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Poverty, Vulnerability, and Reference Dependent Utility

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Abstract

In this paper we argue that the recent evidence on individuals' decision making is of high relevance for the measurement of poverty when switching from a static and certain to a dynamic and uncertain framework. The numerous proposed measures of multi-period poverty and vulnerability have until now not taken into account the insights from behavioural economics. Building on reference dependent utility models we propose a new measure of both (perceived) multi-period poverty and vulnerability, where the poverty status of an individual is not only a function of (expected) consumption levels but also of (expected) losses and gains in consumption. We demonstrate the implications of the proposed measures with a small illustrative example.

Keywords: multi-period poverty, vulnerability, reference dependent utility, prospect theory, loss aversions

JEL classification: D60, D81, I32

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Poverty, Vulnerability and Reference Dependent Utility *

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February 8, 2012

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In this paper we argue that the recent evidence on individuals' decision making is of high relevance for the measurement of poverty when switching from a static and certain to a dynamic and uncertain framework. The numerous proposed measures of multi-period poverty and vulnerability have until now not taken into accounts the insights from behavioral economics. Building on reference dependent utility models we propose a new measure of both (perceived) multi-period poverty and vulnerability, where the poverty status of an individual is not only a function of (expected) consumption levels but also of (expected) losses and gains in consumption. We demonstrate the implications of the proposed measures with a small illustrative example.

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‘An object at a given temperature may be experienced as hot or cold to the touch depending on the temperature to which one has adapted. The same principle applies to non-sensory attributes such as health, prestige, and wealth. The same level of wealth, for example, may imply abject poverty for one person and great riches for another – depending on their current assets.’

(Kahneman and Tversky, 1979: 277)

1 Introduction

In recent years, the research agenda on poverty in developing countries has not only moved beyond money-metric to multidimensional measures of poverty (e.g. Sen, 1985, 1999) but has also increasingly noticed the importance of moving from a static to a dynamic and from a certain to an uncertain framework of wellbeing. This research acknowledges (i) that the currently observed wellbeing of a given individual might not necessarily be a good proxy of his future and/or past wellbeing and (ii) that the notion of risk and uncertainty – which is particularly high in developing countries – should be incorporated into measures of poverty. This research has led to numerous definitions and measurements of vulnerability¹ - incorporating the notion of uncertainty - as well as multi-period poverty - incorporating the notion of time.²

Despite conceptual differences of existing vulnerability and multi-period poverty measures, most approaches are based on the classical framework of expected utility theory. This has long been the main positive and normative theory not only to analyze individual decision making but also to analyze individuals’ wellbeing. In the last years, the experimental findings from behavioral economics have, however, questioned that diminishing marginal utility can sufficiently describe observed decisions under certainty and uncertainty. To improve traditional models of decision making, expected utility theory has therefore long been complemented by the insights from behavioral economics, which might also provide a new perspective for poverty measures over time and under uncertainty. Dercon (2005, 2007) has already empha-

¹For an overview of the literature on vulnerability see e.g. Hoddinott and Quisumbing (2003).

²Empirical applications of vulnerability and multi-period poverty often lead to similar results, because past consumption experiences are used for both measures. Theoretically, however, vulnerability and multi-period poverty are distinct concepts. We therefore treat them separately throughout the paper.

sized that behavioral economics should very much enrich our understanding of poverty.

Kahneman and Tversky's (1979) prospect theory has become the most popular alternative to expected utility theory. Important features that distinguish it from expected utility theory, are 'reference dependence', 'loss aversion', 'diminishing sensitivity' and 'subjective decision weights'. Reference dependence refers to the fact that an individual's perception of any outcome does not only depend on the absolute evaluation of that outcome but also on the comparison of that outcome to a reference level. Loss aversion describes the phenomenon that individuals dislike losses to a specific reference level more than they like same sized gains to that reference level. Diminishing sensitivity means that the marginal utility of both, gains and losses, decreases with size. Last, subjective decision weights describe the tendency of people to perceive probabilities (i.e. risks) in a non-linear way.

Within the framework of prospect theory, especially reference dependence and loss aversion have been empirically verified in both industrialized and developing countries (e.g. Schechter, 2007; Harrison et al., 2009; Yesuf and Bluffstone, 2009). Moreover, reference dependence and loss aversion have been found for both, decisions under certainty - typically in trading goods experiments - (e.g. Kahneman, Knetsch and Thaler, 1990, 1991) and decisions under uncertainty - typically in experiments on choice over risky gambles - (e.g. Barberis, Huang and Thaler, 2006). In contrast, and especially for poor populations, there is only limited and mixed experimental evidence for diminishing sensitivity in losses (Gheysens and Günther, 2011) and subjective decision weights (Humphrey and Verschoor, 2004; Delavande et al., 2010). In addition, subjective decision weights are hard to capture in populations with a limited understanding of probabilities.

We argue that especially reference dependence and loss aversion might be interesting to incorporate in measures of poverty over time and uncertainty: First, most vulnerability measures are based on expected utility theory, either based on the idea that (positive) decision theory on risky gambles might reveal individuals' preferences towards risky consumption from which we can derive (normative) wellbeing measures; or, because desirable axioms for vulnerability analysis led to such measures.³ But if recent experimental studies have shown that preferences towards risky outcomes can be better explained

³The literature on vulnerability has followed both paths.

by reference dependent utility models than by expected utility theory, vulnerability measures might be extended with the insights from this latest evidence.

Second, loss aversion nicely captures the broad consensus of policy makers and researchers that vulnerability measures should be specifically concerned about the impact of downside risks on individuals' wellbeing. For example, the World Development Report (2000) states that 'vulnerability measures the resilience against a shock- the likelihood that a shock will result in a decline in wellbeing'. Calvo and Dercon (2005) define vulnerability as 'exposure to threats, to downside risks'. Similarly, when moving from a static poverty to a dynamic assessment of poverty, reference dependent utility theory can capture a recently proposed axiom for multi-period poverty (Bossert and D'Ambrosio, 2009): *path-dependency*. Reference dependent utility models provide an empirically validated framework how the *history* or *path* of consumption can be incorporated into dynamic poverty assessments. Different approaches how to incorporate consumption histories in multi-period poverty measures have been proposed by Calvo and Dercon (2007) and Bossert and D'Ambrosio (2009).

Last, there are some studies, which have already emphasized the role of references and losses for (perceived) individuals' wellbeing. For example Gilboa and Schmeidler (2001) and D'Ambrosio and Frick (2007) find that current subjective wellbeing is not only dependent on current income but also on past incomes. D'Ambrosio and Frick (2007) further find in a set of regressions, that a previous income loss has a 15 times larger (negative) impact than a previous income gain on a person's reported current wellbeing. Kanbur (2001) notes that the often observed difference in measured *decreases* in poverty (by economists) and perceived *increases* in poverty (by local NGOs) might be due to aggregate improvements in poverty, but with decreasing incomes for some groups. This phenomenon could be explained by loss aversion. Herrera et al.(2006) argue that the often observed difference between temporal measures of subjective and monetary poverty can partly be attributed to different aspiration levels and whether individuals' income is moving upward or downward. However, more research is certainly needed here.

Based on these different strands of literature and reasoning, in this paper we theoretically incorporate the experimental evidence on decision mak-

ing under certainty and uncertainty into poverty analysis to obtain a new and simple measure for multi-period poverty and vulnerability, respectively. The suggested measure of (perceived) multi-period poverty allows to incorporate path dependency, which seems particularly important when moving from a static to a dynamic framework. The proposed vulnerability measure will better reflect the negative impact of downside risks on individuals' (perceived) vulnerability. The proposed measures will be applied to various consumption trajectories and be compared with a sample of other recently proposed dynamic poverty and vulnerability measures (Jalan and Ravallion, 1998; Pritchett et al., 2000; Ligon and Schechter, 2003; Calvo and Dercon, 2005/2007; Foster, 2007).⁴

The paper is structured as follows. In Section 2 we give a brief description of the concept of multi-period poverty and vulnerability and of recently proposed approaches. Section 3 proposes new measures of multi-period poverty and vulnerability based on a reference dependent utility model, which will be illustrated in section 5. Section 4 discusses the properties of our new measures and relate them to other measures of multi-period poverty and vulnerability. Section 6 concludes and gives an outlook for further research.

2 Multi-Period Poverty and Vulnerability

Until very recently, poverty of households has typically been measured using cross-sectional data on consumption expenditures over some relatively short period of time. This static picture of poverty has been regarded as a proxy for the wellbeing of households. A household's observed poverty status, which is a one-time measure of a household's wellbeing, is, however, not a convincing approach to a household's longer-term wellbeing for two main reasons. First, the current consumption level might be a bad indicator of past or future consumption and hence poverty. Second, traditional poverty assessments do not provide much information about the role of risks and uncertainty on the welfare status of a household. It has, hence, been argued that it is critical to go beyond an assessment of who is currently poor to an

⁴In this paper we propose a measure of individual multi-period poverty and vulnerability and leave a discussion of an aggregate measure of poverty over time and under uncertainty incorporating reference dependence to other research (see e.g. Dutta et al., 2011; Jäntti et al., 2011). In other words, in this paper we are interested in the extent of multi-period poverty and vulnerability of certain individuals (or households) and not of a group of individuals (or households).

assessment of the poverty dynamics of households.⁵

Two separate, but indeed very closely related, strands of literature have therefore emerged: multi-period poverty and vulnerability. In contrast to static poverty measures, multi-period poverty measures incorporate a time dimension whereas vulnerability approaches aim to include the notion of future uncertainty into current poverty analysis. Since both concepts are rather new and have data requirements that go way beyond the data necessary to estimate static poverty, no consensus has yet emerged how to analyze multi-period poverty and vulnerability. In the following section, we will therefore briefly review the most cited multi-period poverty and vulnerability indices that have been proposed in the last few years.

2.1 Measures of Multi-Period Poverty

One of the first approaches to measure multi-period poverty are measures of chronic and transient poverty (e.g. Jalan and Ravallion, 1998; McKay and Lawson, 2003). By concentrating on historical consumption variability in and out of poverty those measures distinguish between the chronically poor and the transient poor. Two main measures have evolved: the ‘spells’ approach (e.g. McKay and Lawson, 2003) and the ‘component’ approach (e.g. Jalan and Ravallion, 1998).

The spells approach defines households as chronically poor who have always been poor, i.e. whose per capita household consumption has been below the poverty line in all observed points in time. The transient poor are those who have only temporarily been poor. In contrast, the component approach, being based on the Foster et al. (1984) measures of poverty (FGT), distinguishes permanent (average) consumption of a household from temporary variations in household consumption to derive a chronic and transient component of poverty. More formally, chronic poverty is defined as

$$P^C(x_1, x_2, \dots, x_T) = \left(\frac{z - \bar{x}}{z} \right)^\alpha \quad (1)$$

⁵Note that the welfare dynamics of the poor depend on two elements: the probability and severity of shocks and the strength of the insurance mechanisms against those shocks. If households had recourse to perfect insurance, e.g. could smooth consumption over time, it would be sufficient to measure static poverty. But several studies, with the studies by Townsend (1995) and Udry (1995) probably being the most prominent, have shown that households in developing countries are only imperfectly insured which leads not only to income but also to high consumption fluctuations.

where z is the poverty line, $\alpha > 1$ is a measure of ‘increasing cost of hardship’ (Calvo and Dercon, 2007) and \bar{x} is the mean of consumption over all observed time periods T .⁶ Total multi-period poverty is defined as

$$M_1(x_1, x_2, \dots, x_T) = \frac{1}{T} \sum_{t=1}^T \left(\frac{z - \tilde{x}_t}{z} \right)^\alpha \quad (2)$$

where \tilde{x}_t is consumption in time period t , with all consumption $x_t > z$ set equal to the poverty line z . Transient poverty is the difference between total multi-period poverty and chronic poverty:

$$P^T(x_1, x_2, \dots, x_T) = M_1(x_1, x_2, \dots, x_T) - P^C(x_1, x_2, \dots, x_T). \quad (3)$$

Foster (2007) and Calvo and Dercon (2007) have developed further measures of multi-period poverty, based on the Foster et al. (1984) measures of poverty but extended to a time dimension. Foster (2007) proposes

$$M_2(x_1, x_2, \dots, x_T, \beta) = \frac{1}{T} \sum_{t=1}^T \left(\frac{z - \tilde{x}_t}{z} \right)^\alpha * \mathbb{1}_{[(\sum_{t=1}^T \mathbb{1}_{\{x_t < z\}}) \geq \beta]} \quad (4)$$

where the first part is equivalent to the FGT (1984) measures of poverty (see also equation 2). Here α takes the value 0,1, or 2 with $\alpha = 0$ corresponding to the headcount poverty, $\alpha = 1$ to the poverty gap and $\alpha = 2$ to the poverty severity in a static dimension. The second term is an indicator function which takes the ‘time dimension’ into account, introducing a ‘duration line’ β in addition to a poverty line z . This term simply takes the value 1 whenever the household has been poor for more or equal than β periods of time, else the term takes the value 0 and the household is not considered as poor.

Calvo and Dercon (2007) suggest the following measure

$$M_3(x_1, x_2, \dots, x_T) = \frac{1}{T} \sum_{t=1}^T \beta^{T-t} \left(\frac{z - \tilde{x}_t}{z} \right)^\alpha \quad (5)$$

with $\alpha > 1$ being an indicator of ‘increasing cost of hardship’. $\beta > 0$ allows for some time-adjustment or in other words it represent an index that values present time spells less (if $\beta > 1$), equally (if $\beta = 1$) or more (if $0 < \beta < 1$) than past time spells. Calvo and Dercon (2007) do not conclude which β should be preferred, i.e. whether all poverty time periods should be weighted equally or if current or past time periods should be more emphasized.

⁶If $\bar{x} > z$, \bar{x} is set equal to the poverty line z .

2.2 Measures of Vulnerability

In contrast to multi-period poverty measures, which aim to analyze poverty over a past time horizon T , vulnerability measures aim to incorporate future consumption uncertainty into the wellbeing of individuals at time t .

The approach that has probably become most prominent is to define vulnerability as poverty risk (e.g. Pritchett et al., 2000; Chaudhuri, 2003). Here, vulnerability $V_1(x)$ is defined as the probability that a household's consumption lies below the poverty line. Assuming that consumption is log-normally distributed, the probability of a household to fall below the poverty line at any point in time can be estimated using the (expected) mean and variance of log consumption:

$$V_1(x) = P(\ln x < \ln z) = \Phi \left(\frac{\ln z - E(\ln x)}{\sqrt{E(\sigma_{\ln x}^2)}} \right) \quad (6)$$

where $\Phi(\cdot)$ denotes the cumulative density of the standard normal distribution function, z denotes the poverty line, $E(\ln x)$ the expected mean and $E(\sigma_{\ln x}^2)$ the expected variance of log consumption. Although intuitively easy to understand, as closely related to expected poverty measures, it ignores the potential downside impact of uncertainty on individuals' wellbeing. Moreover, this measure does not account for the magnitude of shortfalls below the poverty line (only for the general risk to fall below the poverty line). Small shortfalls below the poverty line are equally weighted than large shortfalls below the poverty line. An improvement of the above measure, which takes into account this last critique is Christiaensen and Subbarao (2005).

An alternative approach is to define vulnerability as low expected utility. In contrast to expected poverty, an utility framework explicitly takes into account the risk preferences of individuals and their impact on individuals' wellbeing. Expected utility theory states, that holding mean consumption constant, the utility of risk-averse individuals falls if the volatility of consumption prospects rises. Based on this utility function, Ligon and Schechter (2003) propose to measure vulnerability with reference to the utility derived from some level of certain-equivalent-consumption above which we would *not* consider households as vulnerable. We can then write vulnerability $V_2(x)$ as

$$V_2(x) = U(z) - EU(x) \quad (7)$$

where $U(z)$ is the utility derived from a certain-equivalent minimum consumption and the second term is the expected utility from consumption x . Note that z is analogous to the choice of a poverty line in poverty measures. The utility function $U(\cdot)$ is concave with $U'(\cdot) \geq 0$ and $U''(\cdot) \leq 0$. We can further decompose vulnerability $V_2(x)$ into

$$V_2(x) = [U(z) - U(Ex)] + [U(Ex) - EU(x)] \quad (8)$$

where $U(Ex)$ is the utility of expected consumption and $EU(x)$ the expected utility of consumption. The first part of equation (8) refers to poverty induced vulnerability, i.e. the vulnerability that is caused by low expected consumption levels, and the second part refers to risk induced vulnerability, i.e. the vulnerability that is caused by high income fluctuations. This decomposition emphasizes that the predicament of the poor is not only about insufficient consumption, but also about insecurity and risk.

Last, Calvo and Dercon (2005) have proposed to measure vulnerability as one minus the expected value of the ratio of a household's consumption to the poverty line with an exponent for risk aversion:

$$V_3(x) = 1 - E \left(\frac{\tilde{x}}{z} \right)^\alpha \quad (9)$$

where \tilde{x} is a random consumption variable, which is set equal to the poverty line z whenever its realization $x > z$, and α is a parameter of risk aversion with $0 < \alpha < 1$. $V_3(x)$ thus takes any value between 0 and 1. Whereas the approach of Calvo and Dercon (2005) is rather an axiomatic approach and the approach of Ligon and Schechter (2003) is explicitly based on an utility framework, both measures are built on expected utility theory.⁷ The major difference between the two measures is that Calvo and Dercon (2005) equalize any consumption above the poverty line z to the poverty line to focus on downside risks and Ligon and Schechter (2003) allow outcomes above the poverty line to compensate for consumption prospects below the poverty line.

Note that, in contrast to the previous discussed multi-period poverty measures, the time subscript t is missing for vulnerability measures. Whereas multi-period poverty measures analyze poverty over different *experienced time periods* $t = 1, 2, \dots, T$, measures of vulnerability analyze poverty over different *expected states* $i = 1, 2, \dots, I$.

⁷With $\alpha < 1$ as a parameter of risk aversion

The theoretical as well as empirical literature has not yet settled on a preferred measure to analyze multi-period poverty and/or vulnerability, although some preliminary research to compare the different approaches to measure multi-period poverty (Calvo and Dercon, 2007) and vulnerability (Hoddinott and Quisumbing, 2003; Calvo and Dercon, 2005) has recently been undertaken. We argue that it might be instructive to extend both concepts, multi-period poverty and vulnerability, with the insights from prospect theory especially with regard to reference dependence and loss aversion, which we will discuss in next section.

3 A New Measure of (Perceived) Multi-Period Poverty and Vulnerability

3.1 Reference Dependent Utility

Starting with Kahneman and Tversky's (1979) prospect theory, models of reference dependent utility have been extended and modified over the last decades. In the following we present the reference dependent model of Koszegi and Rabin (2006) that provides a utility function that incorporates both consumption levels and consumption changes. Reference-dependent utility (RU) for a consumption outcome $x \in \mathbb{R}^+$ and a reference level of consumption $r \in \mathbb{R}^+$ is given by:

$$RU(x, r) = m(x) + n(x|r) \quad (10)$$

Equation (10) states that the evaluation of a consumption outcome is based on an absolute (level) component (first part) and on a relative (gain-loss) component (second part), which is derived by comparing the consumption outcome to its reference level. The relative component in equation (10) is further defined by

$$n(x|r) = \mu [m(x) - m(r)]. \quad (11)$$

Setting $[m(x) - m(r)] = y \in \mathbb{R}$, $\mu : \mathbb{R} \rightarrow \mathbb{R}$ refers to the value function of Kahneman and Tversky (1979), which satisfies the following properties:

A 1 Differentiable with a Kink at the Reference Point:

$\mu'(y)$ and $\mu''(y)$ exist for $y \neq 0$. $\mu(0) = 0$.

A 2 Increasing:

$\mu'(y) \geq 0$ for $y \neq 0$.

A 3 Loss Aversion:

$\mu'(-y) \geq \mu'(y)$.

A 4 Diminishing Sensitivity:

$\mu''(y) < 0$ for $y > 0$ and $\mu''(y) > 0$ for $y < 0$.

A2 implies that consumption utility is increasing in x and decreasing in r . A3 suggests that the marginal disutility of a loss is strictly greater than the marginal utility of a comparable gain. A4 says that the marginal disutility decreases for larger losses and that the marginal utility decreases for larger gains. A1 specifies that the value function is non-differentiable if there is no consumption change in relation to the reference point, i.e. $x = r$.

3.2 A New Measure

Based on the reference dependent utility model described in section (3.1) we define multi-period poverty $M(\cdot)$ as one minus the relation between the utility the individual obtained out of his experienced consumption path over all time periods $t = 1, 2, \dots, T$ and the utility the individual would have had if he had consumed the consumption level of the poverty line z over all T time periods. This can be written as

$$M(x_1, x_2, \dots, x_T; r_1, r_2, \dots, r_T, z) = 1 - \frac{1}{T} \sum_{t=1}^T \frac{RU(x_t, r_t)}{RU(z, r_t)} \quad (12)$$

where x_1, x_2, \dots, x_T denotes a stream of past consumption, r_1, r_2, \dots, r_T a stream of past reference points, and z the poverty line. $M(\cdot)$ can be interpreted as perceived multi-period poverty over T time periods. We use the term *perceived* to denote that our measure is build on a utility function that is based on experimental and empirical evidence on individuals' preferences. Similarly, we can define the perceived vulnerability of an individual as

$$V(x_1, x_2, \dots, x_I; p_1, p_2, \dots, p_I, r, z) = 1 - \frac{\sum_{i=1}^I [p_i * RU(x_i, r)]}{RU(z, r)}. \quad (13)$$

where x_i denotes each possible future consumption prospect with probability p_i (with $p_i \in [0, 1]$ and $\sum_{i=1}^I p_i = 1$), and r the current reference point of an

individual, to which all future (risky) consumption prospects are compared to. The utility the individual derives out of the risky consumption outcome x in relation to his or her reference point r in relation to the utility from a certain future consumption level at the poverty line z provides us with a notion of perceived vulnerability.

Note that both measures are built on the same utility function. The difference is that $M(\cdot)$ is defined over T time periods whereas $V(\cdot)$ is defined over I prospects. Moreover, $M(\cdot)$ is calculated over different *observed* consumption outcomes x_1, x_2, \dots, x_T in the past, whereas $V(\cdot)$ is calculated over different *possible* consumption outcomes x_1, x_2, \dots, x_I of the future. Both measures $V(\cdot)$ and $M(\cdot)$ lie between 0 and 1, with 0 denoting no multi-period poverty or vulnerability, respectively.

We also need to specify the reference point which is crucial for all reference dependent utility functions. For multi-period poverty, we define the reference point as

$$r_t = x_{t-1} \quad (14)$$

for $t = 2, \dots, T$ and $r_1 = x_1$. This means that the reference point for consumption in point t is the consumption of the previous period $t - 1$. This kind of reference point has often been used in the literature because there is empirical and theoretical support for habit formation (and its psychological counterpart, adaptation level theory). It is argued that current consumption is compared to the pre-period's consumption level because individuals get used to a certain level of consumption over time. Hence, any change in consumption to that level is perceived as a gain or a loss. Although this assumption might be relaxed either by an aspiration level that is shaped by more than just one past period (Gilboa and Schmeidler, 2001) or by different strengths of reference point adaptation or habit formation, it is an assumption that has often been used within the framework of habit formation (see e.g. Easterlin, 2001; Rayo and Becker, 2007).⁸ For vulnerability we define the reference point as

$$r = x_0. \quad (15)$$

This means that the reference point for all future consumption prospects x_i is the current consumption level x_0 . In the wide literature on choice

⁸In addition, one could also think of a reference point that is not only intra- but also interdependent, i.e. among individuals within a reference group (Vendrik and Woltjer (2007)).

under uncertainty, it is argued that outcomes are either compared to a status quo level (Kahneman and Tversky, 1991; Benartzi and Thaler, 1995), hence $r = x_0$ or to one's expectations about that outcome. However, even if the reference point is the expectation about consumption outcomes, r might still be equal to x_0 . The reason is that either one expects to keep the status quo or because r is the mean of expected outcomes under uncertainty (see e.g. Loomes and Sugden, 1986). With the reference points being defined we can now rewrite equation (12) as

$$M(x_1, x_2, \dots, x_T, z) = 1 - \frac{1}{T} \sum_{t=1}^T \frac{RU(x_t, x_{t-1})}{RU(z, z)}. \quad (16)$$

The reference point for experienced consumption x_t at t is x_{t-1} . The reference point for an individual that had always consumed the consumption level of the poverty line z over all time periods T is $z_{t-1} = z_t = z$. The vulnerability measure $V(\cdot)$ of equation (13)) becomes

$$V(x_1, x_2, \dots, x_I; p_1, p_2, \dots, p_I, x_0, z) = 1 - \frac{\sum_{i=1}^I [p_i * RU(x_i, x_0)]}{RU(z, z)}. \quad (17)$$

The numerator in equation (17) denotes the expected reference dependent utility, where all possible consumption outcomes x_i are compared to the current consumption level of a person x_0 .

The advantage of these proposed multi-period poverty and vulnerability measures is that they are based on an empirically validated utility function and, that they explicitly take into account (i) path-dependency for multi-period poverty and (ii) the negative impact of downside risks for individuals' vulnerability.

3.3 Parameterization

In a next step we need to parameterize the utility function as outlined in Section 3.1. For the consumption level utility (see first part of equation 10), we propose

$$m(x) = x. \quad (18)$$

For the gain-loss utility (see second part of equation 10 and equation 11) we propose

$$n(x|r) = \mu(y) = \begin{cases} \lambda[y]^\alpha & \text{if } y \geq 0 \\ -2\lambda[-y]^\alpha & \text{if } y < 0 \end{cases} \quad (19)$$

with $y = [m(x) - m(r)] = [x - r]$. We further set $0 < \lambda \leq 1$ and $0 < \alpha < 1$, which fulfills the axioms specified in A1-A4 and allows for an easy interpretation of both the proposed multi-period poverty and the vulnerability measure. In line with the experimental literature, the negative impact of losses is twice as high as the positive impact of gains. λ refers to the weight we want to give to the gain-loss utility relative to consumption utility. If zero weight is given to the gain-loss utility, i.e. $\lambda = 0$, the proposed measure reduces to the average past (in case of multi-period poverty) or the expected future poverty gap (in case of vulnerability). Whenever we want to enter path dependency or loss aversion into a normative analysis of multi-period poverty or vulnerability, $\lambda > 0$ might be an interesting option. α is a measure for decreasing sensitivity to gains and losses.⁹ x , r and z are normalized to the poverty line z .

4 Properties

Before turning to a small empirical illustration, we would like to discuss some properties of the proposed measures.¹⁰ Multi-period poverty and vulnerability measures are a time and risk extension of poverty measures in a static and certain environment. We therefore relate the discussed properties to a set of axioms that are generally accepted for static poverty measures: monotonicity, scale invariance, anonymity, transfer sensitivity, and focus. In the following, we extend those axioms to a time dimension t (for multi-period poverty) and a risk dimension i (for vulnerability), so that the poverty measure becomes $M = M^T : \mathbb{R}^T \rightarrow \mathbb{R}$ and the vulnerability measure becomes $V = V^I : \mathbb{R}^I \rightarrow \mathbb{R}$ (see also Foster, 2007 and Calvo and Dercon, 2005 for comparison). As before $M^T(x)$ is measured over a span of T (past) time periods whereas $V^I(x)$ is measured over a range of I uncertain consumption outcomes. We start with a discussion of the properties of multi-period poverty

⁹Although initially Tversky and Kahneman (1992) distinguished between diminishing sensitivity for gains and losses, we assumed equal α for both, gains and losses. This seems appropriate because there is mixed evidence how the α for gains and losses differs (for a review of the evidence see Köbberling, Schwioren and Wakker, 2007).

¹⁰As before we refer to multi-period poverty and vulnerability of individuals and leave a discussion of aggregate multi-period poverty and vulnerability across entire populations for future research.

based on a reference dependent utility model, followed by a discussion of the properties of the proposed vulnerability measure.

4.1 Perceived Multi-Period Poverty

Note that x_t denotes a (past) consumption level at time t and z refers to the poverty line.

Monotonicity. For $\delta > 0$ and $t \in \{1, \dots, T\}$: $M^T(x_1, x_2, \dots, x_t + \delta, \dots, x_T) \leq M^T(x_1, x_2, \dots, x_t, \dots, x_T)$.

Monotonicity requires that an increase (decrease) in consumption in any time period leads to a decrease (increase) of poverty, which is fulfilled by our measure of multi-period poverty with $0 < \lambda \leq 1$ and $0 < \alpha < 1$.

Scale Invariance. For $\alpha, z \in \{\mathbb{R}\}$ and $t \in \{1, \dots, T\}$: $M^T[(x_1, x_2, \dots, x_T) | z] = M^T[(\alpha x_1, \alpha x_2, \dots, \alpha x_T) | \alpha z]$.

Scale invariance specifies that if both, the poverty line and consumption in every single time period, are scaled up or down by a certain factor, the measured multi-period poverty should not change. This property is fulfilled by the proposed measure, as consumption streams are normalized to the poverty line.

Anonymity. For $\delta > 0$ and $i, j \in \{1, \dots, T\}$: $x_i = x_j$: $M^T(x_1, x_2, \dots, x_i + \delta, \dots, x_T) = M^T(x_1, x_2, \dots, x_j + \delta, \dots, x_T)$.

Poverty measures are invariant to a permutation of consumption across persons. Similar, most multi-period poverty measures are invariant to a permutation of consumption across time periods.¹¹ A multi-period poverty measure based on a reference dependent utility model does NOT satisfy this property. Although we agree that it should not matter *which* person has a certain consumption level within a society, we think that it matters *when* a certain consumption level occurs for a specific person in a dynamic framework, reflecting path dependency.

Transfer Sensitivity. For $\delta > 0$ and $i, j \in \{1, \dots, T\}$: $x_i < x_j$: $M^T(x_1, x_2, \dots, x_T) < M^T(x_1, x_2, \dots, x_i - \delta, x_j + \delta, \dots, x_T)$. The transfer sensitivity specifies that whenever there is a transfer from a ‘poor’ time period to a ‘less poor’ time period, poverty should increase. A multi-period poverty measure based on reference dependent utility does NOT satisfy this property.

Focus. For $\delta > 0$ and $t \in \{1, \dots, T\}$: $x_t > z$: $M^T(x_1, x_2, \dots, x_t + \delta, \dots, x_T) = M^T(x_1, x_2, \dots, x_t, \dots, x_T)$.

¹¹The exception is Calvo and Dercon (2007).

The focus axiom requires that an increase (decrease) in consumption for *individuals* above the poverty line should not have an impact on the level of poverty within a society. Similar, Foster (2007) and Calvo and Dercon (2007) argue that an increase (decrease) in consumption in a *time period* where consumption is above the poverty line should not have an impact on the measured multi-period poverty of an individual. Our proposed measure of multi-period poverty does NOT satisfy this property. We argue that, whereas it is straightforward that the measured poverty level within a population should not be affected by the consumption status of the non-poor, the wellbeing of an individual over time should be affected by the consumption level in all poor and non-poor time periods.¹²

4.2 Perceived Vulnerability

x denotes future (and risky) consumption where x_i occurs with probability p_i in the i -th state of the world. z refers to the poverty line and r to the reference point.

Monotonicity. For $\delta > 0$ and $i \in \{1, \dots, I\}$: $V^I(x_1, x_2, \dots, x_i + \delta, \dots, x_I) \leq V^I(x_1, x_2, \dots, x_i, \dots, x_I)$.

Monotonicity requires that an increase (decrease) in consumption in any uncertain consumption possibility leads to a decrease (increase) of vulnerability. This is fulfilled by the proposed vulnerability measure, keeping the reference level $r = x_0$, i.e. constant at current consumption.

Scale Invariance. For $\alpha, z \in \{\mathbb{R}\}$ and $i \in \{1, \dots, I\}$: $V^I[(x_1, x_2, \dots, x_I) \mid z] = V^I[(\alpha x_1, \alpha x_2, \dots, \alpha x_I) \mid \alpha z]$.

Scale invariance specifies that if both, the poverty line and consumption in every single possible consumption outcome are scaled up or down by a certain factor, the measured vulnerability level should not change. This property is fulfilled because all consumption prospects are normalized to the poverty line.

Anonymity. For $\delta > 0$ and $i, j \in \{1, \dots, I\}$: $x_i = x_j$: $V^I(x_1, x_2, \dots, x_i + \delta, \dots, x_I) = V^I(x_1, x_2, \dots, x_j + \delta, \dots, x_I)$.

For static poverty measures anonymity means that for the analysis of poverty it does not matter which person has a certain consumption level. In other

¹²After aggregating the consumption of individuals over various time periods, we still think that overall non-poor households cannot compensate for poor households, and we propose to set their poverty status to 0 to maintain the focus axiom for aggregate multi-period poverty.

words poverty is not sensitive to permutations of personal labels. For vulnerability measures anonymity indicates that it does not matter why a certain consumption prospect might occur. Our measure of perceived vulnerability satisfies this property: Changes in vulnerability can only be caused by an increase/decrease of certain consumption prospects (or probabilities).

Transfer/Risk Sensitivity. For $\delta > 0$ and $i, j \in \{1, \dots, I\}$ with $x_i < x_j$: If $x_i < r$ and $x_j < r$: $V^I(x_1, x_2, \dots, x_I) > V^I(x_1, x_2, \dots, x_i - \delta, x_j + \delta, \dots, x_I)$, otherwise: $V^I(x_1, x_2, \dots, x_I) < V^I(x_1, x_2, \dots, x_i - \delta, x_j + \delta, \dots, x_I)$.

Transfer sensitivity specifies that whenever there is a transfer from a ‘poor’ person to a ‘less poor’ person, poverty should increase. In a vulnerability framework, this means that vulnerability increases if the expected volatility of consumption increases, holding expected mean consumption constant. Hence in a vulnerability framework transfer sensitivity is actually *risk sensitivity*. For our measure this is the case whenever there is a transfer from a consumption prospect above (below) the reference level to a consumption prospect below (above) the reference level or whenever there is a transfer within the gain domain. Within losses we see the reverse pattern, i.e. transfers from ‘rich’ to ‘poor’ consumption prospects increase vulnerability because of the diminishing sensitivity property of prospect theory (see Axiom A4).

Focus. For $\delta > 0$ and $i \in \{1, \dots, I\}$: $x_i > z$: $V^I(x_1, x_2, \dots, x_i + \delta, \dots, x_I) = V^I(x_1, x_2, \dots, x_i, \dots, x_I)$.

The focus axiom requires that an increase (decrease) in consumption for *individuals* above the poverty line should not have an impact on the level of poverty within a society. Similar, an increase (decrease) in consumption in a *risky state of the world* where consumption is above the poverty line should not have an impact on the measured vulnerability of an individual. In line with the argument for multi-period poverty, we think that individuals’ vulnerability should be affected by the consumption level in all poor and non-poor states, i.e. non-poor consumption prospects can compensate for poor prospects. The proposed vulnerability measure does hence NOT satisfy the focus property.¹³

Table 1 gives an overview of the discussed multi-period poverty and vulnerability measures and the properties they satisfy. Apart from the con-

¹³Again, we think that non-vulnerable individuals cannot compensate for vulnerable individuals. Hence, across populations the focus axiom should still hold.

Table 1: Properties of Poverty and Vulnerability Measures

	Monotonicity	Scale	Anonymity	Transfer	Focus	Path	Reference
Multi-period Poverty Measures							
Jalan and Ravallion (1998)	Yes	Yes	Yes	Yes/No*	Yes	No	–
Foster (2007)	Yes/No**	Yes	Yes	Yes/No*	Yes	No	–
Calvo and Dercon (2007)	Yes	Yes	No	Yes	Yes	Yes	–
Günther and Maier (2011)	Yes	Yes	No	No	No	Yes	–
Vulnerability Measures							
Pritchett et al. (2000)	Yes	Yes	Yes	No	No	–	No
Ligon and Schechter (2003)	Yes	Yes	Yes	Yes	No	–	No
Calvo and Dercon (2005)	Yes	Yes	Yes	Yes	Yes	–	No
Günther and Maier (2011)	Yes	Yes	Yes	Partly	No	–	Yes

Notes: *Transfer sensitivity is only given for $\alpha = 2$. **Monotonicity is only given for $\beta = 1$.

ventional poverty axioms we add the properties path-dependency for multi-period poverty and reference dependence for vulnerability measures (last two columns). Note that all measures fulfill scale invariance and monotonicity. Transfer sensitivity is satisfied by almost all measures: for Foster (2007) and Jalan and Ravallion (1998) depending on the parameterization of α . In contrast, diminishing sensitivity in losses (see Axiom A4) leads to a rejection of transfer sensitivity. Given that the empirical evidence on diminishing sensitivity in losses is still very limited for poor settings, future empirical and/or experimental research is certainly needed here. Apart from our measure, path dependency is only considered by Calvo and Dercon (2007), who introduce a discounting factor over time. None of the vulnerability measures (except ours) applies an individual (relative) reference line, i.e. takes into account downside risks. All of the presented measures rely on an average (absolute) reference line, i.e. the poverty line.

5 Empirical Application

5.1 Multi-Period Poverty

In a first step we apply the proposed measure of (perceived) multi-period poverty to various consumption paths over time and also compare it with other recently proposed measures of multi-period poverty. Table 2 shows

illustrative consumption trajectories for six households over a four years time period. The consumption paths are normalized to the poverty line z , so that z is equal to 100 and consumption levels can be read as a percentage of the poverty line.

Table 2: Consumption History Matrix

	year x_1	year x_2	year x_3	year x_4	\bar{x}	SD(x)
HH 1	60	70	80	90	75	12.9
HH 2	120	90	90	70	92.5	20.6
HH 3	80	80	80	80	80	0
HH 4	90	70	90	70	80	11.5
HH 5	150	120	80	60	102.5	40.3
HH 6	60	80	100	120	90	25.8

Notes: year x_1 - year x_4 denote yearly per capita consumption. SD denotes standard deviation. HH denotes household.

Household 1 shows the lowest mean in consumption, but is on an increasing consumption path. Household 2 and household 6 have a very similar mean and variance in consumption, but household 2 is on a decreasing and household 6 on an increasing consumption path. Moreover, household 2 has been below the poverty line more often. Household 3 and 4 have very similar mean consumption levels (and lower than household 2 and 6), but the variance in consumption is significantly higher for household 4. Household 5 shows the highest mean in consumption. However, this higher mean is mostly driven by consumption levels above the poverty line.

The upper panel of Table 3 displays the numerical results of the various proposed measures of multi-period poverty. For each measure, the first three rows display the parameterizations for α (transfer sensitivity), β (time sensitivity), and λ (path dependency). Note that besides our proposed measure of reference dependent multi-period poverty, also Foster (2007) and Calvo and Dercon (2007) incorporate a measure of ‘time’. Foster (2007) specifies a ‘duration line’, which indicates the least number of time spells a household has to be below the poverty line to be considered poor (in this example 3). Calvo and Dercon (2007) apply a ‘time multiplier’ that either gives more weight to current ($\beta < 1$) or past ($\beta > 1$) time spells. Applying a utility function that incorporates loss aversion to multi-period poverty leads to an even

Table 3: Multi-Period Poverty Measures Applied

	Jalan/Ravallion	Foster	Calvo/Dercon	Günther/Maier
α	–	1.2	1.2	0.8
β	–	3	0.8	–
λ	–	–	–	1
HH1	0.19	0.19	0.13	0.20
HH2	0.09	0.09	0.08	0.21
HH3	0.14	0.14	0.11	0.20
HH4	0.15	0.15	0.12	0.28
HH5	0.12	0.00	0.11	0.20
HH6	0.12	0.00	0.07	0.02
HH1	1	1	1	3
HH2	6	4	5	2
HH3	3	3	4	5
HH4	2	2	2	1
HH5	4	5	3	4
HH6	4	5	6	6

stronger version of ‘time sensitivity’, i.e. to path dependency. The magnitude of all measures is quite similar, as they are all based on variations of the FGT1 measure of poverty (Foster et al., 1984).

Based on the numerical results of the upper panel of Table 3, the ranking from the poorest (1) to the wealthiest (6) household over time is shown for each measure in the lower panel of Table 3. This ranking differs considerably across the analyzed measures. Foster (2007) and Jalan and Ravallion (1998) show very similar results. The major difference is that Foster (2007) is very sensitive to the specified duration line, so that Foster (2007) comes to the conclusion that household 2 is poorer than household 5 and 6, which are both non-poor, whereas household 2 is wealthier (but still poor) than household 5 and 6 according to Jalan and Ravallion (1998).

Except the measure of Calvo and Dercon (2007) with $\beta \neq 1$, none of the existing measures incorporates the notion of path-dependency, i.e. makes a difference between increasing and decreasing income trajectories. Thus, Foster (2007) and Jalan and Ravallion (1998) consider household 5 and 6 as equally poor, whereas Calvo and Dercon (2007) and our measure evaluate household 5 significantly poorer than household 6, because household 5 is

on a decreasing consumption path. Our measure of path-dependency is even stronger: we rank household 1 higher (i.e. less poor) than all other measures. Even if household 1 has the lowest mean consumption it is on a strong increasing consumption path. Our measure is also the only one that considers household 2 much poorer than household 3. Household 2 has a significantly higher mean consumption (and is above the poverty line at one point in time); it shows, however, a highly fluctuating and decreasing consumption path, whereas consumption of household 3 is very stable over time.

In section 4.1 we further argued that applying a focus axiom in a dynamic framework might be problematic. Comparing household 2 and household 5 in Table 3, we see that all existing multi-period poverty measures consider household 5 poorer than household 2, although household 5 has a significant higher mean in consumption. A strong focus axiom does, however, not pay any attention to consumption levels above the poverty line, which are significantly higher for household 5 than for household 2. In contrast, our measure suggests that household 2 is poorer than household 5.

5.2 Vulnerability

Similar to the previous section, we apply the proposed new measure of (perceived) vulnerability to various future consumption prospects and compare it with other recently proposed measures of vulnerability. Table 4 shows four per capita consumption prospects x_1, x_2, x_3, x_4 (for simplicity each consumption prospect has a probability of 0.25) for six households. In addition, current consumption x_0 - i.e. the reference point - of each household is stated. Consumption is normalized to the poverty line z , so that z is equal to 100 and consumption levels can be read as a percentage of the poverty line.

Table 5 displays the numerical results of existing as well as of our proposed measure of vulnerability. For each measure, the first row displays the parameterizations for α , i.e. the magnitude of risk-aversion. Hence, α specifies the sensitivity of the vulnerability measure to a transfer from a ‘poor’ prospect to a ‘less poor’ prospect. λ is only relevant for our proposed measure. It indicates the weight given to changes in consumption relative to absolute consumption levels.

The interpretation of the numerical values in Table 5 is only possible for the measure of Pritchett et al. (2000) and - to some extent - for our

Table 4: Consumption Prospect Matrix

	$r = x_0$	state x_1	state x_2	state x_3	state x_4	E(x)	SD(x)
HH 1	70	75	80	80	85	80	4.08
HH 2	100	70	80	80	90	80	8.16
HH 3	130	110	100	110	100	105	5.77
HH 4	100	70	60	130	130	97.5	37.74
HH 5	100	80	90	90	80	85	5.77
HH 6	60	100	70	70	100	85	17.32

Notes: $r = x_0$ denotes reference consumption, i.e current consumption. state x_1 - state x_4 denote possible future consumption prospects with probability $p_1 = p_2 = p_3 = p_4 = 0.25$. SD denotes standard deviation. HH denotes household.

Table 5: Vulnerability Measures Applied

	Pritchett et al.	Ligon/Schechter	Calvo/Dercon	Günther/Maier
α	–	0.5	0.5	0.5
λ	–	–	–	1
HH 1	1.00	1.06	0.11	0.17
HH 2	0.99	1.06	0.11	0.29
HH 3	0.19	0.00	0.00	0.05
HH 4	0.58	0.27	0.10	0.06
HH 5	0.99	0.78	0.08	0.22
HH 6	0.81	0.82	0.08	0.10
HH 1	1	2	2	3
HH 2	2	1	1	1
HH 3	6	6	6	6
HH 4	5	5	3	5
HH 5	3	4	5	2
HH 6	4	3	4	4

measure. Pritchett et al. (2000) measures the probability to fall below the poverty line. Our measure can be interpreted within the framework of the expected poverty gap (where consumption prospects $x_i > z$ are *not* set equal to the poverty line z) - with the addition that possible losses (gains) in consumption - measured relative to current consumption - increase (decrease) the expected poverty gap. The expected poverty gap is equal to our measure if we set $\alpha=1$ (no risk sensitivity) and $\lambda=0$ (no weight is given to changes in consumption). The numerical value of Calvo and Dercon (2005) does not

allow for a direct interpretation - with the exception that the measure varies between 0 (no vulnerability) and 1 (full vulnerability). The measure of Ligon and Schechter (2003) is not bound to any values.

For better comparison, for each measure the ranking from the most vulnerable (1) to the least vulnerable (6) household is shown in the second panel of Table 5. The first observation is that different measures do not agree on the ranking of individual households - even if we exclude our newly proposed vulnerability measure. Assuming that vulnerability measures should be sensitive to risk-aversion, we would expect that all measures show that household 2 is more vulnerable than household 1. Household 2 shows the same expected mean but twice the expected variance in consumption (see Table 4). However, the measures of Pritchett et al. (2000) suggests that household 1 is more vulnerable than household 2.¹⁴ In contrast, all other measures (including ours) suggest that household 2 is more vulnerable than household 1.

Calvo and Dercon's (2005) ranking differs in the sense that household 4 is much more vulnerable than indicated by all the competing measures. The reason is that Calvo and Dercon (2005) apply the focus axiom to individual consumption prospects. This means that any consumption prospect above the poverty line does not decrease the vulnerability of a household. Other measures assume that compensation for low consumption prospects is possible through high consumption prospects.

The most striking point about a vulnerability measure based on reference dependent utility and loss aversion is that household 1 is less vulnerable than household 5, contradicting all other measures. Household 1 shows a lower expected mean in consumption and an equal variance in consumption than household 5. But household 1 faces a risky gain in consumption whereas household 5 faces a risky loss in consumption - in relation to current consumption. All existing vulnerability measures assume that only the expected *level* and *variance* of consumption are of relevance for vulnerability, and do not explicitly take into account downside risks. Our measure - being based on a theory of (internal) reference dependence - also takes into account the expected *change* in consumption (relative to current levels of consumption),

¹⁴Poverty risk, as proposed by Pritchett et al. (2000), implies higher vulnerability with lower expected variance in consumption if the expected mean of consumption lies below the poverty line: in this case higher variance in consumption means a higher probability of escaping poverty.

where expected losses have an additional (negative) impact on measured vulnerability. This also leads to the fact that our measure (in contrast to all other measures) considers household 3 as vulnerable even though all possible future consumption prospects lie above or at the poverty line: the household faces a risky loss and is close to the poverty line.

6 Critical Discussion and Further Research

In this paper we suggest that the insights from behavioral economics might enrich existing measures of poverty over time and under uncertainty. We base our new proposed measure on a reference dependent utility model that incorporates the biggest behavioral phenomena found for decisions under certainty and uncertainty: loss aversion (implying reference dependence). The objective of this paper is not to propose an ultimate new measure of multi-period poverty and vulnerability. Rather, we try to show that instead of using a concave function for the measurement of expected and experienced utility it might be interesting to apply a S-shaped value function with a kink at the reference point.

Such a function provides alternative measures that are not based on a framework that has been invalidated by various economic experiments: the classical expected utility theory. We think that it is reasonable to extend individual wellbeing measures with the insights from behavioral economics if they have shown to influence the utility of individuals in a systematic way. Only if the downside impact of (certain and uncertain) consumption losses on current and life-time individuals' wellbeing is properly understood, are reasonable policy recommendations – e.g. with regard to insurance mechanisms – possible. That being said, three critical points need to be discussed here:

Since the model we use (Koszegi and Rabin, 2006) has originally been modeled for choice under certainty and uncertainty, for our measure of multi-period poverty we implicitly assume that decision utility equals experienced utility. Although we note that this is a strong assumption, 'economists tend to assume that decision utility and experienced utility are the same' (East-erlin, 2001). But more empirical evidence like the study by D'Ambrosio and Frick (2007) would certainly be needed.

Second, one might argue that multi-period poverty and vulnerability should be analyzed in absolute and not in relative terms. We think that

if we measure wellbeing over time, single periods in time cannot be analyzed in isolation of other periods, i.e. neglecting history. Otherwise we just have a measure of accumulated static poverty instead of a dynamic poverty measure. The concept of vulnerability is explicitly concerned with the exposure to ‘downside risks’ (Calvo and Dercon, 2005). Switching from a certain to an uncertain framework, it seems, hence, reasonable that measures do not only evaluate (possible) poverty outcomes but also (possible) consumption changes. Moreover, losses should be given a higher weight than gains.

Last, the data requirements for multi-period poverty, but especially for vulnerability, are currently not being met by most developing countries. For an empirical analysis of poverty over time and under uncertainty, besides a further development of measures, there is an urgent need to increase the availability of long-term panel data.

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