Transient Seasonal and Chronic Poverty of Peasants: Evidence from Rwanda

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Abstract: Using panel data from Rwanda, we estimate seasonal transient and chronic poverty indices, for different poverty lines, poverty indicators, equivalence scales, and with and without corrections for price variability and for the sampling scheme. We also estimate sampling standard errors for the poverty indices. The worst poverty crises occur after the dry season at the end of the year. Most of the severity of poverty comes from the seasonal transient component of annual poverty, while the seasonal component of the incidence of poverty is much smaller. Thus the actual differences in the severity of poverty, either between developing and industrial countries or between rural and urban areas in LDCs, may be much worse than is shown by the usual chronic annual poverty measures or by measures of seasonal incidence of poverty. The importance of the transient component suggests a need for an income stabilisation policy. However, the contribution of the global transient seasonal poverty is important for households clustered around the poverty line, but low for the poorest part of the chronically poor. Thus, policies fighting seasonal transient poverty are likely to concern the moderately poor rather than the very poor, as compared with policies against chronic poverty, which affect the very poor. The probability transition analysis across seasonal living standard distributions shows that mobility across quintiles is always very strong. The poverty crisis in the last season is more the result of many peasants falling into poverty than a decrease in the flow out of poverty. A ‘safety net’ policy aimed at the poor and the non-poor at this period would then be appropriate. We estimate equations of quantiles for household chronic and transient seasonal poverty. The agricultural choices of peasants are found to affect differently the two components of annual poverty that could therefore be addressed by a combination of policies specific to each component.

Résumé

A partir de données de panel du Rwanda, nous estimons des indices des pauvretés saisonnières et chroniques, pour différentes lignes de pauvreté, indicateurs de pauvreté, échelles d'équivalence-adulte, avec ou sans corrections pour la variabilité des prix, et pour le plan de sondage. Nous estimons également des erreurs-types de sondage pour les indices de pauvreté.

Les pires crises de pauvreté surviennent après la saison sèche à la fin de l'année. La majorité de la sévérité de la pauvreté provient de la composante saisonnière de la pauvreté annuelle, alors que les mesures d'incidence conduisent à des effets bien moindres de la composamte saisonnière. Ainsi, il se peut que les véritables différences de sévérité de pauvreté entre pays en développement ou industriels ou entre zones rurales et urbaines dans les PVD, soient bien pires que ce que montrent les mesures usuelles de pauvreté chronique annuelle ou les mesures d'incidence saisonnières de pauvreté. L'importance de cette composante transitoire suggère de mettre en oeuvre une politique de stabilisation des revenus. Cependant, la contribution au montant global de pauvreté transitoire saisonnière est importante pour les ménages autour de la ligne de pauvreté mais faible pour la partie la plus pauvre des chroniquement pauvres. Ainsi, les politiques luttant seulement contre la pauvreté saisonnière transitoire sont plus susceptibles de toucher les modérément pauvres plutôt que les très pauvres, que les politiques luttant contre la pauvreté chronique.

L'analyse des probabilités de transition entre les distributions saisonnières des niveaux de vie montre que la mobilité entre les quintiles est toujours très forte. La crise de pauvreté lors de la dernière saison est plus le résultat de nombreux paysans devenant pauvres que de la baisse du flux de sortie de la pauvreté à cette période. Une politique sous la forme d'un 'filet de sécurité' visant les pauvres et les non-pauvres á cette période serait appropriée.

Nous estimons des équations de quantiles pour les pauvretés chroniques et saisonnières transitoire des ménages. Les choix agricoles des paysans se trouvent affecter différemment les deux composantes de la pauvreté annuelle qui pourrait donc être traitée par une combinaison de politiques spécifique à chaque composante.

Contents

1. Introduction

The analysis of poverty is central to development economics. On the one hand, there exists a very strong descriptive correlation between the incidence of underdevelopment and of poverty, as suggested by the quasi-coincidence of the map of developing countries and the map of poor countries. On the other hand, theory suggests that a substantial reduction in poverty in a less developed economy is likely to be associated with higher growth and more balanced and dynamic development. Indeed, higher living standards allow households to accumulate physical and human capital. They also help to increase the productivity of inputs, to modernise the technologies and social structures and to stimulate innovations. Moreover, extreme poverty in the economy generates massive negative externalities (epidemics, violent social and political conflicts, subsistence constraints, etc). Finally, higher living standards are associated with lower fertility rates, and facilitate the further increase of living standards by easing the demographic transition. From a more microeconomic point of view, the processus generating income and living standards may be radically different for the rich and the poor, especially since the latter are close to subsistence levels and often face fierce liquidity constraints. This suggests models and statistical treatments that are specific to the poor.

Since most of the poverty in the world corresponds to peasants in rural areas of developing countries (The World Bank (1990))[1], the analysis of poverty should focus particularly on the determinants of income flows of poor agricultural households. Most of their income comes from their agricultural output; therefore the main agricultural inputs, labour and land, as well as climatic fluctuations (Nugent and Walther (1981)) play a dominant role in understanding the nature and the cause of poverty. Aggregate data of LDCs supports the pervasive importance of climatic variations, showing that the agricultural output patterns are closely related to climatic fluctuations.

Due to high seasonal variability of production and the existence of liquidity constraints in agricultural economies, the living standards of peasants vary substantially across seasons, and may permanently or transiently fall under the poverty line. It is therefore not surprising that the analysis of seasonal rural poverty in LDCs has attracted considerable interest both recently (Chambers, Longhurst and Pacey (1981), Chambers (1982), Fortman (1985), FAO (1986), Gill (1991), Lipton and Ravallion (1993)), and historically (Chayanov (1864), Duby (1962)). Chambers, Longhurst and Pacey (1981) conduct a thorough analysis of the nature and consequences of seasonal rural poverty, although this is not directly linked to the measurement of seasonal living standards.

As yet no robust and axiomatically sound measurement of seasonal poverty seems to be available in the literature. Using annual data for several years, Chaudhuri and Ravallion (1992) show that no static indicator can accurately approximate averaged dynamic poverty. One can expect that such approximation would be worse with seasonal data because the variability of living standards of peasants is higher across seasons than across years, especially where severe liquidity constraints exist. Nonetheless, neither the extent of poverty arising from seasonal fluctuations, nor the validity of the annual chronic poverty indicators used in the huge majority of poverty studies is known. However, if the transient seasonal component of poverty is an important part of annual poverty, the whole perspective of poverty comparison studies may be changed. In particular, the difference

[1] Of course, there are poor people in industrial countries, in the cities of LDCs or non-peasants in rural areas, but they are generally less poor than peasants in LDCs and much less numerous.

between rural and urban areas (or between LDCs and industrial countries) may be much worse than is shown with chronic annual indicators. Furthermore, the statistical relationship between poverty (chronic or seasonal), socio-demographic and environment characteristics and agricultural choices of peasants is badly understood. Differences in the correlates for the two components of poverty would suggest differentiated policies. Using seasonal panel data from Rwanda, we provide estimates of these relationships, correcting for heteroscedasticity, non-normality, endogeneity, censorship and small sample size sources of bias.

Atkinson (1987) and Ravallion (1992, 1996) provide general discussions on poverty measurement. The measurement of poverty is usually based on income or consumption distributions, per household or on per capita (or per adult-equivalent) indicators. We control the robustness of our results for household composition by using three alternative equivalence scales. We control also for geographical and temporal price variability.

As Baulch (1996) and Ravallion (1996) stress, few studies are yet available that account for the dynamics of poverty (especially applied studies for Africa where the poverty problem is the most severe), although the literature about income mobility is more developed (Atkinson, Bourguignon, Morrisson (1992)). Most existing studies are limited to the analysis of the incidence of poverty and do not deal with its severity, even though poverty measures founded only on a head-count index are not axiomatically sound (Foster, Greer, Thorbecke (1984)). Bane and Ellwood (1986), Ruggles and Williams (1989) and Sevens (1995) estimate the exit rates out of poverty and the duration of poverty spells for US households, but do not explicitly distinguish between transient and chronic poverty. They also mostly focus on incidence of poverty, but show that the number of poverty spells increases a lot and the typical poverty spell is much shorter, when small duration units are used. Considering the severity of poverty, Ravallion (1988) distinguishes between chronic poverty and transient annual poverty. Using Indian data, he shows that the stabilisation of income over several years reduces poverty, but has little impact on the number of poor. Rodgers and Rodgers (1993) survey several approaches to the analysis of transient annual and chronic poverty. They provide a thorough applied analysis for the US, but do not study the correlates of the two components of poverty. Grootaert and Kanbur (1995) find that the mobility of the poor in the distribution of per capita consumption during four years in Côte d'Ivoire is large. Using six-year panel data in post-reform rural China, Jalan and Ravallion (1996) find substantial transient annual poverty. They study the correlates of transient annual and chronic poverty, and find that they are not qualitatively different for the two components of poverty. However, despite their generally high quality, all these studies are limited in that they generally consider only one specific poverty line or one specific equivalence scale. Robustness of their results is therefore not guaranteed. Furthermore, corrections for price variability and the sampling frame are often absent or quite rough.

The abovementioned studies deal with transient annual poverty over a few consecutive years and not with transient seasonal poverty. One reason for this lacuna is the scarcity of seasonal panel data for peasants in LDCs. Moreover, excellent data in terms of measurement errors are needed to avoid mixing pure stochastic effects (coming from the contamination of the data by measurement errors) with the seasonal variability of living standards. We use very high-quality data that satisfy this requirement. This reduces, although it does not eliminate, the impact of the measurement error problem. Cowell and Victoria-Feser (1996a, 1996b) show that ad hoc controlling methods are generally not reliable for inequality indicators. Some poverty measures are more robust under data contamination (for example FGT(2), see below), although this is not the case for several common indicators (Watts' index for example)[2]. Finally, seasonal and local price data and a description of the sampling frame must be available.

The aim of this article is to analyse the chronic and seasonal poverty of peasants in Rwanda. We adopt deliberate methodological approaches that favour the robustness of the analysis. First, we estimate living standards and poverty indices for 3 equivalence scales, 7 poverty indicators, 6 poverty lines, with and without correction for price variability, and with and without accounting for the sampling scheme. Second, we conduct a thorough study of seasonal poverty by using complementary statistical tools: autocorrelation and variance analysis, stochastic dominance analysis, poverty indices estimation, transition probability analysis between seasonal distributions of living standards, and estimation of correlates of the dynamic components of poverty. Third, we avoid disturbing the analysis by (i) the estimation of behavioural models whose estimated parameters are rarely robust, or (ii) hypotheses involving the variability of preferences, of social welfare functions or of the market context, which are also delicate to specify or estimate with robustness[3]. We present the data and the living standards indicators and discuss the results of autocorrelation and variance analyses in section 2. In section 3, we conduct a seasonal poverty analysis based on estimates of transient seasonal and chronic poverty indicators. We assess the confidence which can be attached to the estimation of poverty indicators, by providing sampling standard errors. We discuss the results of a transition probability analysis across seasonal living standard distributions in section 4. In section 5, we estimate equations of transient seasonal and chronic poverty where the correlates are socio-demographic characteristics and the endowment of households, as well as environmental variables and agricultural decisions. We conclude in section 6.

2. The data

2.1 Country and survey

Rwanda is a small rural country with an estimated population in 1983 of 5.7 million, of whom nearly half were under 15 years of age. We study a more peaceful situation (corresponding to agricultural year 1982–83) than that of the recent civil war. In 1983, per capita GNP was around US$ 270, making Rwanda one of the poorest countries in the world. More than 95 percent of the population lived in rural areas, and agriculture represented 38% of GNP**.** The educational level of the population is low, with half of the adults being illiterate. Health status is very precarious, with a life expectancy of 47 years.

Demographic growth is very high (3.5% a year), with an average of 8.3 children per fertile woman. This results in a great pressure on land (the average farm covers around one hectare).

[2] They note that 'rogue data on the poorest of the poor may completely distort the estimate of aggregate poverty', especially when poverty evaluation functions are very sensitive to subsistence minimum. Measurement errors in the income of the rich or of households close to the poverty line, have much less serious consequences.

[3] This does not mean that such models or hypothesis cannot provide interesting results in themselves. Of course, models and hypotheses are also implicit in the analysis, but they should not overly influence the robustness of our results. One of the contradictions of the estimation of behaviour models with the exploration of the robustness of results comes from the fact that once the model is estimated from inevitably debatable assumptions, the study is often focused on the value of estimated parameters rather than on the examination of a set of different hypotheses for the value of parameters.

Food production per capita fell between 1980 and 1991 at a rate of 1.8% a year. Climatic seasonal fluctuations are known to be substantial (Bulletin Climatique du Rwanda (1982, 1983, 1984)), but are much less so than in most of sub-Saharan Africa, or many other rural developing areas (Chambers, Longhurst, Pacey (1981)). The two main seeding periods are in October and March, followed by rains.

We extracted the data for the calculus and the estimation from the 1983 Rwandan national budget-consumption survey of 270 households that 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 1978 census shows this to be 95% of the population (Bureau National du Recensement (1984)). The survey was conducted from November 1982 to December 1983. Households were surveyed quarterly on their demographic characteristics, their budget, their consumption and their daily activities. We have calculated consumption and production indicators and established decomposition in the main agricultural products. Note that in several aspects the quality of the indicators calculated from this survey is exceptional.[4] Indeed, the collection was exceptionally onerous. The volume of all containers in every household was measured in addition to the traditional measurement units, so as to obtain accurate information about quantities of goods in the survey. Every household was visited at least once a day (and often twice) during two weeks every quarter by one enumerator who asked questions, weighed food and took measures. Every household had to fill in diaries during the absence of the enumerator, who revised them on his/her return to the household. The set of surveyed topics was very broad, and several questions have been repetitiously treated by different methods of collection. It is possible, for instance, to control the transactions and the weighed food consumption, by comparing them with each other and with a daily activities questionnaire. This enabled better-quality collection as well as a thorough cleaning of the data, which was carried out by more than thirty ex-enumerators after the collection under the supervision of the author. We were able to use sophisticated verification algorithms because of the many redundancies present in the data. Finally, we have based the calculus of indicators on algorithms deliberately aimed at reducing the measurement errors from the combination of several information sources. In particular, we use optimal combinations of questionnaires for the calculus of seasonal consumption, accounting for the characteristics of products (in terms of the quality of the observation in each questionnaire) and the frequency of transactions associated with the consumption of each product. This, we expect, led to much smaller measurement errors than usual.[5]

The survey sample represents the total rural population of Rwanda (95% of the whole population). The sampling scheme (modelled in Roy (1983) and completed by our own

[4] The main part of the collection was designed by D. Blaizeau and P.-H. Wirrankoski. The author was involved in this project until the last stage of the analysis, which he supervised.

[5] The measurement error is considered to be one of the main obstacles to the understanding of welfare questions (Cowell and Victoria-Feser (1996)). We have here an opportunity to reduce this problem substantially, even over situations where survey data are excellent (such as for instance in Jalan and Ravallion (1996)). Indeed, when we compared the weekly recall information (one of the best collection methods for data used in the literature) available in our survey with the daily measures that we used, we found a substantial difference in the quality of information. For the main consumption goods, the weekly recall records often show at least 30% average underestimation. A clear signal of the exceptional quality of our indicators is that we obtain very close estimations of consumption and income levels, while in most studies income is significantly underestimated with respect to consumption (see Paxson (1992)).

investigations during our stay at the Direction Générale de la Statistique du Rwanda), has four sampling levels (communes, sectors, districts and households). The drawing of the communes was stratified by prefectures, agro-climatic regions and altitude zones. One district was drawn in each drawn commune and one cluster of three households was drawn in each drawn district. From this information we calculated sampling weights that reflect the probabilities of drawings of units at every stage of the sampling scheme. Using sampling weights substantially changes the results of the descriptive statistics and the estimations of poverty indices and transition matrices.

Table 1 shows the descriptive statistics of the main variables for the sample of households. The average household size is 5.22 members, of which 2.67 are children or adolescents (under 18 years old), and 2.55 are adults (18 years old and over). The average age of members is 24.32 years. Naturally, the average age of the head is much higher (47.45 years), and 21.8% of these heads are women (mainly widows), while 10.9% of heads belong to the Tutsi ethnic group. The average level of education of the head is very low (1.81 years of schooling).

The average land area farmed by each household is very small (1.24 ha), but it enables the average household to produce 57028 Frw (Rwandan Francs[6]) worth of agricultural output. This finances average consumption of 51848 Frw (10 857 Frw per capita). The average surplus (production minus consumption) is only 5180 Frw (10% of the average consumption), but its variability among households is very high (standard deviation of 26522). It is negative on average in the first agricultural quarter (-420 Frw), but becomes positive in the next three quarters (1932 Frw, 1674 Frw, 1994 Frw). See Muller (1989) for a detailed description of the consumption of Rwandan peasants.

2.2 Living standard indicators

The utility levels in the considered social welfare functions can be derived, strictly speaking, from indirect utility functions that depend on exogenous factors, such as income and prices, rather than from direct utility functions depending on consumption. Where it is possible, welfare comparisons referring to consumer theory should therefore be based on income rather than on consumption levels. Anand and Harris (1994) show that the choice of a welfare indicator may have substantial consequences on the estimation of the characteristics of the poor. But as Chaudhuri and Ravallion (1994) and Rodgers and Gray (1994), among others, argue, there are good reasons for preferring welfare measures based on consumption levels, despite the fact that they may be influenced by the decisions of households. Firstly, the income levels cannot seriously be considered outside the scope of these decisions (especially for agricultural households) and to some extent share the same limitations as consumption levels. Secondly, the transient shocks affecting incomes can be extreme (notably in rural areas), and the ‘permanent’ seasonal profiles of purchasing power can be better represented by consumption levels[7]. Thirdly, unlike consumption, the income of peasants

[6] In 1983, the average exchange rate was 100.17 Frw for US$ 1 (source: IMF, International Finance Statistics).

[7] Income is subject to transitory shocks that result from changes in employment, changes in the family unit, and windfall gains or losses. These income shocks may be smoothed somewhat when households are able to borrow, use savings or credit, or get support from persons outside the household to maintain their expenditure levels. However, households will not make long-term adjustments to spending when they think that the changes in their income are temporary. Thus, consumption levels are less variable over time than income levels and may be a better indicator of the welfare of the household. Moreover, respondents are often reluctant or unable to report some of their incomes in household surveys.

is not directly observed. One could argue that income may be assessed from output levels, but it is very difficult to estimate production costs such as those of land, labour and seeds, without clear price references. One approach could be to estimate an agricultural household model and to derive virtual income using separation theorems and implicit prices. However, this method is likely to introduce substantial disturbances coming from prediction errors and the arbitrary assumptions involved in the specification of the model. On the whole, a safe approach seems to be to identify the observed purchasing power at each period, i.e. the total consumption level, and to assume that it approximates exogenous income during this period.

Measurement of the variability of poverty (or living standard) indicators is implicitly based on the identifying assumption that the main fluctuations in consumption are not deliberately chosen in the short term by poor households (or households near the poverty line), but rather mostly imposed upon them by, for instance, past production choices, subsistence and liquidity constraints[8]. Moreover, measurement of poverty or living standard indicators independent of consumer theory may be interesting in itself. Various strategies of protection against risks arising from climatic fluctuations are discussed in section 5.1.

We must now convert the observations of seasonal consumption to indicators of living standards, accounting for the differences in characteristics and environment of households. The two main elements of these differences are household composition and prices. If we refer to consumer theory, assuming a separation between production and consumption decisions, the differences between households should be corrected by a global 'cost-of-living' index (see Singh, Squire and Strauss (1986) for a discussion of non-separability in agricultural household models). The cost-of-living index is defined as a ratio of cost functions that include prices and household composition. We simplify such indices so as to make the correction tractable and the results not too sensitive to the specification of their cost function. Firstly, we assume weak separability of price effects and household composition effects in the cost function, which enables us to correct separately for their

[8] This approach is supported by several elements. First, because of the very low living standards of the poor, close to the subsistence minimum, one is generally very reluctant to consider that this type of household could voluntarily choose to decrease its minimal consumption across the year. Moreover, if some traditional feasts or ceremonies may happen more frequently at some season (the dry season in Rwanda), they are probably not sufficient to substantially modify the consumption flows, and these expenses are often not included in the household consumption expenses but in gifts, social expenses or investment expenses. Secondly, the autocorrelation analyses in section 2.3 (and the transition probability analysis in section 4) show that very rich households (contrary to poor households), that are likely to meet less stringent liquidity constraints, seem to stabilise considerably their per capita consumption, while other categories (except the extremely poor who are subject to subsistence constraints) have much more unstable living standards. This supports the assumption that poor or potentially poor households may not sufficiently smooth their consumption because of liquidity constraints, except when they are constrained by subsistence barriers. In all cases, the fluctuations of living standards result more from constraints than from free choices corresponding to tastes in favour of variability of living standards. Finally, the expectation of seasonal fluctuations should be considered. Whether they are well predicted or mostly a surprise can make a big difference in terms of the evaluation of the risk borne by the households. Thus, a complete model of the welfare fluctuations would involve the estimation of poverty fluctuations, consumer choices of their consumption flows, heterogeneity of liquidity constraints across households, risk protection behaviour and expectations of households. This is clearly out of the scope of this paper and we believe that the hypothesis of constrained poor households is a good approximation of the real situation. It also corresponds to our own direct observations. Finally, a possible endogeneity of consumption fluctuations would not change the estimates of poverty indices but only their interpretation.

variability across households. Secondly, we adopt linear specifications for the two types of effects[9].

We define three different living standard indicators corresponding to three equivalence scales (es0, es1, es2). Muellbauer (1980) provides a theoretical basis for measuring equivalence scales. However, their estimation from demand systems involves theoretical identification difficulties (see Pollack and Wales (1979), Muellbauer (1980), Deaton and Muellbauer (1986), Fisher (1987)). Moreover, there is no agreement among economists as to whether the definition of equivalence scales must be based on consumer behaviour only since public decision makers may have objectives that are not totally linked to individual utility functions. Unfortunately, although these scales provide a simple way of converting consumption into living standards, the robustness of results to the choice of a particular scale is not ensured. Coulter, Cowell and Jenkins (1992) show that it may substantially influence the result of the poverty analysis. Burkhauser, Smeeding and Merz (1995) reveal that the effects of equivalence scales may also vary by country. On the other hand, as Lanjouw and Ravallion (1995) show, the existence of size economies in household consumption seems to blur the relation between poverty and household composition. From Pakistani data they cannot systematically reject the use of the per capita measure[10]. Furthermore, as Çinar (1987) shows, the estimates of equivalence scales are found to be very sensitive to measurement errors of income, which are generally substantial.

The equivalence scale is defined by:

$$es = \sum_k a_k nm_k$$

where nm_k is the number of members in class k and a_k is the adult-equivalent coefficient for a member of class k. Four classes have been defined: male adults (k=1), female adults (k=2), children over 10 years old (k=3), children between 0 and 10 years old (k=4). es0 corresponds to the per capita consumption ($a_k = 1$ for all members); es1 is defined by: $a_1 = a_2 = 1$, $a_3 = 1/3$, $a_4 =$

9 More subtle specifications would be theoretically interesting, since equivalence scales may be specific to each consumed good and may interact with prices. The differences in other household characteristics, such as age and education of the head and his spouse for example, should also influence the tastes of households. The interactions of preferences of different members such as in collective household models (Chiappori (1992)), the changes in household composition across the year, interactions with members of the family outside the household could also matter. Particularly, the distribution of consumption among the members of the household may vary with households' standards of living, especially when the subsistence level is close. This suggests also that the equivalence scales or preferences could vary with the period, parallel with fluctuations in consumption, but also perhaps for exogenous reasons. Another source of variation with the period of living standard indicator is the social perception by the household of its own position (or by the decider) in the seasonal living standard distribution. Indeed, as Adelman and Robinson (1989) discuss, the judgement about living standards is determined by societal values and attitudes and by the perception of what can be feasibly achieved. Other dimensions of welfare such as health, nutrition, leisure and arduousness of work should be accounted for. Each of these elements is interesting and could be the subject of one study in itself. We do not treat them here because of limited space and also because little knowledge is actually available about them. A particular specification or estimation of these phenomena could endanger the robustness of the measurement of seasonal poverty. A further justification for not estimating the equivalence scales is that our context would involve a non-separable agricultural household model, and then is likely to be very difficult.

10 Even if a household-size elasticity of the cost of living of 0.6 seems more plausible in their data.

1/4; es2 is defined by: $a_1 = 1$, $a_2 = 0.7$, $a_3 = 0.2$, $a_4 = 0.15$.[11] We do not consider the change of household composition across the seasons because of the lack of reliable data.[12]

To account for geographical and seasonal price variations, we correct the individual welfare indicators by the individual price indices (see for instance Muellbauer (1973)). We calculate elementary price indices of the main categories of product for every season and every cluster. The prices of each category of product are represented by the price of the main product, which ensures the comparability of prices across seasons and regions with little quality bias[13]. The estimation of a cost function for every household may introduce some variability coming from the inaccuracy of the estimates, which is probably not wise when studying the transient component of poverty. We therefore prefer to approximate the structural individual price index by a price index (I_{it}) specific to each household and each period[14].

[11] The last scale is partially inspired by econometric measures obtained in consumption demand estimations (Muellbauer (1980), Deaton, Ruiz-Castillo and Thomas (1989)) with reasonable adaptation for the inevitable inaccuracy of such estimates. We try also to take into account the important scale economies beyond two persons who are necessary to constitute a 'normal' household and the fact that the decision power in Rwanda is concentrated in the hands of the head (and other adult members). Indeed in Rwanda, children, whatever their age, are traditionally considered as much less important than an adult, the passage to the status of adult being more stressed in Africa than in Western countries. Moreover, the fact that the auto-consumption rate is very high in Rwanda, and the importance of time devoted to domestic activities, are also likely to depart from the simple case of adult-equivalent scales in consumer theory. For example, the cooking of beans in traditional cooking-pots takes hours and consumes a lot of firewood, which does not depend substantially on the number of persons participating in the meals. es1 is related to strong scale economies beyond the adult members (its child cost is close to what minimal needs studies could yield); es2 is a more progressive schedule enabling scale economies beyond male adult members in the household with also a lower weight for children (its child cost is close to econometric estimates).

[12] Indeed, the observed changes in household size may introduce some variability coming from measurement errors in demographic data, and from the fact that the notion of 'normal' household size during one full quarter is a convention attached to the survey process, and to which households may give different answers at different periods. It is therefore safer to stick to the initial measure of household size, for the whole year. This means that demographic changes are neglected. The national demographic growth rate is around 3.5%, slightly lower in rural areas, and much lower than the percentage of the changes in poverty incidence as we shall show in section 3.2. Migration is another source of demographic variability, but in Rwanda in 1983, peasants were often obliged by the government to remain in the district where they were registered (migration to the cities is particularly difficult, which explains the small size of the urban sector: less than 5% of the population). This leads to low migration rates and, on the whole, demographic changes should not qualitatively modify our results.

[13] We obtain optimal price indicators by comparison of market prices, prices extracted from the observation of consumption expenses (denoted 'consumption prices'), and prices extracted from the observation of output sales (denoted 'production prices') at different geographical and temporal aggregation levels for every good. At each stage of the algorithm for the calculus of the price indicators, we account for the number of observations for these types of prices (controlling for their representability) and for their plausibility (controlling for measurement errors). The indicators are the local seasonal prices based on market prices. A descriptive analysis has shown that the market prices are close to the consumption prices and generally higher than the production prices. This preliminary analysis should provide better price indicators than usual in terms of both measurement errors and representativity of the actual population of prices.

[14] That is, similar to a Laspeyres index but weighted by the consumptions of every good for this household at the considered period. We use local and seasonal prices. This is a more precise price correction than the national (or regional) price index generally used in poverty studies. This index enables us to use the same national price basis as a reference for all households.

Because of market imperfections and high autoconsumption rates, production and consumption decisions of most agricultural households are likely to be non-separable. For this reason, shadow prices corresponding to the separating budget constraint would be more appropriate in the calculus of price indices. However, these shadow prices are unobserved and their estimation from a complete agricultural household model may lead to very noisy estimates, in contradiction with our robustness approach[15].

The living standard indicator for household I at period t is defined by

$$y_{it} = \frac{c_{it}}{es_i \; I_{it}}$$

where c_{it} is the value of consumption of household I at period t; es_i is the adult-equivalent scale associated with household I and I_{it} is the price index associated with household I and period t.[16]

2.3 Autocorrelation analysis

We first examine the absolute fluctuations of agricultural output and standards of living in Rwanda. The consumption and the production of the households were observed during the four agricultural quarters of 1983, denoted successively as A, B, C, D. Table 2 shows the autocorrelation coefficients of the values (corrected for price variability) at successive periods for consumption and production and for per capita consumption and per capita production.

The seasonal fluctuations of agricultural production are large. The total output value (and the per capita total output) in one period is weakly correlated with the total output value in the next period (ρ = 0.20 to 0.28). However, fluctuations in consumption are moderate. Indeed, total consumption in period t (and per capita consumption) is strongly positively correlated with consumption (respectively per capita consumption) in the next period t+1 (ρ = 0.55 to 0.61 for total consumption, and 0.55 to 0.68 for per capita consumption) and with consumption in period t+2 (ρ = 0.35 to 0.60), although substantial variability remains. The fluctuations of surplus are very erratic. The surplus (or the per capita surplus) is very weakly correlated with the surplus in the next period (ρ = 0.05 to 0.2).

[15] In an aggregate annual approach, these shadow prices could be intermediate between the observed consumption prices and production prices (see de Janvry, Sadoulet, Fafchamps (1991)). A examination of national averages of the different observed prices in the survey for several products shows that the difference between consumption and production prices can be significant: 24.4% for beans; 31.5% for sorghum; 36.8% for potatoes; but only 1.7% for sweet potatoes. However, at the local geographical and temporal level, consumption prices correspond better to the timing of the observed consumption of households, and market prices have been specifically collected to valorise the observed weighted food for consumption. These market prices are very close to the consumption prices and are a good approximation of purchase and sale prices at the very moment of consumption although they do not account for transport and other transaction costs. The market price minus the consumption price is: 2.3% for sorghum; 16.6% for sweet potatoes; 1.1% for potatoes; 2.1% for beans. On the whole, observed prices may be a reasonable approximation for shadow prices.

[16] Different price indices have been tried. They naturally yield differences in the estimation of the share of transient poverty, although this share is always very important and the estimates shown give rather a moderate picture of it. The study of the influence of the price index in these estimations will be the object of a specific article.

We turn now to fluctuations in economic variables for each quintile, ranked by annual per capita consumption, paying particular attention to the very poor (first quintile) and the moderately poor (second quintile). The autocorrelation coefficients of per capita consumption vary a lot among the quintiles. Per capita consumption is stable for the very rich (last quintile), for which the autocorrelation coefficients are always positive (0.30, 0.24, 0.51 for the three respective successive transitions). These households can probably smooth their consumption considerably on account of their financial capacity. Per capita consumption of the very poor is very stable in at least two transitions (ρ = 0.63 in AB, ρ = 0.75 in CD). This suggests several possible explanations. First, there may be some selectivity coming from the mortality of very poor households when they cross the subsistence line (however, this is not observed in our sample). Second, they may be constrained in their agricultural technology and specialisation so as to reach this subsistence minimum in every season. This may imply choice of cultures characterised by low returns. Third, they may carry out deliberate extraordinary efforts to avoid the crossing of this poverty line and to smooth their consumption. Fourth, they may be helped by neighbours and family on a regular subsistence basis. In any case, this seems to be a constrained situation rather than a free choice of these very poor households. The per capita consumption of the moderately poor (ρ = -0.13, -0.10, -0.08) is both much more irregular and lower, since they are unable to perfectly smooth their consumption. Indeed, the traditional lending system (usurers but also mixed contracts with landlords, local tradesmen and neighbours) is for them a financial constraint that the rich do not encounter. This instability in consumption per capita is also shared by the third and fourth quintiles. Note that the autocorrelation coefficients of total consumption in every quantile are much higher, and show a general relative stability of consumption for all quantiles. However, consumption per capita is generally believed to be more closely related to the well-being of households as the final object of income smoothing. These differences invite us to use different equivalence scales to explore the robustness of analysis of fluctuations in living standards.

Even if aggregate agricultural fluctuations play a substantial role in explaining fluctuations in living standards across the year, there is still considerable room for idiosyncratic individual variations. Indeed, Table 3 shows the sums of squares corresponding to several analyses of variance for the three living standard indicators and their variations across successive seasons. When period and individual fixed effects are included, 61–77% of the variability of living standards (y_{it}) is described by these dummy variables. The variability described by the individual effects (60 to 66%) is much larger than the variability described by period effects (1.4%). When cluster effects are included instead of individual effects, only 32% of the variability is described by the dummies for the clusters. These simple statistics show that local characteristics of the environment and individual characteristics of households explain more of the present living standards of households than the observation of these living standards at a specific period. The picture is very different when one considers the analysis of variance of the changes of living standards between two successive periods ($\Delta y_{it} = y_{it} - y_{i,t-1}$). Here, only one-fifth of the variability is described by the individual fixed effects and period fixed effects. If the variability described by the individual dummies is still the highest (15–16% of the whole variability), the variability described by the dummies of periods is of the same order of magnitude (4–4.8%), and becomes comparable if only period and cluster fixed effects are included (these last ones describe 6.8 to 7.2% of the global variability). In summary, the seasons contribute substantially to the description of living standard fluctuations, but individual and even geographical differences are dominant in the description of the levels of living standards. This invites us to distinguish between chronic and seasonal components of welfare indicators when studying the effect of fluctuations of living standards on annual poverty[17].

3. Poverty analysis

3.1 Definition of poverty indices and their estimators

From a strictly theoretical point of view, the poverty indicators can be interpreted in terms of social welfare functions satisfying reasonable (though sometimes debatable) properties[18]. We use several poverty indicators, poverty lines, equivalence scales, following Atkinson (1991), in order to assess the robustness of the results of poverty comparisons. Our unit of analysis is the household, because we do not have information about individual allocations or incomes.

We calculate three poverty lines for severe poverty and three for moderate poverty, expressed in terms of Rwandan Francs (Frw). Different types of poverty lines have been proposed (see, for instance, van Pragg, Spit and van der Stadt (1982)). In the absence of a definitive doctrine in this matter, we use definitions based on quintiles of the living standards distributions for all periods[19]. We denote as ‘very poor’ the population whose living standards indicators are below the poverty line calculated from the first quintile. Those whose living standards indicators are below the poverty line calculated from the second quintile are the ‘poor’, that is, the sum of the ‘very poor’ and the ‘moderately poor’. We denote:

> z_1, the first quintile of the annual standard of living indicator;
> z_2, the sum of the first quintiles of the seasonal standard of living indicators;
> z_3, four times the minimum of the first quintiles of the seasonal standard of living indicators.

z_4, z_5, z_6, are respectively the same type of lines but calculated from second quintiles[20]. Table 4 shows the value of these poverty lines.

17 More accurate results of autocorrelation and variance analyses for the per capita consumption, as well as transition matrices across quintiles of the per capita consumption (though not corrected for the sampling scheme) can be found in Muller (1997).

18 They are generally additive measures of household utilities, assuming firstly the validity of measurement and interpersonal comparisons of utility levels of different households, and secondly that every household has the same utility function when the living standards indicator is properly defined. The equivalence scales and price indices are assumed to compensate for differences in tastes and the environment of households, which justify the assumption of identical utility functions.

19 Note that the use of quintiles of living standards distributions does not mean that we attach a particular importance to these quintiles in the definition of poverty lines. We merely want to obtain reasonable poverty lines, located in relevant parts of the distribution. Any other choice of 6 arbitrary absolute poverty lines could have been made, for example poverty lines based on different notions of subsistence minima, although their definition also presents specific difficulties. Thus, we do not consider a possible inaccuracy in the estimation of quintiles in the definition of these lines.

20 In a very poor country like Rwanda, one could consider higher quintiles since from a industrial country point of view most of the population could be seen as poor. However, rational poverty policies are generally directed towards a minority of the population. Thus, we prefer to consider levels of poverty line more appropriate to the actual state of Rwandan society.

We calculate Foster–Greer–Thorbecke (FGT) poverty indices ($P_{at}(z)$) for every quarter t in 1983, where t = A, B, C, D and a = 0, 1, 2, 3, is a poverty aversion parameter. This is done for the six different poverty lines. Foster, Greer and Thorbecke (1984) analyse the properties of these indices, which are additively decomposable (the total poverty level is a weighted average of the subgroup poverty levels). They are considered as axiomatically sound for some values of parameters[21].

$$(1) \qquad P_a(z) = \int_0^z (1 - y/z)^a \, d\mu(y)$$

where y is the living standard indicator, z a poverty line, a the (severity) poverty aversion parameter, and µ is the probability measure of the living standards distribution. The parameter a is also sometimes interpreted as accounting for the inequality across the poor. To assess the robustness of our results to the indicator formula, we also compute the poverty indices proposed by Clark, Hemming and Ulph (1981), denoted CHU(c) with c = 1, ½ and **a**, and Watts (1968), denoted W. They are:

$$(2) \qquad CHU(c) = \frac{1}{c} \int_0^z (1 - (y/z)^c) \, d\mu(y)$$

where $0 < c \leq 1$ is a parameter, and

$$(3) \quad W = - \int_0^z \ln(y/z) \, d\mu(y)$$

We estimate the poverty indices at period t with ratios of Horwitz–Thompson estimators:

$$(4) \quad \hat{P}^t(z) = \frac{\sum_{s=1}^{n} \frac{f(y_{st}, z) 1_{[y_{st} < z]}}{\pi_{st}}}{\sum_{s=1}^{n} \frac{1}{\pi_{st}}} \qquad \text{where } \pi_{st} = \frac{m_h r_{hij} q_{hijk}}{M_h N_{hi} R_{hij} Q_{hijk}}$$

π_{st} is the inclusion probability (in the sample) of household s at date t (s = 1,...,n); f is the kernel function associated with the poverty index; M_h is the number of communes in strata h; m_h is the number of communes drawn in strata h; N_{hi} is the number of sectors in commune I of strata h

[21] The FGT indices satisfy the monotonocity axiom (for a>0), the transfer axiom (for a>1), the transfer sensitivity axiom (for a>2), and the subgroup monotonocity axiom. Foster and Shorrocks (1991) analyse the importance of the subgroup consistency of poverty indices, which ensures that overall poverty does not respond perversely to changes in poverty levels within population subgroups. The Watts index satisfies the monotonicity, transfer and transfer sensitivity axioms. The CHU indices satisfy the monotonicity axiom. They satisfy transfer and transfer sensitivity axioms for c < 1.

(only one sector is drawn in any drawn commune), R_{hij} is the number of districts in sector j of commune I of strata h, r_{hij} is the number of drawn districts in sector j of commune I of strata h, Q_{hijk} is the number of households in district k of sector j of commune I of strata h, and q_{hijk} is the number of households drawn in district k of sector j of commune I of strata h.

The sampling standard errors of the poverty indicators are less easy to estimate, because of the complexity of the actual sampling scheme.[22] In particular, only one sector was drawn at the second stage of the sampling plan in every primary unit, which does not allow the direct calculus of the inter-strata variance. Another difficulty is the small sample size at several stages of the sampling scheme. This does not allow a robust use of classical sampling variance formula that are based on asymptotic properties. We use an estimator for sampling standard errors inspired from the method of balanced repeated replications (see Krewski and Rao (1981), Roy (1984) for discussions of the properties of this type of estimator). This estimator is adapted to the actual survey (see appendix 1).

Most of the definitions for transient and permanent poverty found in literature are based on the incidence of poverty (see the survey in Rodgers and Rodgers (1993)) and ignore the severity of poverty. However, Ravallion (1988) and Rodgers and Rodgers (1993) propose transient and permanent poverty indices based on the definition of the aggregate (or 'for several years') poverty index as an arithmetic average (weighted by the length of periods if necessary) of the period-specific indices: $\overline{P} = \frac{1}{T}\sum_{t=1}^{T} P_t$

where P_t is the poverty index of period t.

The permanent (or chronic) poverty index (CP) is measured by the poverty index formula applied to the annual stabilised (or permanent) living standards measure (sum of the living standards measures of all periods). Of course, the poverty line is made proportional to the length of the considered period. Transient poverty is defined as the difference between $\overline{P}$ and CP : $TP = \overline{P} - CP$, implicitly assuming that $\overline{P} > CP$. This is in practice satisfied for all our indicators. In that case, $\overline{P} - CP$ is the poverty increase that can be attributed to the

22 See Gouriéroux (1981) for properties of usual estimators in sampling theory. Kakwani (1993) provides an estimator for sampling standard errors of poverty indices, but this is only valid for a simple random sample frame, which is not the case in most national surveys.

variability of living standards during the year.[23] A natural measure of the share of poverty caused by the fluctuations, when $\overline{P} > CP$ is the ratio[24]:

$$(5)\ F = \frac{(\overline{P} - CP)}{\overline{P}}$$

The direct aggregation of period poverty indices in the annual poverty index involves implicit assumptions about the subjacent welfare theory. Indeed, the poverty index can be considered as the decision criteria of a public decision-maker that weights identically the individual utility functions. An example of an individual utility function is, for the FGT index P_a, $u(y) = -(1-y/z)^a\ 1_{[y<z]}$, where a is the poverty aversion parameter of the household[25].

3.2 Estimates of poverty measures

Rothschild and Stiglitz (1970) and Atkinson (1970) show that stochastic dominance analysis provides a partial ordering on distributions which is consistent with any additive risk or inequality indicators. A stochastic dominance ordering that meets this criterion for poverty indicator can also be defined from the poverty curves. Atkinson (1987) and Foster and Shorrocks (1988) also discuss less demanding poverty orderings[26]. Figures 1a to 1c show the poverty curves associated with the four periods and the three equivalence scales. Each curve shows on the Y-axis the average living standards of the poor for the considered period, when the poverty line goes from

[23] Of course we would rather have seasonal data for several years to be able to define seasonal poverty from residuals of moving averages of living standards, rather than mere observations of poverty at only four seasons. This would also allow the separation of the trend and random shocks from the seasonal component which is not possible with only four seasons.

[24] Note that we could have proposed estimators for the random variables TP and F, accounting for the correlations between the P_t. However, so as to obtain the coherence between the different estimated poverty indices of all types, and also to stick to simple robust methods, we base our analysis on H.-T. estimators of P_t and CP only.

[25] In fact, *a* can be seen both as the poverty aversion parameter of the public decision-maker and as the risk aversion parameter of the households (or the curvature of their utility function). To distinguish these two types of parameter in FGT indices would not change their final general formula in annual poverty. It would, however, change the interpretation of the parameter that is the product of individual risk aversion and social poverty aversion. Of course, one can argue that it is not useful to separate the two aversions, since the main risk here is that of an increase in poverty. In any case, these considerations strengthen the need to consider a large range of poverty indicators, so as to take into account the indeterminacy associated with the choice of the relevant aversion parameter. Finally, a direct use of P_a indices is also possible without reference to consumer theory.

A related question is how to consider the subjective interest rate in the aggregation of several periods. The subjective interest rate of the households may be different from that of the public decision maker. This may not substantially change the results when households are observed across only one year, as in our case, but it may matter for longer periods.

[26] From a theoretical point of view, Kanbur and Stromberg (1988) analyse stochastic dominance relationships between sequences of income distribution mechanisms. They derive necessary and sufficient conditions on these mechanisms for a dominance relationship to continue once established. These conditions are very unlikely to occur in the long term. However, when comparing seasons of the same year, dominance relationships are much more plausible and the use of poverty curves instead of Lorenz curves makes dominance situations quite possible because of the existence of absolute aggregate shifts of income.

zero to a maximum level that does not exceed the median of the distribution of living standards. The proportion of poor is measured on the X-axis. Period D is clearly dominated by the other three periods. The order between the other periods depends on the poverty line, the equivalence scale and the poverty indicator. We estimate poverty indicators so as to assess the quantitative influence of fluctuations in annual poverty. Such indices can be derived from the poverty curves conditional to a specific social welfare function and corresponding to specific social value judgment.

Tables 5 to 10 show the estimates of poverty indices for the poor and the very poor. Because of space considerations, we do not provide tables for indicators without correction for prices or sampling scheme. It is clear from the contradictions in these indices that no dominance between the living standards distributions occurs between periods B and C, which naturally rejoins the results obtained with poverty curves. Of course, the higher the poverty aversion parameter (a) in the FGT's indicators, the lower the poverty index (since $1-y/z < 1$), while the higher the level of the poverty line (z), the higher the poverty index.

In terms of incidence of poverty, the worst period for both the very poor and the poor is the last agricultural quarter, just after the dry season, when the stocks have not yet been reconstituted. The best period for the very poor and the poor is generally the first quarter. These two results are robust to the choice of the level of the poverty line, the poverty indicator, the equivalence scale, and the correction for price or sampling scheme. The poverty crises touch most of people in the last quarter, when many are in a very severe situation. With poverty line z_4 the proportion of the poor in the population increases during the year to a maximum of 57%, while with poverty line z_1, the proportion of the very poor reaches 38%. The second-worst period for the poor is the second or the third quarter, depending on the chosen indicator or poverty line. By contrast, per capita non-corrected indicators reveal unambiguously that the second quarter is the second-worst period for the poor, and then give a false impression of the robustness of this result which disappears with corrected indicators.

Whatever the indicator, the increase of the incidence of poverty during the year is dramatic. Annual incidence increase ranges from 54.7 to 101.7% for the very poor (depending on the poverty line used for per capita indicator); 58.2 to 67.9% for the first equivalence scale; 50.7 to 60.7% for the second equivalence scale, and respectively 37.5 to 48.9% (with es0), 42.9 to 66.4% (with es1); 35.5 to 56.5% (with es2) for the poor.

The analysis of the volume and the severity of poverty supports the result that the last quarter is the worst period, while the best one is the first or the second quarter. The greatest volume of poverty (described by P_1) and the greatest severity of poverty (described by P_2 or P_3) correspond to the last quarter irrespective of the poverty line chosen. 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. The lowest severity of poverty corresponds to the first or second quarter (on three occasions) for the very poor. Their lowest volume of poverty is always during the first quarter. The lowest volume or severity of poverty corresponds to the first quarter for the poor. However, the second-best or -worst periods in terms of the volume of poverty are less unambiguously determined, and could be the second or third quarters, depending on the indicator and the poverty line used. Per capita non-corrected indicators show that any one of the first three quarters could be a possible best period and may therefore be misleading.

Using only chronic poverty measures generally makes the picture less dramatic, and provides an overoptimistic assessment of the situation of the poor. The incidence of chronic poverty is notably lower for the poor than the incidence of annual poverty. The incidence of chronic poverty varies from 10% to 22% (instead of 18% to 31% with annual poverty) for the very poor, and from 28% to 41% (instead of 35% to 48% with annual poverty) for the poor.

The influence of living standards fluctuations is moderate for the incidence of poverty for the whole population but it becomes important if one considers only the very poor. F_0 varies from 12% to 21% for the incidence of poverty among the poor as a whole, and from 11% to 42% for the very poor only. The fluctuations are more important in describing the annual volume of poverty of both the very poor and the poor. F_1 varies from 48 to 64% for the very poor only, and from 34 to 46% for the poor. Finally, the fluctuations are extremely important in describing the annual severity of poverty for both the very poor and for the poor. F_2 varies from 61 to 72% for the very poor, and from 48 to 58% for the poor. F_3 varies from 69 to 78% for the very poor, and 51 to 67% for the poor. Since indicators accounting for the severity of poverty are considered as more relevant from an axiomatic point of view, the measurement of the seasonal component of poverty is essential for the validity of poverty analysis in Rwanda. This dramatic result is not the consequence of a 'bad year' or 'bad seasonal shocks', since 1982–83 is considered a normal agricultural year, unlike, for example, 1984, which was a year of drought and consequently involves an exceptional negative shock to living standards. The observed 'bad state' in period D of 1983 can then be considered as a normal phenomenon and not an unusual shock. In Rwanda, the seasonal component constitutes the greater part of annual poverty, and even the moderate share associated with this component as shown by indicators of poverty incidence can be misleading. This is another reason to favour indices accounting for severity of poverty. Whatever the used indicator, the share of transient poverty always increases when a lower poverty line is used[27]. This is consistent with a higher variability of living standards for the very poor. However, since the extremely poor are also chronically poor, the extreme end of the distribution of living standards may contribute only moderately to the proportion of transient poverty[28].

To assess the robustness of the results with respect to the formula of poverty indicators, we estimate CHU and Watts indices (see Tables 8 to 10). Naturally, an increase in the poverty line augments the value of the poverty indices. Both the poverty and the severe poverty described by the Watts index are higher in period D and lower in period A (or B for some poverty lines in the case of extreme poverty). The poverty described by both the CHU-Watts and FGT indices shows the same pattern, especially when the whole population of the poor is considered. The increase in poverty across the year is always very substantial whichever poverty line or indicator is used: ranging from 58.5 to 79.3% for Watts indicators; from 55.6 to 77.2% for CHU(½); and from 56.3 to 78.3% for CHU(1/3). The share of transient seasonal poverty in annual poverty is always very substantial (ranging from 33.5 to 66.7%). The share of transient seasonal poverty is generally

27 Remember that $z_4 > z_5 > z_6 > z_1 > z_2 > z_3$.

28 Our estimations using per capita non-corrected indicators with a high poverty line, show that the fluctuations in consumption may decrease the annual incidence of poverty level, because many households that are below the poverty line after the stabilisation are only poor in certain periods before the stabilisation. This phenomenon disappears with the corrected indicators.

higher for the group in severe poverty (35.2 to 66.7% with one exception) than for global poverty (33.5 to 50.7%). In this case too, non-corrected indicators show greater variability.

The qualitative results about the evolution of poverty during the year, or the ordering of periods, do not depend particularly on the equivalence scale used. However, the choice of this scale does play a role in both the measurement of chronic poverty and the magnitude of the share of transient seasonal poverty. For the FGT indices and for the very poor, the per capita living standards indicators (with es0) generally reveal a lower level of chronic poverty than if other scales are used. In the case of the poor, the indicators show a higher level of chronic poverty than with the es2 scale, although this exceeds the level using the es1 scale. For the poor, the es2 scale corresponds to a larger share of transient poverty, followed by the share with es1 scale, and then by the share with the per capita indicator. However, the comparison of these percentages is more blurred for the poor. The picture shown with the Watts and CHU indicators is similar, although there are slight differences. Here, the level of chronic poverty for the very poor is higher with the es1 scale, as compared with the poor where it is lower. For both the very poor and the poor, the share of transient poverty is higher for the es2 scale, and followed by the share with es1 scale, then the share with per capita indicators. On the whole, using es2 leads to a larger measurement of the share of transient seasonal poverty than using es1, which is itself larger than the share of transient seasonal poverty obtained with per capita indicators. To this extent, using per capita indicators may hide part of the share of the transient seasonal poverty, because it gives too little importance to the variability of living standards of large families.

The correction of price variability decreases measured transient seasonal poverty for the very poor. After the price correction for the poor, the share of transient seasonal poverty increases for z_1 (for which it was low and sometimes negative), but diminishes for z_2 and z_3. In any case, the share of transient seasonal poverty remains very substantial, but with indicators not corrected for prices, seasonal and geographical price variability is added to the seasonal variability of poverty.

Table 18 shows the estimates of sampling standard errors, which allow the assessment of the significance of estimated poverty indices. We provide the formula of the sampling error estimators in Appendix 1. The size of sampling errors generally increases with the season in parallel with the increase of income variability associated with higher poverty. The comparisons of price indices that we analysed are generally statistically significant at the 10% and less often at the 5% level (neglecting the correlations between poverty indicators).[29] Every comparison of indicators should also involve estimation of the sampling correlations between the two compared indicators, but a complete set of statistics would fill dozens of pages and in order to save space we do not show them. Generally, we can expect a greater significance of the hypothesis of non-identity of two poverty indicators than we can of an inference omitting this correlation – which is expected to be

[29] One must however be aware that the accuracy of the estimators of these sampling errors is limited by several elements: the sample size is rather low; the estimator is an approximation corresponding rather more to an upper bound of these errors; the real survey involves features that could potentially contribute to better accuracy than that which is assumed by the usual sampling formula (i.e. correlation of successive observations; optimal combination of 'super-strata' used in the calculus of estimators of errors; and post-stratification). These questions are complicated and interesting enough to be treated in a separate article.

generally very highly positive[30]. An examination of the sampling errors shows that our results based on comparisons of poverty indicators are not mere statistical artefacts but can be considered as characteristic of the whole rural population of Rwanda.[31]

We have therefore robustly established that most of the severity of poverty comes from the seasonal transient component of annual poverty. If we generalise this result to other contexts, it suggests that the actual differences of poverty between developing countries and industrial countries, or between rural and urban areas in LDCs, is much worse than is shown by chronic annual poverty indices or even by measurement of the seasonal incidence of poverty.

It suggests also that governments could implement income stabilisation policies in order to fight transient seasonal poverty. However, a careful analysis shows that this type of policy may touch mostly the less poor amongst the poor. Figure 2 shows the cumulative curve of the transient poverty (calculated from indicator FGT(2) based on per capita consumption with line z_1) when households are arranged according to their logarithm of mean annual living standards[32]. This share is very low for the chronically poorest households. It increases sharply until the poverty line is reached. Most of the transient poverty corresponds to households around the poverty line. This type of profile has been found also in Jalan and Ravallion (1996) for transient annual poverty. They argue that because of the proximity of the subsistence level, the poorest household cannot afford a large variability of income. Another reason for the low contribution of the extremely poor

[30] We have derived a formula of estimators of confidence intervals for the share of transient poverty, accounting for the sampling correlations across poverty indicators of several periods, still inspired from BRR methods. We have not carried out this estimation on the grounds that inevitable measurement errors are still present in the data, and statistical tests or intervals based on sampling considerations could provide a false impression of certainty. However, a simple approximation of the formula for the variance of the share of transient poverty can be obtained by Taylor expansions. Then, the sampling covariance terms can be eliminated by majorations and a reasonable majorant of this variance can be obtained from the provided tables. The calculus for per capita FGT poverty indices and lines z_1 (for first and second quintiles) show that the order of magnitude of the standard-error majorant is generally between 0.15 and 0.20. This leads us to consider that the estimates of the share of the annual incidence of poverty corresponding to the transient component are non-significant at the 5% level, while at the same level, the shares of transient poverty corresponding to P_1, P_2 or P_3 are all significant and substantial. For example, the share for P_2 (which is a popular indicator with good properties), based on z_1 associated with the first quintiles, is included in the interval [0.244; 0.974]. This ensures the significance of the character substantial for the transient poverty. Of course, unbiased confidence interval estimators (accounting for sampling covariances) are likely to lead to much narrower intervals.

[31] 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 generally small compared to the seasonal fluctuations. Indeed, the main economic shocks for the peasants in 1983 were the climatic shocks which had a large seasonal component. Agricultural households are generally very isolated from the modern economic mechanisms (as shown by the high rate of auto-consumption) and the national or 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. Migrations are controlled by the government. Every year the quality of the land worsens because of its intensive use although the rate of decline is still limited. Bezy (1990) notes that in 1984, 50.2% have declared that the productivity of their fields was diminishing. On the whole the variation of poverty during the year is likely to be mostly explained by seasonal fluctuations rather than by economic trends of the economy or by other events. Accidental events, such as droughts, also add to the transient component of poverty in Rwanda, although 1982–83 is considered a fairly normal agricultural year.

[32] That is, the global transient poverty of the population under a certain level of income, over the global transient poverty of the whole population, plotted by the time-mean welfare variable.

to global transient poverty is that these households are also chronically poor. Therefore, their contribution to the transient poverty comes only from the direct variability of their living standards, and not from discrete changes that would occur if they crossed the poverty line at some periods during the year. The general shape of the curve is robust to different poverty lines, poverty indicators (except incidence of poverty) and living standard indicators.

4. Results from transition matrices

In order to investigate more accurately the situations of households in different classes of living standards and also to distinguish flows into and out of these classes, we now study the transition probabilities across seasonal living standards distributions. Let f_t be the p.d.f. of the living standard variable y_{it} at date t, for household I = 1,...,N and period t = 1,..., T. The relationship between f_t and f_{t+1} can be described by the transition probability function $p_{t,t+1}$ such that

$$(6)\quad f_{t+1}(y_{t+1}) = \int p_{t,t+1}(y_{t+1};y_t) f_t(y_t)\, d\lambda(y_t).$$

The probability of a household being in quantile h during period t is:

$$(7)\quad P(quant_t = h) = \int_{\underline{y_h}}^{\overline{y_h}} f_t(u)\, d\lambda(u)$$

where $\overline{y_h}$ and $\underline{y_h}$ are the boundaries of quantile h.

The probability of a household being in quantile k during period t+1, conditional on being in quantile h in period t, is:

$$(8)\quad P(quant_{t+1} = k \mid quant_t = h) =$$

$$\int_{\underline{y_k}}^{\overline{y_k}} \int_{\underline{y_h}}^{\overline{y_h}} p_{t,t+1}(y_{t+1},y_t) f_t(y_t)\, d\lambda(y_t)\, d\lambda(y_{t+1}).$$

These probability numbers are called the transition probabilities from quantile h to quantile k. Since they can be considered as weighted means of $p_{t,t+1}$ associated with different sub-samples of households, they summarise the information included in the transition probability. We estimate each cell of the table with Horwitz–Thompson estimators based on weights calculated from the sample scheme, correcting for price variability as previously for poverty measures. These estimators can be considered as MLE of the probability numbers associated with a first-order homogeneous and seasonal-stationary Markov chain model. Only three transitions are observed.

The estimates are presented in transition matrices (in tables 11 to 13) across quintiles of living standard indicators. To shorten the exposition we comment primarily on the per capita results (in table 11), although it is possible that using another equivalence scale may lead to slightly different results.

In transition AB, the situation of the very poor (first quintile) clearly improves[33]: 14% become moderately poor (second quintile), 24% 'average' (third quintile), 4% rich (fourth quintile) and 7% very rich (fifth quintile). The evolution of the moderately poor is more ambiguous: 27% become average, 10% rich, 3% very rich, but 30% very poor. The change is therefore unfavourable for the average, the rich and the very rich. Transition BC is less favourable for the very poor, who more rarely escape from poverty – 21% become moderately poor, only 12% average, 7% rich and 8% very rich – but more favourable for the moderately poor (although 19% become very poor, 28% become average, 13% rich and 21% very rich). This transition is still not favourable for the average and the very rich. Transition CD is the worst for the very poor: 21% become moderately poor, 8% average, 4% rich, 1% very rich, and dramatically negative for the moderately poor: 40% become very poor, even if 17% become average, 7% rich and 6% very rich. The evolution is also very bad for the rich and the very rich, which leads to a strong increase in the number of very poor and a growth of the number of moderately poor.[34] Thus, the poverty crisis in transition CD does not result as much from a greater difficulty in escaping from poverty and severe poverty, as from a large number of peasants 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.

The worst transition is CD, starting from the end of the dry season at the time when food stocks are almost exhausted. The global annual effect is an increase of 48% to 50% (depending on the equivalence scale) in the number of very poor, and an increase of 32% to 38% in the number of moderately poor across the year. However, mobility is very strong in every transition (the immobility ratio and the strict improvement ratios[35] are respectively (34% to 35% for the different equivalent scales) and 24% in transition AB, (33% to 35%) and (38% to 40%) in BC, (38% to 40%) and (41% to 43%) in CD). Many peasants can escape poverty at every period.[36]

In Rwanda the most stable population is the very poor who escape poverty only with difficulty throughout the year. Indeed, they have high immobility ratios at every transition (50%, 52%, 66% respectively for the successive transitions) which is not so much the case for the moderately poor with immobility ratios of respectively 31%, 18%, 30%.

[33] Note that the situation of the very poor cannot worsen in the transition matrices, and that of the very rich cannot improve, since they are the extreme categories in the tables.

[34] See table 14 for the number of households of the sample in every category at each season, for the three equivalence scales.

[35] The strict improvement ratio is the percentage of households that move into a strictly superior quintile.

[36] It is also possible that this mobility is overestimated because of random effects coming from the inevitable measurement errors. However, the fact that exit rates are notably different from entry rates pleads against large contaminations of data reduced to a white noise. Note that non-corrected indicators lead to very different results with a higher variability and where the general changes are less apparent.

There are some differences in transition matrices corresponding to different indicators. In transition AB, indicators based on es1, or es2, apparently lead to a much worse situation for the poor than indicators based on per capita consumption (respectively 71% or 72% of the very poor remain poor, while respectively 76% or 72% of the moderately poor remain poor, instead of 64% of the very poor and 66% of the moderately poor with per capita indicator). By contrast, in transition BC the situation of the very poor appears worse with per capita indicators (73% remain poor instead of respectively 64% and 65% with es1 and es2). However, the situation of the moderately poor appears better with es0 (38% remain poor instead of 57% with es1 and 46% with es2). Variations in the critical transition, CD, are very similar, for all equivalence scales.

5. Equations of seasonal transient and chronic poverty

5.1 The model

We investigate now the correlates of chronic and transient seasonal poverty indices for peasants in Rwanda. The understanding of factors related to poverty has attracted substantial and very varied interests in the recent literature. Tables composed of poverty indices for different populations (poverty profiles) have been made possible by the existence of classes of decomposable poverty indices (Foster and Shorrocks (1984, 1991)). For example, Shari (1979), Glewwe (1987) and Slesnick (1993) present tables of incidence of poverty by groups of households. Rodgers and Rodgers (1992) and Alwang et al. (1996) show tables of poverty indices by groups of households.[37] Econometric analyses of poverty indices are less frequent. 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. Paxson (1992), Gabriel and Cornfield (1995) and Coulombe and McKay (1996) present least squares estimates for equations of logarithms of earnings or incomes, or living standards of households. 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. Finally, Jalan and Ravallion (1996) estimate censored quantile regressions of chronic and annual transient poverty indices. These last authors are the only ones who estimate equations for (annual) transient poverty. The independent variables included in the different studies are very varied, and seem often to reflect more the availability of data rather than clear theoretical choices.

In all the abovementioned studies, the questions of causality and possible endogeneity of correlates are not treated.[38] The direction of causality for the effects of all independent economic

[37] Note that Slesnick, and Rodgers and Rodgers, do not study populations of peasants in LDCs.

[38] A problem related to causality, but not equivalent, is that of the endogeneity of some correlates. Indeed, even if we consider that the econometric estimates correspond to a mere descriptive model without any explanatory ambition, it is still important to correct for the possible endogeneity of independent variables in the poverty equations. These equations describe the probability density function of poverty conditionally to the value of the independent variables. However, when some independent variables are endogenous, some parameters of the conditional density also appear in the second part of the joint density which is the marginal density of the independent variables. Then, the estimation of the conditional density would be influenced by the marginal density, i.e. the processus generating the independent variables, which hampers the investigation of the law of the phenomena under study. Even for descriptive models, corrections for endogeneity should be applied as soon as we have even vague ideas (not structural models) about potential reasons of this endogeneity. The reason for this requirement, is that the descriptive model here is in fact a first step towards the specification of an explanatory model of poverty.

variables, and perhaps also of household characteristics, is ambiguous since in the long run these variables may influence the living standards of the household. They may also have been determined by the household, given its economic means. The estimation of a complete structural model of living standard generation for agricultural household with a multi-output production is outside the scope of this paper and we propose only to investigate the correlates of transient and chronic poverty indices and not pure causality relationships. However, we present two sets of estimates that are affected differently by possible simultaneity bias. The first set corresponds to the inclusion of all independent variables. In order to correct partially for endogeneity problems, we replace the variables associated with agricultural choices (which are likely to convey the worst short-term endogeneity problems) by their predictions obtained from instrumental equations. The share of products and the auto-consumption ratio are predicted from Arcsinus models, while the diversification indices are predicted from ordered probit models. The main instrumental variables, besides the assumed exogenous variables in the model, are seasonal prices for the first three periods, household composition and various other socio-demographic variables. Other predictions with linear models have also been tried but lead to poorer results. For the second set, the variables associated to agricultural choices have been eliminated. Some remaining endogeneity problems may persist, but the small sample size does not enable us to correct for the endogeneity of all independent variables[39]. One expects that equations for TP are less sensitive to problems of long-term endogeneity if seasonal fluctuations have a strong non-stationary component. This may be the case, given the instability of the climate in this region from one year to another (see Bulletin Climatique du Rwanda (1982, 1983, 1984).

The estimated model is as follows[40]. Two dependent variables are considered:

TP_i : the transient poverty index of household I;
CP_i : the chronic poverty index of household I.

TP_i and CP_i are null for a large set of observed households and strictly positive for others. We define two latent variables, respectively associated with 'latent transient poverty' and 'latent chronic poverty': TP_i^* and CP_i^*. We specify equations for the opposite of poverty indices so as to use the same notations as Powell (1986):

$-TP_i^* = X_i' \beta + u_i$ and $-CP_i^* = X_i' \gamma + v_i$

39 No coefficient is significant in estimation in which we have instrumented all possible endogenous variables.

40 Another modelling approach could have been to estimate the dynamic income process of the households and to derive chronic and transient poverty indices from the income model, similarly to Lillard and Willis (1978). There are several reasons for not choosing this method. First, this would necessitate strong stochastic assumptions such as joint normality of error terms at every period, which leads to the estimation of an autoregressive model of dimension four, a process that is likely to be difficult. Second, measurement errors associated with household income, especially for the households under study, are typically very high, and the process in which income is transformed into per capita consumption is unknown and probably complex since it involves liquidity or subsistence constraints. Finally, because our major concern is the study of poverty, it seems more relevant to focus on the population of the poor and examine directly the transient and chronic poverty indices, rather than to estimate an income model for all the population, which may be excessively influenced by the characteristics of the rich (as shown in Yitzhaki (1996)).

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. Then,

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

We estimate models of TP and CP calculated from per capita P_2 FGT-indicators with three different poverty lines based on second quintiles of the corrected per capita consumption distributions[41]. We carry out normality and homoscedasticity tests from IV-Tobit estimates (for all TP and CP indicators), following the method described in Pagan and Vella (1989) and inspired by the principle of generalised residuals proposed by Gouriéroux, Monfort, Renault and Trognon (1987). Normality is very strongly rejected at the 1% level for all poverty lines (associated Student's t ranges from -4.18 to -8.80). Homoscedasticity is rejected at the 5% level for different types of heteroscedasticity (orthogonally to household composition, land area and prices). This suggests the use of censored quantile-regression (CQREG) estimates that are robust to heteroscedasticity and non-normality (as in Jalan and Ravallion (1996)). The properties of these estimators have been studied by Powell (1983, 1986). We estimate confidence intervals of estimates of β and γ by the bootstrap method with 1000 bootstrap iterations so as to take into account the low sample size. Hahn (1995) shows that confidence intervals calculated with the bootstrap percentile method have asymptotically correct probabilities (although convergence is only weak)[42].

The CQREG estimates (e.g. for β) are defined by the minimisation with respect to β of the function:

[41] This approach corresponds to assuming that we have no a priori knowledge about the distributions of seasonal living standards. Indeed, if we had assumed that we knew the shape of these distributions, say for example joint lognormal, then indicators CP_i and TP_i would not be independent. In particular, one would expect that TP_i is often null for the very rich or the very poor (in the sense of CP_i). The knowledge of a model of earnings generation would also permit the derivation of correlations between CP_i and TP_i. However, our approach is more descriptive. We assume that such information is not available and we estimate separate equations for CP_i and TP_i. Of course, the interpretation of estimates can partially account for possible correlations between the equations.

[42] Unfortunately, neither the asymptotic normality nor the formula of the asymptotic variance-covariance matrix is known for the two-stage CQREG estimator. Moreover, a joint bootstrap simulation of the joint variance-covariance matrix for poverty and instrumentation equations is impossible because it is too costly in CPU time with our Pentium micro-computer. Therefore, we are forced to neglect the uncertainty coming from the prediction of possible endogenous agricultural choices, for the inferences in equations including these variables. We merely replace the most disturbing endogenous variables by exogenous predictions. This problem does not occur for equations without agricultural choices. Note that Amemiya (1982) studies the two-stage least-absolute-deviation estimators, but only for simple cases related to normality assumptions. The asymptotic variance is known only in normal and a few non-normal cases for two-stages LAD.

$$(9)\ \ Q_n(\beta,q) = \frac{1}{N}\sum_{i=1}^{N} \rho_q(-TP_i - Max(0, X_i^{/}\beta))$$

where q is the considered quantile, and

$$\rho_q(x) \equiv (q - 1_{[x < 0]}).x$$

where $1_{[.]}$ is the indicator function.

Contradictory logic may direct the choice of the quantile in censored quantile-regressions. Firstly, one may want to obtain results representative of the distribution of living standards (or rather here of 'latent' poverty indices). This would correspond to the specification of a central tendency of the distribution, and induce the use of Tobit estimates (specification of the mean) or Least Absolute Deviation estimates (specification of the median in CQREG). Alternatively, one may prefer to focus on the poverty problem, looking specifically at the poor and the potentially poor, and the extremely poor. This would correspond to the specification of a quantile close to 1 in the censored quantile-regressions (of the opposite of poverty indices). Finally, as both the censorship and the robustness of estimation methods are associated with a loss of accuracy, one may favour the estimation of quantiles close to 1 in the CQREG estimation, so as to dispose of most of the information described by poverty indicators in the maximised objective function. Quantiles 0.90 and 0.975 are estimated for transient poverty, and 0.975 for chronic poverty. Using this method, we correct for bias coming from selectivity, endogeneity and heteroscedasticity problems[43].

We discuss now the choice of correlates, keeping in mind that the descriptive model is a preliminary step towards a causal model[44]. The choice of independent variables in poverty equations is a difficult question. We have identified three competing explanatory alternatives which are generally not completely expounded in the empirical literature on chronic poverty[45].

First, some authors focus on the direct origins of the income from economic activities, and include the quantity and the type or quality of land which is the major input in agriculture. They often account for the existence of employment opportunities off the farm, especially for regular jobs. The presence or loss of income-earning members, the quality of the working potential of members or their participation rates may also be considered.

Second, earnings functions can be specified, by analogy with earnings functions of wage earners, derived from human capital or life-cycle theories (Willis (1986)). This means incorporating the age, experience, education levels and activity types of members, and also sometimes the nutrition

43 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. The bootstrap estimation of the variance–covariance matrix of parameters is applied when convergence has been obtained.

44 We stress again the fact that the aim is not to estimate a structural model. This would be premature.

45 See however Wolfersperger (1986) for a general discussion of the explanation of income inequalities.

status of active members, or their wage rates. This approach is in fact an extension of the first logic with a more explicit modelling of the quality of labour inputs in the earning process. However, for peasants in a context of imperfect markets, the usual separation theorems of the Arrow–Debreu framework may not apply. This invalidates most results coming from the earnings functions literature. Even the meaning of the effects of age and education on living standards is unclear in this context. This augments the interest of an applied study since the theoretical guides are fragile in this case. Land and capital, as two of the main production factors, are likely to influence output and living standards, by contrast with the typical results of the earnings function literature.

Third, a closely related approach consists in including the endowments, assumed exogenous, that describe the main production factors, with a preference for specifications in terms of stocks rather than flows: land, number of active household members, physical capital and assets, human capital and access to markets.

By contrast, a fourth set of variables is better associated with specification of indicators and the control of econometric misspecifications. The most frequent incorporated socio-demographic variables are: household composition and its dependency ratio; characteristics of the head (age and sex, education) and various socio-demographic variables describing for example the religion or the marital status of the members, the caste or the ethnic group. We consider that socio-demographic variables can play at least three roles. They help to control for an imperfect choice of equivalence scales, for unobserved heterogeneity of households; and for omitted demographic changes correlated with poverty status (such as fertility). They may also embody some complementary information about the preferences of the household (and its internal decision process), that may influence its income and consumption decisions, especially when production and consumption decisions are non-separable. Finally, they may account for segregation restricting the access of the household to certain resources. Regional dummy variables can play a similar role, while also accounting for geographical heterogeneity of the environment.

It is remarkable that agricultural choices are generally not included while they can be modified in the short term much more easily than other explanatory variables. We try to fill this lacuna. Moreover, no systematic description of the production structure has been investigated as a correlate of poverty. This is important here because most households in Rwanda are characterised by multiple activities and multi-output production. Some cultures may have higher returns than others and peasants may not always be well aware of these differences. However, von Braun, de Haen and Blanken (1991) show that in a specific commune of Rwanda (Giciye), the stated reasons by peasants for growing or not growing a particular crop are varied and complex, although reasons associated with commercialisation, monetary and labour costs, and return of sales are generally not very important. Still in the same commune, the fact that fields might not be good for the crop is an important reason not to grow potatoes, sweet potatoes and sorghum. It may also be that the poor are constrained in specific cultures by lack of endowments. Production theory suggests that the restricted profit function (or the revenue function) depends on levels of inputs as well as on different output prices. However, when included in our estimates, prices are usually insignificant[46]. Alternatively, the composition of output can be incorporated, since if we assume a common multi-output production function for all households, the production levels are completely determined by input levels and shares of products in the total output value.

Since agricultural context is characterised by substantial risks associated with levels of outputs and prices, or food supply, we also consider responses of households to these random elements. These responses are not specific to Rwanda and are common to all the African Great Lakes countries (Sindayizeruka (1993)). Similar strategies can be found for peasants in most LDCs. A successful strategy of protection against agricultural risks should have substantial consequences in terms of poverty levels. The choice of more or less 'risky' activity is an obvious protection (see Peemans (1993) in the very similar context of Burundi), while seasonal crops are more likely to be associated with high levels of seasonal poverty. Beans are sometimes considered in Rwanda as a relatively risky crop (see von Braun, de Haen, Blanken).

However, more subtle responses need to be considered since the theory of decision under uncertainty suggests that the composition of efficient financial portfolios depends on both the vector of return expectations and the complete variance–covariance matrix of returns (here of different productions), rather than only on the levels and variances of these returns. Of course, return functions in agricultural contexts are more complicated than those in financial markets. They notably involve decreasing returns to scale that are specific to agricultural technologies. However, one may still consider that correlations between productivity levels of different products matter and that a diversification strategy is a relevant behaviour in this context. A particularly efficient form of diversification is the intercropping that is widely developed in the Great Lakes (Cochet (1993) and Sindayizeruka (1993)), which enables peasants to increase both the global productivity of land and protection against agricultural risks, by using labour more intensively. We include the shares of the main products in the output and diversification indices for every season (number of main products that are cultivated) in the set of independent variables. Of course, past choices of diversification may lead to very different consequences in terms of variations in income, and, therefore in terms of transient and chronic poverty.

Finally, a protection strategy against price shocks and food supply risk commonly adopted by peasants consists in preferring auto-consumption of outputs to their commercialisation. Von Braun, de Haen and Blanken show in commune Giciye that the most important reason stated by peasants for growing a particular crop is generally that they want to eat it. We account for this by including the 'auto-consumption rate' (percentage of non-purchased consumption). A high auto-consumption rate may equally 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 explanation of welfare loss due to the inability of households to extract optimal exchange gains from the market. To account for this, and to partially separate risk considerations included in the auto-consumption rate from market imperfection considerations, we use the distance to the closest market as an index of these imperfections. Households having better access to markets – and more aware of their advantages – may be better able to generate differential income from their transactions. Even

[46] Note that the effects of prices interfere with the use of imperfect price indices in the calculus of living standards. As their inclusion diminishes the number of degrees of freedom, we choose to exclude them. Moreover, in a non-separable context, unobserved shadow prices should be included rather than market prices.

here reverse causality is possible, since the degree of market insertion may be the consequence of living standards. For example, local migration must be costly. We designate 'agricultural choices' the share of products in the value of total output, the diversification indices and the auto-consumption rate. One expects that agricultural choices, especially those related to risk considerations, will vary for poor and rich households. Indeed, assets and risk aversion levels are likely to be quite different for these two categories of households.

Other risk protection strategies could also have been considered. For example, exchanges of gifts or helping neighbours or extended family is a traditional institution, which assists the diversification of risks and smoothing of consumption. Traditional insurance systems are also possible. However, since many households are extremely poor, even during a good season, they may not be able to insure themselves, their risks exceeding the premium that they could afford[47].

5.2 The estimation results

Tables 15 (with agricultural choices) and 16 (without agricultural choices) show estimates of IV-Tobit and two-stage quantile-censored regressions. We comment on the estimates only globally. The reader can refer to the tables for the detailed characteristics of each estimation set, especially for cases where the effects commented on are not significant. Table 18 summarises the significant effects in each estimation. The discussion which follows provides suggestive interpretations based on significant parameters common to several trials. We stress again that the results are simply correlates and do not necessarily relate to a structural causality model.

The choice of the estimation method (CQREG or Tobit) is important, especially for the correlates of transient poverty, with a loss of efficiency in CQREG. The results are also sensitive to the choice of the poverty line, although a certain stability in signs of coefficients occurs when they are significant. In fact, beyond common similarities, different correlation structures correspond to severe poverty (low poverty line) and moderate poverty (high poverty line), whether chronic or seasonal. The inclusion of agricultural choices modifies some effects of socio-demographic variables, even if the most robust ones persist. The results of Jalan and Ravallion (1996), who analyse transient annual poverty in China, differ in that the correlates of transient seasonal poverty are clearly different from those of chronic poverty.

Note first that some variables are never significant: number of adolescents, the dummy for the North-West region, the share of beans or of non-food in the total value of output and the diversification index in period C. Several effects are consistent with the beneficial influence of volume and quality of the main inputs (land and labour) on living standards. Land area is associated with lower CP, although the number of active members (youngs and adults) is associated with lower TP, and the education level of the household head is often correlated with both lower CP and lower TP.

By contrast, the number of babies and young children has a negative effect on living standards. This may reflect the fact that these categories of members are mostly a burden for households. It may also stem from imperfect adult-equivalent scales, since with per capita indicators the weights

[47] The test of community insurance against agricultural risks for these households will be the topic of another paper.

of children in the living standards indicator are likely to be overestimated. Female heads (and perhaps elderly heads) are associated with higher CP. This may be caused by lower productivity, since these households are generally directed by an elderly widow, and by bad access to economic and labour opportunities. Households directed by a Tutsi head are associated with highest CP and TP, which is consistent with past negative shocks on their living standards due to political events[48]. The dummy variables for the South-West, Centre-South and East sometimes have significant effects, although they are difficult to interpret because of the large size of these regions. Distance from the market has positive effects on chronic poverty and negative effects on transient poverty. Costly access to the market reduces opportunities for transactions and jobs, and results in the lowest permanent exchange gains; it also makes the household less sensitive to seasonal price shocks (or catering shocks), which helps to stabilise its standard of living.

We examine now the effects of agricultural variables. The share of labour (i.e. wages) in the output value has a negative effect on the level of transient poverty. This may reflect the high value of some employment opportunities (like public service, or private firms or development projects) and/or the stabilising effects of regular activity (or of jobs in bad seasons) on living standards. The fact that salaries are paid mostly in money contributes also to alleviate liquidity constraints and may constitute the main contribution of this variable. No significant effects appears in CP equations. The share of other fruit and vegetables influences TP negatively. This product is mostly bananas (excluding varieties of banana used specifically for beers). This contributes to the smoothing of consumption, since bananas can be gathered most of the year. The share of sweet potatoes has a positive impact on CP. Indeed, this product is well known in Rwanda as a staple food, intensively consumed by the poor. Its low price reflects its low nutritional value. Sweet potatoes are mostly auto-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, banana (Peemans (1993)). The negative effect of the share of sweet potatoes on living standards may also come from an unobserved poor quality for land and/or labour, restricting the choice of other crops. The share of other tubers, mainly cassava with some potatoes, has a negative effect on the level of TP. This is consistent with the well-known character of cassava as a product used to fight famines and bad climatic shocks. Indeed, this product can be kept in the ground most of the year and be used to smooth the consumption (Cochet (1993)). The share of traditional beers (sorghum beer and banana wine) has a negative effect on TP. Since one- third of this product is commercialised and one-third is given and received in gifts, it also enables the peasants to alleviate their liquidity constraint. Note also that banana trees are one of the main forms of capital accumulation in the African Great Lakes (Cochet (1993)) and that this could be associated with preventive savings. It is surprising that the share of beans is not significant even in the TP equations, despite the high seasonality of this crop. Since a large part of this product is commercialised, it may be that an adverse seasonality effect offsets the increased financial capacity. Relatively long-term conservation of beans, compared to cereals or tubers for instance, may also explain its low impact on TP.

Diversification indices in periods A and B have generally negative effects on levels of CP and TP. This is consistent with better management of agricultural risks and perhaps also with a better specialisation of each plot cultivated by the household. Indeed, since Rwanda is a mountainous

48 Civil troubles in 1959 and 1973 severely affected the Tutsi community.

country, the agronomic properties of the parcels are very varied and depend on land quality, altitude, slope and orientation of the plot. Most households cultivate several heterogeneous plots.

Finally, the positive effect of auto-consumption rate on CP may be the result of better protection against agricultural shocks across different years. It contradicts, at least for the poor, the preferences of many economists for strong market insertion of peasants. As for the specialisation strategy, what is good for the rich is not necessarily good for the poor.

Note that the dummy for female household head and land area have no effect on the TP which may be explained by the permanent rather than the transient character of the influence of these variables (stocks rather than flows) on poverty. By contrast, the share of wages, other fruit and vegetables, other tubers and traditional beers have no effect on CP while they influence TP. Diversification indices in periods A and B affect both CP and TP, the latter more significantly. This may indicate that specialisation choices, notably because of the seasonality of crops, may affect transient poverty more than chronic poverty.

6. Conclusion

In Rwanda, seasonal fluctuations in agricultural output strongly affect the fluctuations of living standards of peasants. The lowest level of poverty generally occurs in the first quarter and the highest in the last quarter after the dry season when stocks are exhausted. The incidence of poverty increases substantially in the course of the year. The analysis of the intensity or the severity of poverty strengthens these conclusions and suggests policy interventions concentrated at the end of the year.

The population touched by transient seasonal poverty is very substantial with a majority in the last quarter. In fact, the most severe poverty comes from the seasonal transient component of the annual poverty. Consequently, the real differences in poverty between LDCs and industrial countries or between rural and urban areas are likely to be much worse than shown by annual poverty measures or even by measures of seasonal incidence of poverty. If it is the case, the stabilisation of living standards would be very efficient in reducing the aggregate amount of annual poverty. However, further analysis shows that this policy would touch the moderately poor more than the very poor.

Mobility across quintiles of the distribution of living standards, is always very strong. The poverty crisis in the last transition corresponds more to peasants falling into poverty than to a much lower exit flow out of poverty during this period. A temporary ‘safety net’ policy directed to the poor and the non-poor during this period would then be appropriate.

We estimate equations of chronic and transient seasonal poverty for households. Several socio-economic and environment characteristics, and the agricultural decisions of households, are incorporated into a descriptive model. Although there are some similarities, different correlates tend to be associated with transient seasonal and chronic poverty. Particularly, the agricultural specialisation or diversification of households, their auto-consumption ratio and market insertion appear as major correlates of the two components of annual poverty, even after correcting for the endogeneity of the variables. Moreover, their effects are very different for each of the two components of annual poverty.

The estimation results suggest that specific policies may address the different components of annual poverty, by using different instruments, for example incentives directed to agricultural choices, or structural interventions related to household endowments. They also suggest the definition of target groups of households corresponding to each specific policy. Indeed, a combination of policies seems appropriate in order both to reduce the aggregate poverty in Rwanda by tackling the dominant seasonal transient component, and to raise the living standards of the poorest of the poor, who suffer most severely from chronic poverty, and finally to protect peasants from falling into poverty at the crucial end of the dry season.

In order to design these poverty policies a question remains: why are the poor unable to insure themselves against the risks coming from climatic fluctuations?

Tables

Table 1: Descriptive statistics of the main variables

Variable	Mean	Standard deviation
Total consumption	51 847.7	25409.4
Total production	57 027.8	36 682.1
Per capita total consumption	18 856.7	5 344.5
Total Surplus	5180.2	26521.7
Female head	0.208	0.406
Age of the head	47.45	16.32
Household size	5.22	2.34
Average age of members	24.32	13.40
Tutsi head	0.109	0.313
Land area (m^2)	12398	13156
Number of children 0–3	0.853	0.877
Number of children 4–10	1.072	1.058
Number of adolescents 11–15	0.743	0.926
Number of youngs 16–20	0.509	0.774
Number of adults	2.042	0.750
North-West	0.147	0.355
South-West	0.158	0.366
Centre-North	0.200	0.401
Centre-South	0.249	0.433
East	0.245	0.431
Education of the head	1.808	2.498

Table 2: Autocorrelations coefficients $\left(\rho_{(t,t+1)}\right)$

(the variables have been corrected for price variability)

Variable		A–B	B–C	C–D
Total consumption		0.56775	0.55399	0.61319
Per capita consumption		0.54813	0.57363	0.67671
1st quintile:	Total consumption	0.61234	0.49135	0.68521
2nd quintile:		0.70943	0.63085	0.68771
3rd quintile:		0.39237	0.44216	0.61275
4th quintile:		0.44853	0.55259	0.36196
5th quintile:		0.63679	0.46220	0.58581
1st quintile:	Per capita total consumption	0.63474	0.19241**	0.75069
2nd quintile:		-0.12656**	-0.09811**	-0.08442**
3rd quintile:		-0.29923	-0.30470	-0.13410**
4th quintile:		-0.11457**	-0.20450**	-0.17188**
5th quintile:		0.30176	0.24229*	0.50984
Total production		0.24079	0.19539	0.24090
Per capita production		0.20235	0.25875	0.28015
1st quintile:	Total production	0.26723	0.35323	0.26778*
2nd quintile:		0.52776	0.37183	0.33286
3rd quintile:		0.05224**	-0.03348**	0.13085**
4th quintile:		0.40632	0.33191	-0.03851**
5th quintile:		0.21944**	0.30821	0.48878
1st quintile:	Per capita total production	0.07227**	0.28469	0.41088
2nd quintile:		0.33271	0.15225**	0.13003**
3rd quintile:		-0.05920**	-0.15578**	-0.05513**
4th quintile:		0.32782	0.40171	-0.04511**
5th quintile:		-0.04660**	0.13658**	0.29802

** = non-significant at 10% level, * = non-significant at 5% level

Table 3: Sum of squares of the analysis of variance

	Total (x 10^9)	Household effect (x 10^9)	Cluster effect (x 10^9)	Period effect (x 10^9)	Residual sum of squares (x 10^9)
Y_{it} (ES0)	3.115	2.044		0.04368	1.027
Y_{it} (ES1)	6.133	3.673		0.09061	2.370
Y_{it} (ES2)	8.203	4.923		0.1177	3.162
Y_{it} (ES0)	3.115		1.010	0.04600	2.059
Y_{it} (ES1)	6.133		1.928	0.09240	4.113
Y_{it} (ES2)	8.203		2.583	1.188	5.502
$\vartriangle Y_{it}$ (ES0)	1.956	0.300		0.0946	1.561
$\vartriangle Y_{it}$ (ES1)	4.426	0.7025		0.1758	3.548
$\vartriangle Y_{it}$ (ES2)	5.893	0.937		0.233	4.733
$\vartriangle Y_{it}$ (ES0)	1.956		0.134	0.0956	1.726
$\vartriangle Y_{it}$ (ES1)	4.426		0.3159	0.1758	3.935
$\vartriangle Y_{it}$ (ES2)	5.893		0.420	0.223	5.250

	Total (x 10^9)	Household effect (x 10^9)	Cluster effect (x 10^9)	Period effect (x 10^9)	Residual sum of squares (x 10^9)
$\ln Y_{it}$ (ES0)	333.37	206.71		2.46	124.20
$\ln Y_{it}$ (ES1)	304.90	178.24		2.46	124.20
$\ln Y_{it}$ (ES2)	186.74	184.28		2.46	124.20
$\ln Y_{it}$ (ES0)	333.37		107.32	2.48	223.57
$\ln Y_{it}$ (ES1)	304.90		94.30	2.35	208.26
$\ln Y_{it}$ (ES2)	310.94		96.64	2.31	211.99
$\vartriangle \ln Y_{it}$	229.40	35.88		7.33	186.19
$\vartriangle \ln Y_{it}$	229.40		16.24	7.31	205.84

Y_{it} is the living standard indicator of household i in period t, $\vartriangle Y_{it} = Y_{it} - Y_{i,t-1}$.
ESi denotes use of indicators based on the i^{th} equivalence scale.

Table 4: poverty lines

	equivalence scales		
line/indicator (in Frw)	es0	es1	es2
first quintile: z1	6 990.93	11 253.00	12 669.09
first quintile: z2	6 149.09	9 790.04	11 263.38
first quintile: z3	5 666.28	9 215.44	10 602.92
second quintile: z4	8 557.28	13 879.92	16 007.69
second quintile: z5	8 167.98	12 800.08	14 654.81
second quintile: z6	7 640.2	11 860.64	13 788.84

Table 5: Estimates of FGT's poverty indices (P_{at})
(Indicator per capita corrected by price index and sampling plan)

poverty lines based on the first quintile												
	z_1				z_2				z_3			
a	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**2**
A	0.221	0.0568	0.0225	0.0111	0.170	0.0386	0.0151	0.00745	0.119	0.0300	0.0117	0.00579
B	0.293	0.0715	0.0266	0.0122	0.211	0.0475	0.0170	0.00768	0.178	0.0354	0.0127	0.00569
C	0.274	0.0733	0.0292	0.0141	0.218	0.0509	0.0195	0.00920	0.170	0.0397	0.0149	0.0697
D	0.357	0.0939	0.0382	0.0195	0.263	0.0655	0.0261	0.0136	0.240	0.0513	0.0203	0.0109
$\bar{P}_a$	0.286	0.0733	0.0289	0.0141	0.215	0.0501	0.0192	0.00939	0.177	0.0388	0.0148	0.00728
CP_a	0.220	0.0381	0.0113	0.00412	0.138	0.0210	0.00602	0.00204	0.102	0.0149	0.00390	0.00124
$\frac{\bar{P}_a - CP_a}{\bar{P}_a}$	0.230	0.480	0.609	0.707	0.360	0.580	0.687	0.782	0.422	0.615	0.736	0.830

poverty lines based on the second quintile												
	z_4				z_5				z_6			
a	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**
A	0.392	0.102	0.0411	0.0205	0.350	0.0887	0.0358	0.0178	0.29413	0.073219	0.029395	0.014565
B	0.469	0.126	0.0504	0.0242	0.417	0.111	0.0438	0.0208	0.35163	0.092349	0.035607	0.016617
C	0.423	0.121	0.0516	0.0262	0.385	0.107	0.0455	0.0228	0.31241	0.091003	0.037835	0.018619
D	0.539	0.156	0.0672	0.0347	0.487	0.140	0.0593	0.0305	0.43793	0.11873	0.049263	0.025176
$\bar{P}_a$	0.456	0.126	0.0522	0.0262	0.410	0.111	0.0458	0.0228	0.34903	0.093222	0.037707	0.018580
CP_a	0.401	0.0834	0.0274	0.0110	0.347	0.0698	0.0226	0.00886	0.28764	0.054493	0.016940	0.0064489
$\frac{\bar{P}_a - CP_a}{\bar{P}_a}$	0.120	0.336	0.475	0.582	0.153	0.371	0.507	0.611	0.176	0.415	0.551	0.653

Table 6: Estimates of FGT's poverty indices (P_{at})

(Indicator with es1 and corrected by price index and sampling plan)

poverty lines based on the first quintile

	z_1				z_2				z_3			
a	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**
A	0.239	0.0605	0.0253	0.0131	0.166	0.0414	0.0172	0.00887	0.140	0.0347	0.0145	0.00749
B	0.332	0.0828	0.0312	0.0143	0.221	0.0534	0.0195	0.00860	0.190	0.0442	0.0157	0.00682
C	0.296	0.0742	0.0292	0.0140	0.190	0.0486	0.0189	0.00886	0.173	0.0410	0.0156	0.00718
D	0.378	0.100	0.0436	0.0230	0.267	0.0710	0.0302	0.0158	0.235	0.0605	0.0256	0.0134
$\bar{P}_a$	0.311	0.0785	0.0317	0.0157	0.211	0.0526	0.0209	0.0102	0.184	0.0441	0.0173	0.00841
CP_a	0.224	0.0391	0.0122	0.00476	0.145	0.0218	0.00649	0.00242	0.117	0.0163	0.00489	0.00177
$\frac{\bar{P}_a - CP_a}{\bar{P}_a}$	0.280	0.502	0.614	0.696	0.312	0.586	0.689	0.763	0.363	0.631	0.718	0.790

poverty lines based on the second quintile

	z_4				z_5				z_6			
a	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**
A	0.401	0.108	0.0452	0.0235	0.330	0.0858	0.0362	0.0188	0.259	0.0699	0.0293	0.0152
B	0.508	0.146	0.0599	0.0291	0.429	0.119	0.0471	0.0223	0.391	0.0969	0.0371	0.0172
C	0.427	0.128	0.0540	0.0270	0.379	0.105	0.0430	0.0211	0.329	0.0863	0.0343	0.0166
D	0.573	0.168	0.0748	0.0401	0.480	0.139	0.0610	0.0324	0.431	0.115	0.050	0.0265
$\bar{P}_a$	0.477	0.136	0.0577	0.0293	0.404	0.111	0.0461	0.0231	0.352	0.0912	0.0370	0.0184
CP_a	0.409	0.0884	0.0298	0.0122	0.344	0.0665	0.0214	0.00858	0.278	0.0490	0.0154	0.00608
$\frac{\bar{P}_a - CP_a}{\bar{P}_a}$	0.143	0.352	0.484	0.583	0.150	0.404	0.537	0.629	0.211	0.463	0.584	0.670

Table 7: Estimates of FGT's poverty indices (P_{at})
(Indicator with es2 and corrected by price index and sampling plan)

poverty lines based on the first quintile												
	z_1				z_2				z_3			
a	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**
A	0.214	0.0585	0.0246	0.0127	0.168	0.0428	0.0177	0.00919	0.152	0.0358	0.0149	0.00778
B	0.324	0.0816	0.0311	0.0144	0.242	0.0570	0.0209	0.00941	0.210	0.0472	0.0169	0.00751
C	0.275	0.0698	0.0282	0.0138	0.199	0.0500	0.0198	0.00947	0.173	0.0420	0.0164	0.00775
D	0.344	0.0971	0.0426	0.0226	0.267	0.0730	0.0314	0.0165	0.229	0.0632	0.0267	0.0140
$\bar{P}_a$	0.289	0.0755	0.0307	0.0153	0.219	0.0545	0.0217	0.0107	0.191	0.0458	0.0180	0.00883
CP_a	0.224	0.0354	0.0113	0.00473	0.133	0.0212	0.00700	0.00287	0.116	0.0163	0.00220	0.152
$\frac{\bar{P}_a - CP_a}{\bar{P}_a}$	0.227	0.531	0.631	0.691	0.392	0.611	0.677	0.731	0.394	0.644	0.695	0.750

poverty lines based on the second quintile												
	z_4				z_5				z_6			
a	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**
A	0.397	0.109	0.0464	0.0243	0.320	0.0861	0.0365	0.0191	0.276	0.0731	0.0310	0.0161
B	0.483	0.149	0.0630	0.0311	0.422	0.122	0.0490	0.0235	0.396	0.104	0.0407	0.0192
C	0.435	0.130	0.0551	0.0280	0.385	0.104	0.0430	0.0215	0.331	0.0888	0.0361	0.0179
D	0.538	0.170	0.0767	0.0415	0.489	0.139	0.0616	0.0331	0.432	0.119	0.0528	0.0282
$\bar{P}_a$	0.463	0.138	0.0593	0.0304	0.404	0.111	0.0466	0.0236	0.359	0.0950	0.0392	0.0197
CP_a	0.410	0.0920	0.0308	0.0128	0.350	0.0672	0.0214	0.00878	0.305	0.0524	0.0164	0.00676
$\frac{\bar{P}_a - CP_a}{\bar{P}_a}$	0.114	0.335	0.480	0.579	0.134	0.397	0.541	0.628	0.152	0.448	0.582	0.657

Table 8: Estimates of Clark's and Watt's poverty indices
(Indicator per capita corrected by price index and sampling plan)

poverty lines based on the first quintile												
	z_1				z_2				z_3			
index	**W**	**C(1)**	**C(1/2)**	**C(1/3)**	**W**	**C(1)**	**C(1/2)**	**C(1/3)**	**W**	**C(1)**	**C(1/2)**	**C(1/3)**
A	0.0751	0.0568	0.0324	0.0224	0.0509	0.0386	0.0220	0.0152	0.0395	0.0300	0.0171	0.0118
B	0.0920	0.0715	0.0403	0.0278	0.0604	0.0475	0.0266	0.0183	0.0450	0.0354	0.0199	0.0137
C	0.0965	0.0733	0.0418	0.0289	0.0662	0.0509	0.0288	0.0199	0.0513	0.0397	0.0224	0.0155
D	0.127	0.0939	0.0539	0.0375	0.0883	0.0655	0.0376	0.0261	0.0693	0.0513	0.0294	0.0205
$\bar{P}_a$	0.0968	0.0733	0.0418	0.0289	0.0658	0.0501	0.0285	0.0197	0.0508	0.0388	0.00806	0.00546
CP_a	0.0457	0.0381	0.0208	0.0142	0.0250	0.0210	0.0114	0.00778	0.0175	0.0149	0.0220	0.0152
$\frac{\bar{P}_a - CP_a}{\bar{P}_a}$	0.527	0.480	0.502	0.510	0.620	0.580	0.598	0.605	0.657	0.615	0.634	0.641

poverty lines based on the second quintile												
	z_4				z_5				z_6			
index	**W**	**C(1)**	**C(1/2)**	**C(1/3)**	**W**	**C(1)**	**C(1/2)**	**C(1/3)**	**W**	**C(1)**	**C(1/2)**	**C(1/3)**
A	0.135	0.102	0.0581	0.0403	0.118	0.0887	0.0507	0.0352	0.0972	0.0732	0.0418	0.0290
B	0.165	0.126	0.0716	0.0496	0.145	0.111	0.0628	0.0435	0.120	0.0923	0.0923	0.0523
C	0.163	0.121	0.0695	0.0483	0.144	0.107	0.0618	0.0429	0.121	0.0910	0.0522	0.0362
D	0.214	0.156	0.0904	0.0630	0.190	0.140	0.0807	0.0562	0.161	0.119	0.0683	0.0476
$\bar{P}_a$	0.169	0.126	0.0721	0.0501	0.149	0.111	0.0637	0.0442	0.124	0.0932	0.0533	0.0370
CP_a	0.103	0.0834	0.0461	0.0316	0.0857	0.0698	0.0385	0.0263	0.0662	0.0545	0.0299	0.0204
$\frac{\bar{P}_a - CP_a}{\bar{P}_a}$	0.390	0.336	0.360	0.370	0.423	0.371	0.395	0.404	0.466	0.415	0.438	0.447

Table 9: Estimates of Clark's and Watt's poverty indices
(Indicator with es1 and corrected by price index and sampling plan)

poverty lines based on the first quintile

	z_1				z_2				z_3			
index	**W**	**C(1)**	**C(1/2)**	**C(1/3)**	**W**	**C(1)**	**C(1/2)**	**C(1/3)**	**W**	**C(1)**	**C(1/2)**	**C(1/3)**
A	0.0818	0.0605	0.0348	0.0242	0.0557	0.0414	0.0238	0.0165	0.0468	0.0347	0.0200	0.0139
B	0.107	0.0828	0.0467	0.0322	0.0680	0.0534	0.0300	0.0206	0.0559	0.0442	0.0247	0.0170
C	0.0973	0.0742	0.0422	0.0292	0.0632	0.0486	0.0275	0.0190	0.0529	0.0410	0.0231	0.0160
D	0.138	0.100	0.0582	0.0406	0.0972	0.0710	0.0410	0.0286	0.0828	0.0605	0.0350	0.0244
$\bar{P}_a$	0.104	0.0785	0.0449	0.0311	0.0695	0.0526	0.0300	0.0208	0.0581	0.0441	0.0251	0.0174
CP_a	0.0476	0.0391	0.215	0.0147	0.0262	0.0218	0.0119	0.00811	0.0196	0.0163	0.00891	0.00607
$\frac{\bar{P}_a - CP_a}{\bar{P}_a}$	0.544	0.502	0.521	0.528	0.623	0.586	0.603	0.609	0.663	0.631	0.645	0.651

poverty lines based on the second quintile

	z_4				z_5				z_6			
index	**W**	**C(1)**	**C(1/2)**	**C(1/3)**	**W**	**C(1)**	**C(1/2)**	**C(1/3)**	**W**	**C(1)**	**C(1/2)**	**C(1/3)**
A	0.146	0.108	0.0620	0.0431	0.116	0.0858	0.0495	0.0344	0.0947	0.0699	0.0403	0.0280
B	0.194	0.146	0.0834	0.0578	0.156	0.119	0.0678	0.0469	0.126	0.0969	0.0548	0.0378
C	0.172	0.128	0.0737	0.0512	0.140	0.105	0.0602	0.0418	0.114	0.0863	0.0491	0.0340
D	0.234	0.168	0.0979	0.0684	0.192	0.139	0.0808	0.0564	0.159	0.115	0.0669	0.0467
$\bar{P}_a$	0.184	0.136	0.0786	0.0546	0.149	0.111	0.0639	0.0444	0.122	0.0912	0.0522	0.0362
CP_a	0.110	0.0884	0.0490	0.0336	0.0817	0.0665	0.367	0.0251	0.0598	0.0490	0.0270	0.0184
$\frac{\bar{P}_a - CP_a}{\bar{P}_a}$	0.405	0.352	0.376	0.385	0.454	0.404	0.426	0.435	0.508	0.463	0.483	0.490

Table 10: Estimates of Clark's and Watt's poverty indices
(Indicator with es2 and corrected by price index and sampling plan)

poverty lines based on the first quintile												
	z_1				z_2				z_3			
index	**W**	**C(1)**	**C(1/2)**	**C(1/3)**	**W**	**C(1)**	**C(1/2)**	**C(1/3)**	**W**	**C(1)**	**C(1/2)**	**C(1/3)**
A	0.0794	0.0585	0.0337	0.0235	0.0577	0.0428	0.0246	0.0171	0.0484	0.0358	0.0206	0.0143
B	0.106	0.0816	0.0461	0.0318	0.0730	0.0570	0.0321	0.0221	0.0601	0.0472	0.0265	0.0182
C	0.0923	0.0698	0.0398	0.0276	0.0656	0.0500	0.0284	0.0197	0.0548	0.0420	0.0238	0.0165
D	0.135	0.0971	0.0564	0.0394	0.101	0.0730	0.0423	0.0295	0.0868	0.0632	0.0365	0.0255
$\overline{P}_a$	0.101	0.0755	0.0432	0.0300	0.0723	0.0545	0.0311	0.0216	0.0606	0.0458	0.0261	0.0181
CP_a	0.0436	0.0354	0.0196	0.0134	0.0262	0.0212	0.117	0.00803	0.0202	0.0163	0.00904	0.00619
$\frac{\overline{P}_a - CP_a}{\overline{P}_a}$	0.567	0.531	0.547	0.554	0.638	0.611	0.623	0.627	0.667	0.644	0.654	0.658

poverty lines based on the second quintile												
	z_4				z_5				z_6			
index	**W**	**C(1)**	**C(1/2)**	**C(1/3)**	**W**	**C(1)**	**C(1/2)**	**C(1/3)**	**W**	**C(1)**	**C(1/2)**	**C(1/3)**
A	0.149	0.109	0.0629	0.0439	0.117	0.0861	0.0497	0.0346	0.0995	0.0731	0.0422	0.0294
B	0.200	0.149	0.0857	0.0595	0.160	0.122	0.0694	0.0480	0.136	0.104	0.0591	0.0408
C	0.176	0.130	0.0749	0.0521	0.139	0.104	0.0598	0.0415	0.118	0.0888	0.0507	0.0352
D	0.238	0.170	0.0994	0.0696	0.194	0.139	0.0810	0.0566	0.166	0.119	0.0695	0.0486
$\overline{P}_a$	0.188	0.138	0.0799	0.0556	0.150	0.111	0.0641	0.0445	0.128	0.0950	0.0545	0.0379
CP_a	0.114	0.0920	0.0510	0.0350	0.0827	0.0672	0.0371	0.0254	0.0643	0.0524	0.0289	0.0197
$\frac{\overline{P}_a - CP_a}{\overline{P}_a}$	0.391	0.335	0.361	0.371	0.450	0.397	0.421	0.430	0.496	0.448	0.470	0.479

Table 11: Estimates of transition matrices
(Indicator per capita corrected by price index and sampling plan)

A \ B	1	2	3	4	5
1	50.42	13.92	24.22	4.38	7.06
2	30.33	30.56	26.59	9.76	2.77
3	30.49	35.20	15.92	11.50	6.89
4	12.53	22.84	21.36	27.31	15.95
5	10.29	8.25	22.67	15.48	43.31

B \ C	1	2	3	4	5
1	51.78	21.16	12.00	6.93	8.13
2	19.34	18.45	27.92	12.91	21.38
3	27.81	12.98	19.74	17.10	22.37
4	5.48	23.51	11.78	26.99	32.25
5	2.33	11.21	11.56	18.91	55.98

C \ D	1	2	3	4	5
1	65.83	20.75	8.35	3.89	1.18
2	40.13	29.71	17.44	6.53	6.18
3	28.94	25.92	26.62	11.57	6.95
4	14.98	15.12	21.89	19.33	28.68
5	9.42	15.49	23.60	16.23	35.27

i_{AB} = 34.6%; i_{BC} = 34.98%; i_{CD} = 40.68%

Table 12: Estimates of transition matrices
(Indicator with first adult-equivalent scale and corrected by price index and sampling plan)

A \ B	1	2	3	4	5
1	52.49	19.03	6.62	13.79	8.08
2	44.09	32.26	6.49	12.46	4.70
3	35.48	21.76	8.07	22.99	11.70
4	24.90	12.64	17.52	26.85	18.10
5	13.70	8.35	16.39	18.20	43.36

B \ C	1	2	3	4	5
1	45.76	17.67	5.89	20.13	10.55
2	36.46	19.40	11.90	19.41	12.82
3	19.61	3.77	16.46	24.45	35.72
4	21.09	8.66	15.70	23.59	30.96
5	9.29	9.47	12.49	10.39	58.36

C \ D	1	2	3	4	5
1	67.49	16.20	5.29	6.51	4.51
2	49.40	20.53	13.76	11.48	4.84
3	24.93	6.64	23.31	23.72	21.39
4	27.92	27.26	12.94	24.73	7.17
5	11.92	22.58	7.89	17.06	40.55

i_{AB} = 34.6%; i_{BC} = 34.6%; i_{CD} = 43.34%

Table 13: Estimates of transition matrices

(Indicator with second adult-equivalent scale and corrected by price index and sampling plan)

A \ B	1	2	3	4	5
1	55.82	15.70	7.36	12.17	8.95
2	38.24	33.76	8.16	15.29	4.55
3	32.57	22.10	16.60	16.40	12.33
4	26.77	8.00	25.32	18.46	21.45
5	12.70	5.05	21.45	16.38	44.43

B \ C	1	2	3	4	5
1	46.06	19.26	13.11	12.02	9.55
2	29.45	16.80	11.68	25.30	16.77
3	20.93	15.25	13.19	19.14	31.49
4	20.18	13.11	9.28	21.80	35.62
5	6.93	12.82	9.76	15.19	55.29

C \ D	1	2	3	4	5
1	62.83	22.55	8.49	2.66	3.47
2	44.00	24.18	10.08	7.86	13.88
3	40.82	5.35	22.52	24.49	6.82
4	19.11	18.18	25.55	35.02	2.14
5	7.41	20.18	16.04	18.57	37.81

i_{AB} = 34.22%; i_{BC} = 33.08%; i_{CD} = 41.02%

Table 14: number of observed households by categories and period

es0:

period \ category	1	2	3	4	5
A	55	47	49	43	69
B	67	57	58	38	43
C	69	46	42	38	68
D	82	53	53	30	45

es1:

period \ category	1	2	3	4	5
A	64	42	38	53	66
B	88	45	33	51	46
C	80	36	31	45	71
D	96	50	30	40	47

es2:

period \ category	1	2	3	4	5
A	58	47	44	49	65
B	86	43	42	41	51
C	75	44	30	41	73
D	86	53	40	43	41

Table 15: Regressions of the transient and chronic poverty indices (with production variables)

(opposite of) poverty indicators	Chronic poverty (q=0.025)		
independent variables	z_4	z_5	z_6
constant	-0.531 (-1.615)	-0.618 (-1.969)	-0.627 (-0.481)
nb babies	-0.0375 (-1.809)	-0.0665 (-3.026)	-0.0588 (-3.119)
nb children	-0.199 (-1.083)	-0.0297 (-1.979)	-0.0236 (0.297)
nb adolescents	-0.00838 (-0.396)	-0.0177 (-0.912)	-0.00635 (-0.240)
nb youngs	-0.00229 (-0.098)	-0.00761 (-0.293)	-0.0297 (1.162)
nb adults	-0.0353 (-1.450)	-0.0409 (-1.562)	-0.0415 (-0.504)
Tutsi head	-0.183 (-1.911)	-0.160 (-1.969)	-0.162 (-1.501)
Female head	-0.0939 (-1.800)	-0.109 (-1.998)	-0.128 (-1.866)
Age of the head	0.000808 (0.559)	-0.000792 (-0.582)	0.0000843 (-0.482)
Education of the head	-0.00404 (-0.415)	-0.0131 (-1.119)	-0.0172 (-0.696)
Distance to market	-0.000459 (-0.549)	-0.000226 (-0.272)	0.000310 (-0.622)
Land	0.00179 (1.381)	0.00117 (0.910)	0.000697 (0.686)
North-West	-0.0123 (-0.174)	-0.00645 (-0.085)	-0.0448 (-0.003)
South-West	-0.0211 (-0.340)	0.0332 (0.464)	0.00457 (-0.356)
Centre-South	-0.00471 (-0.080)	0.0227 (0.341)	0.00319 (-0.161)
East	-0.0304 (-0.619)	-0.0844 (-1.500)	-0.123 (0.221)
% wages	0.409 (1.330)	0.289 (0.931)	0.458 (0.316)
% beans	-0.0904 (-0.250)	-0.153 (-0.408)	-0.360 (-0.293)
% fruit and vegetables	0.176 (0.515)	0.00163 (0.005)	0.0892 (-0.194)
% sweet potatoes	-0.407 (-1.032)	-0.761 (-1.978)	-0.955 (-1.107)
% other tubers	0.245 (0.789)	0.166 (0.515)	0.0843 (-0.584)
% traditional beers	0.294 (1.035)	0.343 (1.223)	0.142 (0.124)
% other food	-0.263 (-0.833)	-0.410 (-1.281)	-0.0655 (-0.769)
Diversification index of period A	0.0195 (0.907)	0.0237 (1.146)	0.0310 (1.479)
Diversification index of period B	0.0056 (0.182)	0.0145 (0.400)	0.0442 (0.246)
Diversification index of period C	-0.00118 (-0.061)	0.00503 (0.245)	0.00856 (-0.777)
Diversification index of period D	0.0261 (1.011)	0.0477 (1.891)	0.0269 (0.253)
subsistence ratio	0.330 (1.445)	0.591 (2.323)	0.516 (0.666)
% censored	6.8	15.8	19.8

Student’s t in parentheses.

(opposite of) poverty indicators	Transient poverty	(q=0.1)	
independent variables	z_4	z_5	z_6
constant	-0.0554	-0.0476	-0.0880
	(-0.438)	(-0.370)	(-0.665)
nb babies	-0.131	-0.0130	-0.0113
	(-1.532)	(-1.635)	(-1.327)
nb children	-0.00141	-0.00301	-0.00361
	(-0.199)	(-0.453)	(-0.584)
nb adolescents	-0.00635	-0.00879	-0.0104
	(-0.606)	(-0.863)	(-1.090)
nb youngs	0.0107	0.0101	0.00888
	(0.807)	(0.816)	(0.738)
nb adults	0.00408	0.00748	0.00872
	(0.398)	(0.745)	(0.897)
Tutsi head	-0.0174	-0.0257	-0.0249
	(-0.902)	(-1.441)	(-1.494)
Female head	0.00466	0.00773	0.00106
	(0.292)	(0.503)	(0.070)
Age of the head	0.000119	0.000123	-0.0000599
	(0.221)	(0.228)	(-0.109)
Education of the head	-0.000486	0.000446	-0.00133
	(-0.118)	(0.114)	(-0.345)
Distance to market	0.000357	0.000362	0.000430
	(1.232)	(1.343)	(1.515)
Land	-0.000535	-0.000572	-0.000516
	(-0.756)	(-0.827)	(-0.820)
North-West	0.00698	-0.000553	-0.00425
	(0.211)	(-0.016)	(-0.127)
South-West	-0.0268	-0.0458	-0.0368
	(-0.777)	(-1.308)	(-1.075)
Centre-South	0.00986	-0.000308	0.00180
	(0.390)	(-0.012)	(0.073)
East	0.00553	-0.00917	-0.0226
	(0.221)	(-0.387)	(-1.017)
% wages	0.0900	0.0964	0.0974
	(0.874)	(0.95)	(0.968)
% beans	-0.230	-0.241	-0.210
	(-1.127)	(-1.164)	(-1.113)
% fruit and vegetables	0.0847	0.0675	0.0738
	(0.595)	(0.503)	(0.507)
% sweet potatoes	-0.0424	-0.0341	-0.155
	(-0.242)	(-0.204)	(-0.858)
% other tubers	0.0973	0.149	0.153
	(0.635)	(1.030)	(1.056)
% traditional beers	0.0544	0.0742	-0.00607
	(0.492)	(0.717)	(-0.057)
% other food	-0.0624	-0.0527	-0.0557
	(-0.486)	(-0.422)	(-0.434)
Diversification index of period A	0.00586	0.00446	0.00853
	(0.685)	(0.527)	(0.994)
Diversification index of period B	-0.0186	-0.0237	-0.0150
	(-1.133)	(-1.506)	(-1.018)
Diversification index of period C	0.00603	0.0104	0.00801
	(0.693)	(1.255)	(0.937)
Diversification index of period D	-0.00287	-0.00362	-0.00224
	(-0.204)	(-0.272)	(-0.185)
subsistence ratio	0.0679	0.0666	0.0970
	(0.598)	(0.660)	(0.965)
% censored	0.8	0.8	1.2

Student's t in parentheses.

(opposite of) poverty indicators	Transient poverty (Tobit)		
independent variables	z_4	z_5	z_6
constant	-0.0694 (1.19)	-0.0787 (1.31)	-0.100 (1.60)
nb babies	-0.00959 (2.52)	-0.0110 (2.79)	-0.0111 (2.71)
nb children	-0.00581 (1.92)	-0.00701 (2.26)	-0.00685 (2.13)
nb adolescents	-0.00257 (0.79)	-0.00255 (0.76)	-0.00232 (0.66)
nb youngs	-0.00321 (0.78)	-0.00409 (0.97)	-0.00359 (0.82)
nb adults	-0.00381 (0.88)	-0.00292 (0.66)	-0.00340 (0.74)
Tutsi head	-0.0209 (2.44)	-0.0221 (2.51)	-0.0227 (2.50)
Female head	0.00630 (0.80)	0.00720 (0.88)	0.00472 (0.56)
Age of the head	0.000136 (0.52)	0.000077 (0.28)	0.0000575 (0.21)
Education of the head	-0.000438 (0.26)	-0.000269 (0.15)	-0.000915 (0.50)
Distance to market	0.000226 (1.68)	0.000219 (1.59)	0.000254 (1.75)
Land	0.000256 (0.92)	0.000262 (0.91)	0.000259 (0.86)
North-West	-0.00487 (0.43)	-0.00740 (0.63)	-0.00625 (0.52)
South-West	-0.0166 (1.36)	-0.0194 (1.53)	-0.0169 (1.28)
Centre-South	-0.00722 (0.72)	-0.00948 (0.92)	-0.00689 (0.64)
East	0.0176 (1.68)	0.0184 (1.70)	0.0190 (1.69)
% wages	0.169 (3.20)	0.180 (3.27)	0.195 (3.39)
% beans	-0.0526 (0.80)	-0.0417 (0.62)	-0.0252 (0.36)
% fruit and vegetables	0.103 (1.66)	0.110 (1.71)	0.133 (1.96)
% sweet potatoes	0.00244 (0.04)	0.0155 (0.24)	0.00874 (0.13)
% other tubers	0.151 (2.58)	0.167 (2.77)	0.182 (2.90)
% traditional beers	0.0698 (1.52)	0.0782 (1.65)	0.0855 (1.72)
% other food	0.00637 (0.11)	0.0172 (0.30)	0.0161 (0.27)
Diversification index of period A	0.00567 (1.45)	0.00663 (1.65)	0.00821 (1.94)
Diversification index of period B	-0.000397 (0.08)	0.00000625 (0.001)	0.000246 (0.044)
Diversification index of period C	-0.000058 (0.02)	0.00121 (0.30)	0.00160 (0.38)
Diversification index of period D	-0.00582 (1.22)	-0.00702 (1.43)	-0.00635 (1.24)
Subsistence ratio	0.0211 (0.50)	0.0175 (0.40)	0.0186 (0.41)
% censored	26.5	30.4	35.2

Student's t in parentheses.

(opposite of) poverty indicators	Chronic poverty (Tobit)		
independent variables	z_4	z_5	z_6
constant	0.105 (0.57)	-0.0897 (0.46)	-0.0943 (0.45)
nb babies	-0.0488 (3.97)	-0.0481 (3.75)	-0.0463 (3.40)
nb children	-0.306 (3.16)	-0.0327 (3.25)	-0.0329 (3.06)
nb adolescents	-0.0141 (1.37)	-0.0145 (1.35)	-0.0166 (1.48)
nb youngs	-0.0123 (0.91)	-0.0114 (0.80)	-0.0144 (0.94)
nb adults	0.00820 (0.62)	0.0104 (0.72)	0.0118 (0.78)
Tutsi head	-0.0332 (1.25)	-0.0368 (1.36)	-0.0407 (1.42)
Female head	-0.0261 (1.07)	-0.0267 (1.04)	-0.0290 (1.07)
Age of the head	-0.00115 (1.39)	-0.00105 (1.23)	-0.000884 (0.99)
Education of the head	-0.000582 (0.10)	-0.000789 (0.13)	-0.000500 (0.081)
Distance to market	-0.000446 (1.09)	-0.000386 (0.92)	-0.000399 (0.93)
Land	0.000941 (1.00)	0.000538 (0.54)	0.000498 (0.47)
North-West	-0.0382 (1.06)	-0.0359 (0.94)	-0.0433 (1.10)
South-West	-0.0593 (1.50)	-0.0404 (0.98)	-0.0459 (1.06)
Centre-South	-0.0593 (1.85)	-0.0586 (1.75)	-0.0516 (1.45)
East	0.0454 (1.31)	0.0128 (0.36)	0.0140 (0.36)
% wages	0.0400 (0.24)	0.0353 (0.21)	0.0639 (0.35)
% beans	-0.144 (0.68)	-0.0725 (0.33)	-0.0943 (0.40)
% fruit and vegetables	0.107 (0.53)	0.180 (0.85)	0.193 (0.84)
% sweet potatoes	-0.299 (1.53)	-0.275 (1.36)	-0.384 (1.78)
% other tubers	-0.0824 (0.46)	0.0325 (0.17)	0.0361 (0.18)
% traditional beers	-0.0417 (0.28)	0.0112 (0.07)	0.0491 (0.30)
% other food	-0.000713 (0.004)	0.0711 (0.38)	0.171 (0.86)
Diversification index of period A	0.0261 (2.06)	0.0281 (2.13)	0.0225 (1.60)
Diversification index of period B	0.0236 (1.41)	0.0352 (1.96)	0.0385 (1.93)
Diversification index of period C	-0.00500 (0.40)	-0.000913 (0.07)	0.00259 (0.18)
Diversification index of period D	-0.000784 (0.053)	0.00257 (0.17)	0.00150 (0.09)
subsistence ratio	-0.144 (1.06)	-0.0732 (0.53)	-0.0507 (0.34)
% censored	39.1	33.6	27.3

Student's t in parentheses.

Table 16 : Regressions of the transient and chronic poverty indices
(without production variables)

The tables are available on request to the author. They have not been included in this working paper because of space limitations.

Table 17: Sampling standard-error estimates

The tables are available on request to the author. They have not been included in this working paper because of space limitations.

Table 18: Summary of the significant effects in the estimations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Constant				-	+			-	+	+	+	-					(-)					-					
nb babies	(+)	+	+	+	+		+	+	+		+	+		(+)	+	+			+	+	+			+	+	+	
nb children			+	+	+		+	+	(+)	+		+			+	+				+	+				+	+	
nb adolescents																											
nb youngs																	(-)					-					(-)
nb adults									+										(-)								
Tutsi head	(+)				+	+			+	(+)					+	+			+	+						+	+
female head	(+)				+				+																		
age of head				+																				(+)			
education of head						(-)			(+)	(-)						(-)	-				(-)	-					-
distance to market		+		+		+		(+)		(+)		(+)			(-)		(-)					(-)			(-)		
land area		(-)		(-)				(-)																			
North-West																											
South-West										(+)						(-)											
Centre-South			(+)			+																					
East				-		-		-	+			-			(-)					(-)	-				(-)	-	
% wages															-					-					-		
% beans																											
% fruit and vegetables															(-)					(-)		(-)			(-)		(-)
% sweet potatoes					+				+		(+)																
% other tubers															-		-			-		-			-		-
% traditional beers																	-					(-)			(-)		
% other food																											
diversification season A			(-)				-		(-)								-					-			(-)		-
diversification season B							(-)				(-)						-					-					+
diversification season C																											
diversification season D	(-)																										
autoconsumption rate	-				-																						

1 to 12: chronic poverty. 13 to 27: transient poverty.

1 to 4 and 13 to 17: z_1; 5 to 8 and 18 to 22: z_2; 9 to 12 and 23 to 27: z_3.

Large set of explanatory variables: 1, 3, 5, 7, 9, 11, 13, 15, 17, 18, 20, 22, 23, 25, 17.

Tobit: 3, 4, 7, 8, 11, 12, 15, 16, 20, 21, 25, 26.

CSREG with q=0.1: 13, 14, 15, 16, 18, 19, 20, 21, 23, 24, 25, 26.

Signs with (respectively without) parentheses correspond to coefficients significant at 10% level (respectively at 5% level).

Appendix: Sampling standard-errors estimators

We y
indicator of a sub-population is estimated by

$$\overline{y_x'} = \frac{z'}{x'}$$

′ denotes the Horwitz–Thompson estimator for a total (sum of values for the variable of est 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 asso
is then approximated by:

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

which can be obtained from a Taylor expansion at the first or
(E y′ ′) and because E z ≠ d x′
estimated by x′ $\overline{y}'$.

We divide the sample of communes (first actual s
drawn) α = 1 to 5) so
characteristics. Several sectors are assumed to have been drawn in each strata. This allow the ation s
impossible since in fact only one sector had been drawn in each commune. Then, th
Horwitz–Thompson formula for superstrata α

$$z_\alpha' = \sum_h \frac{M_h}{m_{h_\alpha}} \sum_{i\ 1}^{m_{h_\alpha}} \frac{N}{n_{hi}} \sum_{=1}^{n_{hi}} \frac{hij}{q} \sum_{k=}^{q} z_{hijk}$$

and

$$'_\alpha \quad \sum_h \frac{h}{m_\alpha} \sum_{=1}^{h_\alpha} \frac{hi}{n} \sum_{j=}^{n} \frac{Q_{hij}}{hij} \sum_{k\ 1}^{hij} x$$

where M_h i $_{h\alpha}$ is the number of communes in n in superstrata α $_{hi}$ is the number of sectors in commune i of prefecture and superstr α; n_{hi} d
α; Q 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 α. A similar can a y
sector.

′,x) is estimated by:

$$C\hat{o}v\ z'\ x' = \frac{1}{} \sum_{=1}^{5} z'-z).\ x'-x)$$

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

More accurate formulae can be used (with resampling, post-stratification, optimal definition of strata), but this one is believed to be enough to obtain useful assessments of the standard errors. Indeed, the existence of inevitable remaining measurement errors makes illusory the accuracy of inferences based only on sampling errors.

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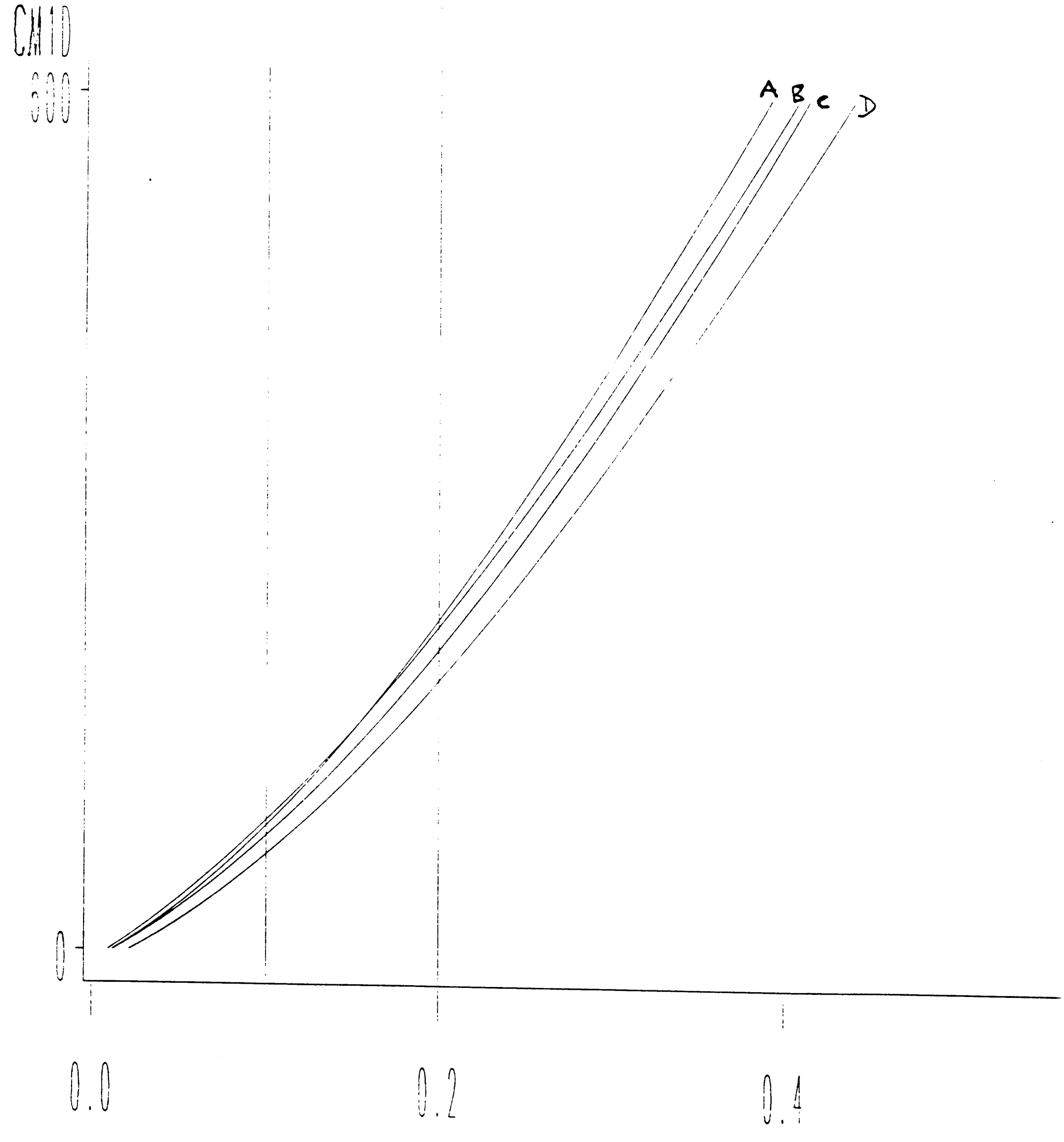
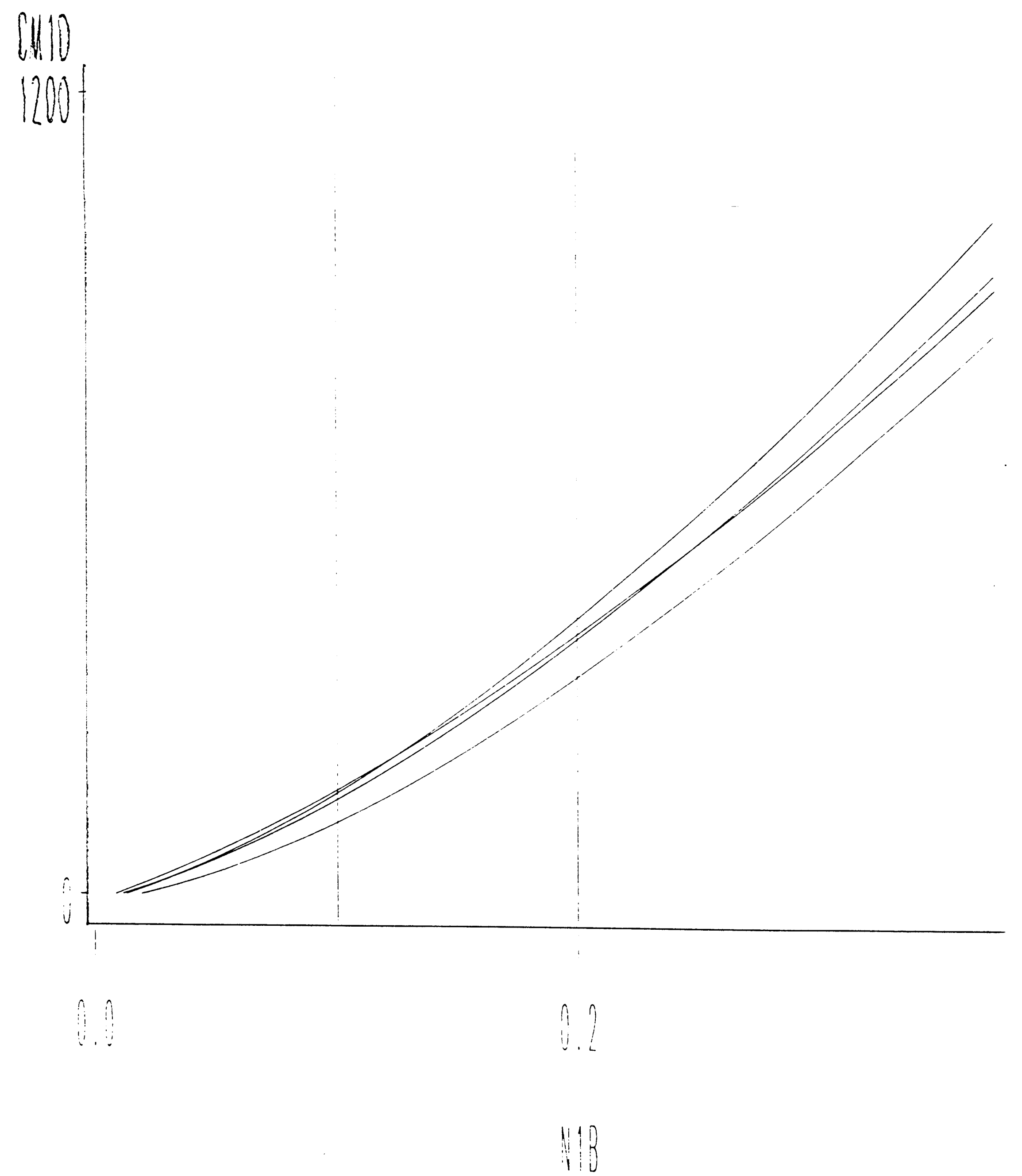
figure 1a: seasonal poverty curves



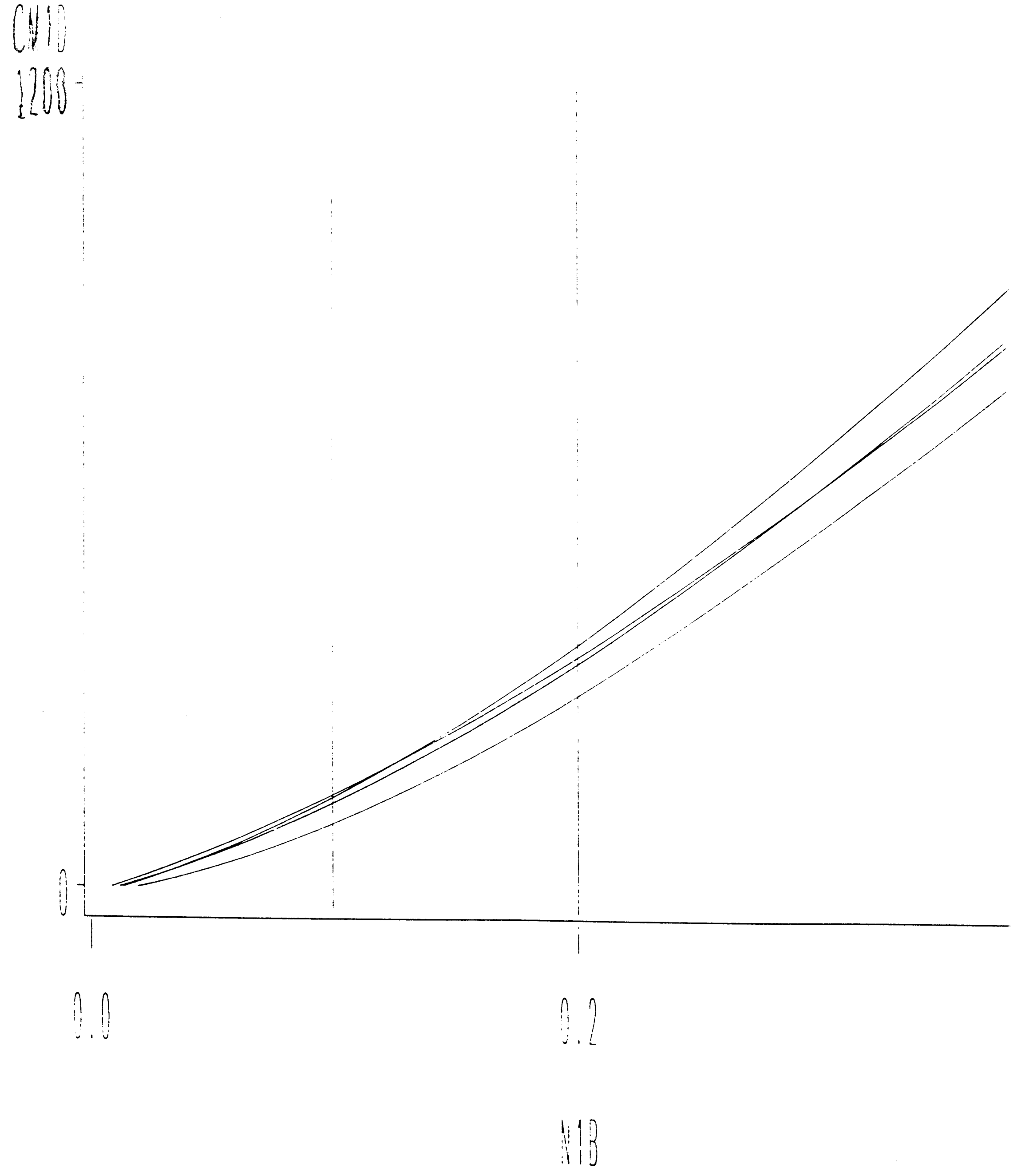
based on per capita consumption (es0)

figure 1b: seasonal poverty curves



based on first equivalence scale (es1)

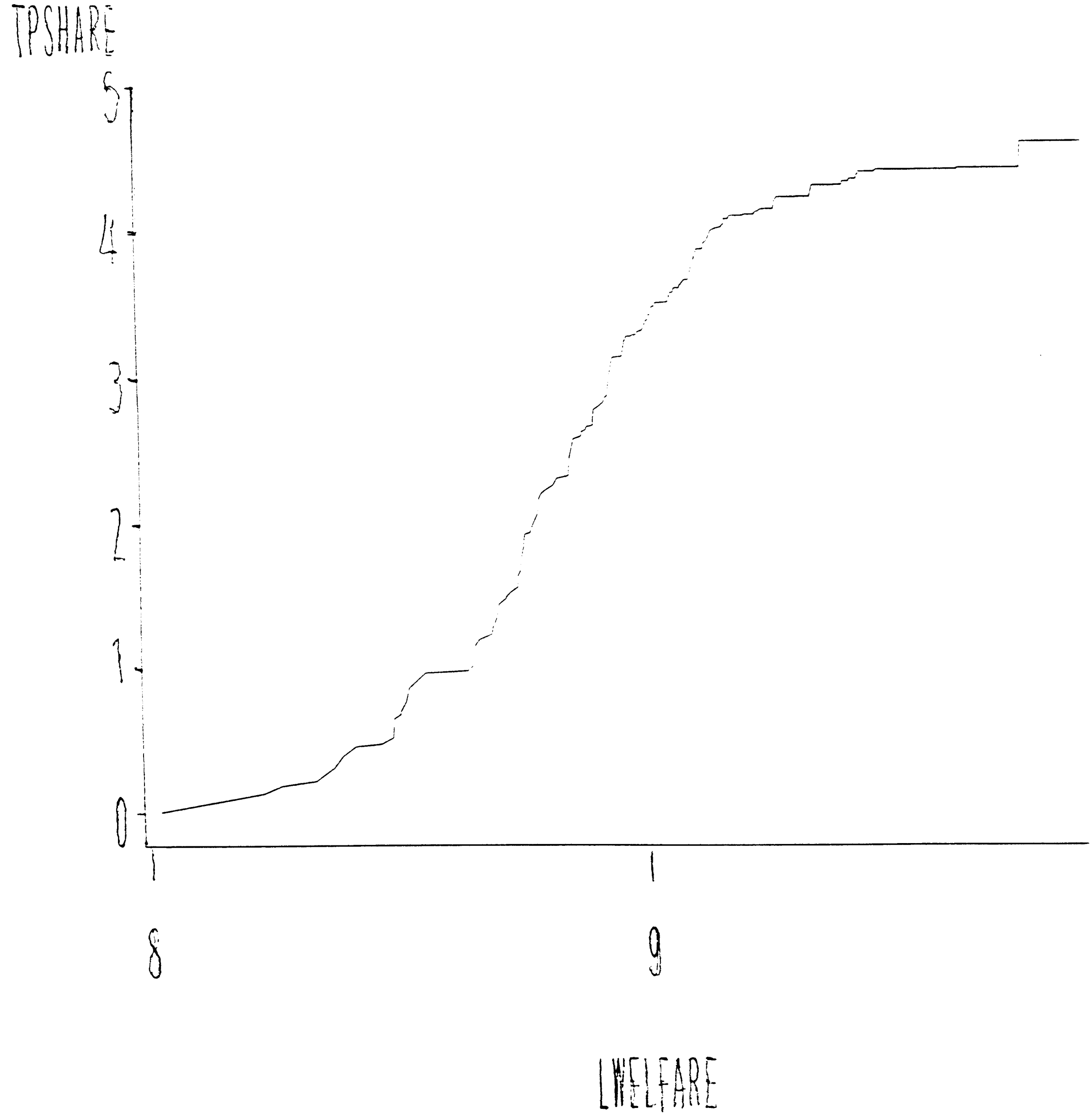
figure 1c: seasonal poverty curves



based on second equivalence scale (es2)

Figure 2: curve of transient poverty

cumuloted cacross log of chronic living standards



PT indicator calculated from FGT(2)
with per capita consumption and line z1