members	24.32	13.40
Tutsi head	0.10	0.31
Land area (m^2)	12398	13156
Number of children 0-3	0.85	0.87
Number of children 4-10	1.07	1.05
Number of adolescents 11-15	0.74	0.92
Number of youngs 16-20	0.50	0.77
Number of adults	2.04	0.75
North-West	0.14	0.35
South-West	0.15	0.36
Centre-North	0.20	0.40
Centre-South	0.24	0.43
East	0.24	0.43
Education of the head	1.80	2.49

Following of table 1:

Variable	Mean	Standard Deviation
Total Consumption (Frw): Quarter A	13521	9527
Total Consumption (Frw): Quarter B	13232	8192
Total Consumption (Frw): Quarter C	13452	8249
Total Consumption (Frw): Quarter D	10969	6092
Total Production (Frw): Quarter A	13240	12178
Total Production (Frw): Quarter B	15548	16610
Total Production (Frw): Quarter C	15416	18171
Total Production (Frw): Quarter D	12952	10662
Per Capita Total Consumption (Frw): Quarter A	2750	1701
Per Capita Total Consumption (Frw): Quarter B	2702	1620
Per Capita Total Consumption (Frw): Quarter C	2850	1968
Per Capita Total Consumption (Frw): Quarter D	2310	1511

Round A: 01/11/1982 until 16/01/1983. Round B: 29/01/1983 until 01/05/1983. Round C: 08/05/1983 until 07/08/1983. Round D: 14/08/1983 until 13/11/1983.

Table 2: Autocorrelations coefficients

Variable	A-B	B-C	C-D
Total consumption	0.56	0.55	0.61
Per capita consumption	0.54	0.57	0.67
Total production	0.24	0.19	0.24

All coefficients are significant at 5% level

Table 3: FGT's Poverty indices

a	0	1	2	3
	0.2915	0.0812	0.0343	0.01770
A	(0.0319)	(0.0102)	(0.00549)	(0.00360)
	0.2548	0.0648	0.0247	0.0146
B	(0.0391)	(0.0109)	(0.00514)	(0.00294)
	0.2840	0.0813	0.0338	0.0169
C	(0.0288)	(0.00861)	(0.00449)	(0.00269)
	0.4133	0.1219	0.0550	0.0317
D	(0.0534)	(0.0200)	(0.0126)	(0.00935)
	0.3108	0.0874	0.0369	0.0194
AP	(0.0288)	(0.00765)	(0.00357)	(0.00225)
	0.2258	0.0446	0.0146	0.00893
CP	(0.0184)	(0.00448)	(0.00175)	(0.000788)
TP	0.0854	0.0428	0.0223	0.0104
	(0.0176)	(0.00577)	(0.00333)	(0.00656)
F	0.3218	0.4897	0.6043	0.5396

All initial poverty measures are significant at 5 % level for all poverty lines.
The first number in each cell is the mean of the poverty measure over the six poverty lines. The number in parentheses is the mean of the standard errors over the six poverty lines.

Table 4: CHUC and Watts' Poverty indices

a	W	1	1/2	1/3
	0.1102	0.0812	0.0469	0.0326
A	(0.0159)	(0.0102)	(0.00626)	(0.00447)
	0.0711	0.0648	0.0366	0.0326
B	(0.0151)	(0.0109)	(0.0063)	(0.00446)
	0.108	0.0813	0.0467	0.0324
C	(0.0125)	(0.00861)	(0.00514)	(0.0036)
	0.185	0.1219	0.0726	0.0515
D	(0.0358)	(0.0200)	(0.0128)	(0.00936)
	0.1220	0.0874	0.0507	0.0354
AP	(0.0121)	(0.00765)	(0.00459)	(0.00328)
	0.0561	0.0464	0.0254	0.01736
CP	(0.00554)	(0.00448)	(0.00248)	(0.00169)
TP	0.0726	0.0238	0.0137	0.00964
	(0.0101)	(0.00577)	(0.00362)	(0.00264)
F	0.5840	0.5148	0.5430	0.5555

All initial poverty measures are significant at 5 % level for all poverty lines.
The first number in each cell is the mean of the poverty measure over the six poverty lines. The number in parentheses is the mean of the standard errors over the six poverty lines.

Table 5: Share of the transient-seasonal component in the annual food poverty

Poverty index: Povert line:	W	CHUC(1) and FGT(1)	CHUC(½)	CHUC(1/3)	FGT(0)	FGT(2)	FGT(3)
Z_A	0.884	0.802	0.830	0.847	0.623	0.910	0.964
Z_B	0.819	0.723	0.755	0.773	0.555	0.848	0.926
Z_C	0.697	0.577	0.616	0.639	0.356	0.748	0.857
Z_D	0.672	0.553	0.591	0.613	0.394	0.721	0.837
Z_E	0.590	0.469	0.508	0.530	0.206	0.642	0.769
Z_F	0.509	0.384	0.425	0.447	0.172	0.564	0.700

Table 6: Sensitivity of the share of the transient poverty to measurement errors

σ	Z	FGT(0)	FGT(1)	FGT(2)
Uncorrected	Z_C	0.301	0.523	0.665
0.008	Z_C	0.301	0.523	0.666
0.016	Z_C	0.301	0.523	0.666
0.030	Z_C	0.302	0.525	0.668
0.054	Z_C	0.306	0.530	0.673
0.13	Z_C	0.331	0.567	0.715
0.32	Z_C	0.660	~1	~1
Uncorrected	Z_F	0.158	0.347	0.507
0.008	Z_F	0.158	0.347	0.507
0.016	Z_F	0.158	0.347	0.507
0.030	Z_F	0.158	0.348	0.508
0.054	Z_F	0.159	0.351	0.512
0.13	Z_F	0.164	0.371	0.543
0.32	Z_F	0.219	0.660	~1

The values ~1 can exceed 1 because of imperfect accuracy of the estimates. In that case 1 belongs to the confidence interval and has been substituted.

Table 7: Share of the transient-seasonal component in the annual poverty using the extended definition of annual poverty

			CHUC(1)	CHUC(1/2)	CHUC(1/3)
ρ = 1	α = 1	β = 1	0.523	0.550	0.562
ρ = 0.1	α = 1	β = 1	0.447	0.469	0.478
ρ = 0.2	α = 1	β = 1	0.369	0.386	0.393
ρ = 0.3	α = 1	β = 1	0.287	0.300	0.305
ρ = 0.5	α = 1	β = 1	0.137	0.144	0.146
ρ = 0.1	α = 0.5	β = 1	0.340	0.357	0.364
ρ = 0.1	α = 1	β = 1/1.1	0.447	0.469	0.478
ρ = 0.1	α = 2	β = 1	0.507	0.530	0.540
ρ = 0.1	α = 0.5	β = 1/1.1	0.340	0.357	0.364
ρ = 0.1	α = 2	β = 1	0.567	0.530	0.540
ρ = 0.5	α = 0.5	β = 1	0.154	0.161	0.164
ρ = 0.5	α = 2	β = 1	0.269	0.219	0.222
ρ = 0	α = 1	β = 1	0.523	0.550	0.562
ρ = 0	α = 1	β = 1/1.1	0.442	0.473	0.487
ρ = 0	α = 1	β = 1/1.1	0.620	0.644	0.653

Table 8: Estimates of transition matrices

A \ B	1	2	3	4	5
1	40.7	15.2	22.4	15.5	5.9
2	36.3	30.1	18.7	9.6	5.1
3	15.3	20.1	30.3	8.2	25.9
4	16.1	15.8	19.8	20.9	27.2
5	7.4	12.0	19.6	14.6	46.2

B \ C	1	2	3	4	5
1	49.1	18.8	11.7	6.5	13.7
2	32.4	18.8	14.8	17.4	16.3
3	32.7	10.0	26.8	17.0	13.3
4	21.5	8.1	11.4	31.1	27.7
5	1.7	12.1	7.2	30.8	48.0

C \ D	1	2	3	4	5
1	68.4	19.7	6.0	3.3	2.3
2	50.7	26.5	16.5	0.0	6.2
3	45.8	16.3	23.2	4.9	9.6
4	19.1	26.0	25.0	10.7	18.9
5	13.6	15.6	9.6	21.4	39.6

The numbers 1, 2, 3, 4, 5 refer to the classes of households defined by their boundary equals to the original quintiles of living standards.

Table 9: Regressions of the transient and chronic poverty indices

poverty	CP	CP	TP	TP
Poverty line	Z_D	Z_F	Z_D	Z_F
constant	-0.463	-0.433	-0.243	-0.122
	(0.017)	(0.006)	(0.000)	(0.072)
nb babies	-0.0508	-0.0467		
	(0.017)	(0.020)		
nb children	-0.0389	-0.0335		
	(0.005)	(0.015)		
nb adolescents		-0.0173		
		(0.305)		
nb young adults		-0.0155	0.0250	0.0225
		(0.326)	(0.005)	(0.017)
nb older adults			-0.00809	-0.0190
			(0.352)	(0.101)
Tutsi head			-0.128	
			(0.375)	
Female head	-0.0855	-0.122		
	(0.042)	(0.014)		
Age of the head	-0.00220			
	(0.029)			
Education of the head			0.0105	0.00613
			(0.015)	(0.104)
(Distance to market)/1000			0.772	0.655
			(0.009)	(0.051)
Land			-0.000753	
			(0.185)	
North-West	-0.126	-0.0748		
	(0.030)	(0.147)		
Centre-South	-0.0643	-0.0566	0.0453	0.0285
	(0.091)	(0.091)	(0.003)	(0.048)
East	-0.0467			
	(0.360)			
% beans		-0.172	0.201	
		(0.356)	(0.088)	
% fruit and vegetables			0.282	0.0870
			(0.000)	(0.344)
% sweet potatoes	-0.549	-0.479		
	(0.029)	(0.032)		
% other tubers	0.176	-0.216	0.393	0.400
	(0.388)	(0.210)	(0.001)	(0.006)
% traditional beers		-0.0919	0.0876	0.113
		(0.512)	(0.278)	(0.227)
Diversification index at quarter A	0.0540	0.0607	0.0328	0.0217
	(0.011)	(0.001)	(0.000)	(0.012)
Diversification index at quarter B	0.0568	0.499	-0.0459	-0.0351
	(0.045)	(0.034)	(0.004)	(0.043)
Diversification index at quarter D				-0.0156
				(0.280)
Own-Consumption rate	0.180			0.0840
	(0.238)			(0.379)

P-values in parentheses. 256 observations.