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Poverty, Vulnerability and Loss Aversion

Isabel Guenther and Johannes Maier

For additional information please contact:

Name: Isabel Günther
Affiliation: University of Göttingen

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Isabel Günther
University of Göttingen

Johannes Maier
University of Munich

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Abstract

The numerous proposed measures of multi-period poverty and vulnerability have until now ignored the literature on experimental and behavioral economics. We argue that especially the insights from prospect theory on loss aversion are of high relevance for the measurement of welfare when switching from a static (certain) to a dynamic (uncertain) framework. Building on the reference dependent models of Koszegi and Rabin (2006, 2007) we propose a new measure of both, multi-period poverty and vulnerability, where the wellbeing of an individual is not only a function of (possible) consumption levels but also of (possible) losses and gains in consumption. We demonstrate the implications of our proposed measure with a small illustrative example.

***JEL* Classification:** D60, D81, I32.

Key words: Multi-Period Poverty, Vulnerability, Reference Dependent Utility, Prospect Theory, Loss Aversion.

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1 Introduction

In recent years, the research agenda on poverty in developing countries has not only moved beyond money-metric to multidimensional measurements of poverty but also beyond static assessments of poverty, considering dynamic aspects of poverty. This research acknowledges (i) that the currently observed wellbeing of a given individual might not necessarily be a good approximate of his wellbeing over time as well as (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 multi-period poverty (incorporating the notion of time) as well as vulnerability (incorporating the notion of uncertainty).[1] However, there are shortcomings that are present to all of the measures in these two lines of research.

Although multi-period poverty assesses poverty over time, the notion of *path dependency* has so far been disregarded in the literature. This means that holding consumption in each period constant, but changing the order of appearance should therefore not affect multi-period poverty. In this sense, existing measures are e.g. invariant to the fact whether one is on an increasing or decreasing consumption path. But when moving from a static to a dynamic setting, we rather propose a multi-period measure that is not only a summary of the statics but also allows for interdependencies between the periods.

Vulnerability assesses how vulnerable an individual is depending on the uncertain environment she faces. Despite differences in the risk sensitivity of existing vulnerability measures, most are based on the classical framework of expected utility theory going back to Bernoulli (1738) and Cramer (1728). This has long been the main positive and normative theory not only to analyze individual decision making under risk but also to analyze individual welfare under risk. The underlying assumption is that individual's economic decision making reveal certain preferences, which can also help to determine the welfare of individuals. But what if expected utility theory is not the way people make decisions? When moving from a certain to an uncertain

[1] In applications vulnerability and multi-period poverty measures are fairly identical, since ... SCHREIB DAS DU FERTIG. Theoretically, however, they are quite distinct and build on different economic concepts. We therefore treat them separately throughout the paper. For an overview of the literature on vulnerability see e.g. Hoddinott and Quisumbing, 2003

environment, it becomes particularly important how uncertainty is perceived by individuals, since this is where expected utility theory is also based on.

In decision theory, expected utility theory has long been complemented by the findings from behavioral economics, using the results from various economic experiments to enrich traditional models of decision making. Just as well, these insights might be of high relevance for the measurement of welfare. Indeed, several authors have analyzed the impact of behavioral phenomena on social choice as well as social welfare (see Bernheim and Rangel, 2007 for an overview). In contrast, individual welfare measures have so far ignored the evidence of behavioral economics. However, Dercon, who has a long research-record on vulnerability, has recently emphasized that behavioral economics should very much enrich our measures and analysis of vulnerability (Dercon 2005, 2007).

Kahneman and Tversky's (1979) prospect theory has become *the* alternative to expected utility theory in recent years. Features that distinguish it from expected utility theory are 'reference dependency', 'loss aversion', 'diminishing sensitivity' and 'subjective decision weights'. Reference dependency refers to the fact that outcomes (i.e. consumption) are evaluated as gains and losses with regard to a reference level. Loss aversion captures the experimental evidence that losses have a higher impact on well-being than corresponding gains. 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.

However, reference dependency, loss aversion and diminishing sensitivity have not only been applied in uncertain environments, but also in deterministic models. These issues seem also most relevant for dynamic *and* risk-sensitive welfare measures.[2] In this paper we will use the reference-dependent models of Koszegi and Rabin (2006, 2007) and apply them in order to derive a new measure of perceived multi-period poverty and perceived vulnerability. For multi-period poverty this new measure allows to incorporate path dependency, which seems particularly important when moving from a static to a dynamic framework. When moving from a certain to an uncertain environment, these behavioral features also enrich the measurement of vulnerability

[2]We disregard subjective decision weights, because it is not clear to what extent it should be used for welfare measures.

since they reflect the way people make decisions.

Hence, in this paper we will first theoretically incorporate the experimental evidence on decision making under certainty and uncertainty – namely reference dependency, loss aversion and diminishing sensitivity – into a multi-period poverty as well as vulnerability measure. In a second step, the proposed measure will be applied to various consumption trajectories and compared with other recently proposed multi-period and vulnerability measures of Jalan and Ravallion (1998), Pritchett et al. (2000), McKay and Lawson (2003), Ligon and Schechter (2003), Calvo and Dercon (2006) and Foster (2006).

The paper is structured as follows. In Section **??** we give a brief description of the concept of multi-period poverty and vulnerability as well as recently proposed measures. Section **??** gives a short introduction and literature review into loss aversion and the closely related concepts of reference dependency and diminishing sensitivity. In Section **??** the two strands of literature are brought together in order to propose a new measure of multi-period poverty and vulnerability. These new measures will be illustrated in section **??**. Moreover, section **??** discuss the properties of our new measure and relates it to the other recently proposed measures. Section **??** concludes and gives an outlook into further research.

2 Multi-Period Poverty and Vulnerability

Until very recently, poverty of households has typically been measured using cross-sectional data on consumption expenditure over some relatively short period of time. This static picture of poverty has been regarded as a proxy for the well-being of households. A household's observed poverty level *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 lifetime consumption or poverty. Second, traditional poverty assessments do not provide much information about the role of risks and uncertainty – and the consumption fluctuations linked with it – 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 assessment of the welfare dynamics

of the poor.[3]

Here two separate, but indeed very closely related, strands of literature have emerged: multi-period poverty and vulnerability. In contrast to static poverty measures, multi-period poverty measures incorporate a time dimension whereas vulnerability aim to include the notion of uncertainty into poverty analysis. As both concepts are rather new, they are not yet well defined and in the last few years there have been various proposals on how to measure multi-period poverty and vulnerability, which will briefly be discussed in the following section.

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, Greer and Thorbecke (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 $P^C(x_t)$ is defined as

$$P^C(x_1, x_2, ..., x_T) = \left(\frac{z - \bar{x_t}}{z}\right)^{\alpha} \tag{1}$$

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

[3] Note 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 (1994), Deaton (1997), and Udry (1995) probably being the most prominent, have shown that households in developing countries are only imperfectly insured leading not only to income but also to consumption fluctuations.

time periods T. Total multi-period poverty is defined as

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

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 $P^T(x_t)$ is then the difference between total multi-period poverty and chronic poverty:

$$P^T(x_1, x_2, ..., x_T) = M_1(x_1, x_2, ..., x_T) - P^C(x_1, x_2, ..., x_T) \tag{3}$$

Hence, whereas the spells approach classifies households as either chronic poor or transient poor the component approach calculates the chronic and transient component of households' poverty.

Foster (2006) and Calvo and Dercon (2007) have only recently developed a further measure of multi-period poverty, again being based on the FGT (1984) measures of poverty but extended by a time dimension. Foster (2006) proposes

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

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 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.

Last Calvo and Dercon (2007) suggest the following measure:

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

again 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 more (if $\beta > 1$), equally (if $\beta = 1$) or less (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.[4]

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 try to incorporate the notion of risk and rather measure the vulnerability of future wellbeing at a certain point in time t. Here, in all so far proposed measures it is implicitly assumed that the vulnerability of a household does not change over time (see discussion below).

The approach that has probably become most prominent is to define vulnerability as poverty risk (e.g. Pritchett et al., 2000; Chaudhuri et al., 2002). 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 (historically observed) mean and variance of log consumption:

$$V_1(x) = P(\ln x < \ln z) = \Phi\left(\frac{\ln z - \ln \bar{x}}{\sqrt{\sigma^2_{\ln x}}}\right) \tag{6}$$

where $\Phi(\cdot)$ denotes the cumulative density of the standard normal distribution function, z denotes the poverty line, $\ln \bar{x}$ the mean and $\sigma^2_{\ln x}$ the variance of log consumption.

An alternative approach is to define vulnerability as low expected utility. Here, holding mean consumption constant, the utility of risk-averse individuals falls if the volatility of consumption 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

$$V_2(x) = U(z) - EU(x) \tag{7}$$

where $U(z)$ is the utility derived from a certain-equivalent minimum consumption and the second term is the expected utility from consumption x.

[4] Calvo and Dercon (2007) also propose some other measures of multi-period poverty, however they strongly argue for the one presented here.

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

$$V_2(x) = \overbrace{[U(z) - U(Ex)]}^{poverty\ induced} + \overbrace{[U(Ex) - EU(x)]}^{risk\ induced} \tag{8}$$

where $U(Ex)$ is the utility of expected consumption and $EU(x)$ the expected utility of consumption. The first part of equation (**??**) refers to the poverty induced vulnerability, i.e. the vulnerability that is caused by low expected consumption levels, and the second part refers to the 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 recently 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:

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

where $\tilde{x}$ is consumption, which is set equal to the poverty line z whenever $x > z$, and α is a parameter of risk aversion with $0 \leq \alpha \leq 1$. $V_3(x)$ thus takes any value between 0 and 1.

Note that in contrast to the previous discussed multi-period poverty measures the time subscript t is missing in vulnerability measures. Rather than measuring poverty over different time periods $t = 1, 2, ..., T$ (as multi-period poverty measures do) vulnerability is a measure of poverty over different expected states $i = 1, 2, ..., I$. However, in the empirical applications of vulnerability measures expected estates usually have to be approximated with empirically observed past outcomes, such that x in equation ??-?? is also estimated via $x_1, x_2, ..., x_T$.

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. Nor have there been attempts to bring the closely related concepts together. We argue that it might be instructive to extend

both, multi-period poverty and vulnerability measures, with the insights from prospect theory especially with regard to loss aversion, which will be discussed in next section.

3 The Concept of Loss Aversion

'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 asset.' (Kahneman and Tversky, 1979 p.277)

It seems quite intuitive 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, which is usually referred to as *reference dependency*. Moreover, within the framework of reference dependency *loss aversion* has been found particularly relevant in both experimental studies on decision utility as well as in empirical studies on experienced utility (see discussion below). 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.

When considering multi-period poverty, this concept becomes particularly important as people change these reference levels according to their changes in consumption. With changing reference levels, similar outcomes might be evaluated differently depending on the reference level or past consumption patterns. In this sense, the *history* or *path* becomes particularly important for the evaluation of an outcome (e.g. Bowman, Minehart and Rabin, 1999 use that insight in a consumption-savings model). So, when moving from a static to a dynamic assessment, reference levels individually start to change depending on past individual consumption patterns and thereby making reference dependency particularly important.

With regard to vulnerability, this concept becomes important as it has long been recognized as alternative explanation for attitudes towards risk. Several recent studies (among them Schmidt and Traub, 2002; Brooks and Zank, 2005; Abdellaoui, Bleichrodt and Paraschiv, 2005) concluded that most individuals can be characterized as loss averse and not as classical expected utility maximizers. If preferences towards risky outcomes (i.e. lotter-

ies in experimental settings) can indeed be better explained by a framework of prospect theory[5] than by expected utility theory, it is self-explanatory why vulnerability measures should also be extended by such a concept.

In the following we give a short literature review on loss aversion, before we show how loss aversion can be modeled within a framework of reference dependent utility.

3.1 Evidence on Loss Aversion

The evidence on loss aversion can be broadly divided into experimental evidence on decision utility and empirical evidence on experienced utility, with a strong emphasis on the former. Within decision utility, loss aversion has been found for both, decisions under certainty (typically in trading goods experiments involving mugs, pens or chocolate bars, e.g. Kahneman, Knetsch and Thaler, 1990, 1991; Bateman et al., 1997) and decisions under uncertainty (typically in experiments on choice over risky gambles, e.g. Barberis, Huang and Thaler, 2005).

For decisions under certainty, the findings helped to explain phenomena like the endowment effect (Thaler, 1980), status quo bias (Samuelson and Zeckhauser, 1988) or the willingness to accept–willingness to pay–gap commonly observed in contingent valuation studies (for an overview see Horowitz and McConell, 2002; Plott and Zeiler, 2005). For decisions under uncertainty, experimental findings and Rabin's (2000) calibration theorem showed that classical expected utility theory (i.e. only risk aversion) is unable to explain the risk people are actually averse to. He showed that the degrees of risk aversion typically observed in choice experiments over small and moderate stakes imply unreasonable high degrees of risk aversion over large stakes within the expected utility framework and that loss aversion can explain this pattern (see also Rabin and Thaler, 2001).

The above mentioned evidence shows that loss aversion is a robust phenomenon for decision utility, both under certainty and uncertainty. It therefore also led to numerous applications (for an overview see Camerer, 2000),

[5]Prospect theory has another important feature - subjective probability weighting. However, we do not apply this feature here, firstly because of simplicity, and secondly because it is not clear to what extent it should indeed be used for normative purpose. In addition, Humphreys and Verschoor (2004) empirically test subjective probabilities in Africa and find that farmers in Uganda attach lower weights to small probabilities and higher weights to high probabilities. Note that this is the reverse pattern of existing evidence.

most prominently in the areas of labor (e.g. Goette, Huffman and Fehr, 2004; Camerer et al., 1997) and finance (e.g. Benartzi and Thaler, 1995). Unfortunately, the literature of loss aversion is rather sparse with regard to experienced utility as measured ex post[6] and more research is certainly needed here.

However, there are quite a number of studies, which have emphasized the role of past experience for measures of wellbeing, which at least supports the notion of reference dependence in experienced utility measures (see e.g. Gilboa and Schmeidler, 2001 or D'Ambrosio and Frick, 2007, where current utility is dependent on current income but also on past incomes). However, the role of loss aversion has mostly been neglected in these studies. For instance, D'Ambrosio and Frick (2007) find in an empirical study (with German panel data) that past incomes and the question whether an individual is now better or worse off relative to the past have a significant effect on income satisfaction. However, the authors do not interpret the huge numerical difference associated with being better or worse off although the effect of one's history in their regression is up to 15 times larger for losses than for gains. Vendrik and Woltjer (2007) use the same panel data in order to test the properties of Kahneman and Tversky's (1979) value function (i.e. loss aversion and diminishing sensitivity[7]). Although, gains and losses are considered in a framework of social comparison and hence in relation to a reference group's income and not in relation to one's past income, the authors find loss aversion (but reject diminishing sensitivity).

3.2 Modeling Loss Aversion

Starting with Kahneman and Tversky's (1979) prospect theory, models of reference dependent utility incorporating loss aversion have been extended and modified over the last decades. Here, we will follow the most recent approaches of Koszegi and Rabin (2006, 2007) defined over discrete time periods with $t = 1, 2, ..., T$. Reference-dependent utility (RU) for a riskless consumption outcome $x_t \in \mathbb{R}^+$ and a riskless reference level of consumption $r_t \in \mathbb{R}^+$ is given by

[6] Galanter (1990) finds loss aversion for experienced utility as measured (predicted) ex ante.

[7] Diminishing sensitivity refers to the shape of the value function. More precisely, it refers to fact that utility is concave in the gain domain but convex in the loss domain

$$RU_t(x_t, r_t) = \overbrace{m(x_t)}^{consumption\ utility} + \overbrace{n(x_t|r_t)}^{gainloss\ utility} \tag{10}$$

Equation (**??**) states that the evaluation of a consumption outcome is based on an absolute component (i.e. consumption utility) and on a relative component (i.e. gain-loss utility), which is derived by comparing the consumption outcome to its reference level. This framework will be useful (in section **??**) with regard to multi-period poverty. If the consumption outcome is instead risky and F_t is the distribution function of x_t, expected reference-dependent utility (ERU) is given by

$$ERU_t(F_t, r_t) = \overbrace{\int m(x_t)\ dF_t(x_t)}^{exp.\ consumption\ utility} + \overbrace{\int n(x_t|r_t)\ dF_t(x_t)}^{exp.\ gainloss\ utility} \tag{11}$$

Equation (**??**) shows that the evaluation of a risky consumption outcome is not only based on expected consumption utility but also on expected gain-loss utility, where the latter is derived by comparing each possible realization of x_t with r_t.[8] This framework will be useful with regard to vulnerability.

The gain-loss function in equation (**??**) and (**??**) is further defined by

$$n(x_t, r_t) = \mu\left[m(x_t) - m(r_t)\right] \tag{12}$$

where $\mu(\cdot)$ refers to the value function of Kahneman and Tversky (1979) and satisfies the following properties (see Bowman, Minehart and Rabin, 1999):

A 1 ***Increasing, Continuous and Differentiable.*** *$\mu(x)$ is strictly increasing, continuous for all x, twice differentiable for $x \neq 0$, and $\mu(0) = 0$.*

A 2 ***Loss Aversion - Small Stakes.*** *$\frac{\mu'_-(0)}{\mu'_+(0)} \equiv \lambda > 1$, where $\mu'_-(0) \equiv lim_{x\to 0}\mu'(-|x|)$ and $\mu'_+(0) \equiv lim_{x\to 0}\mu'(|x|)$.*

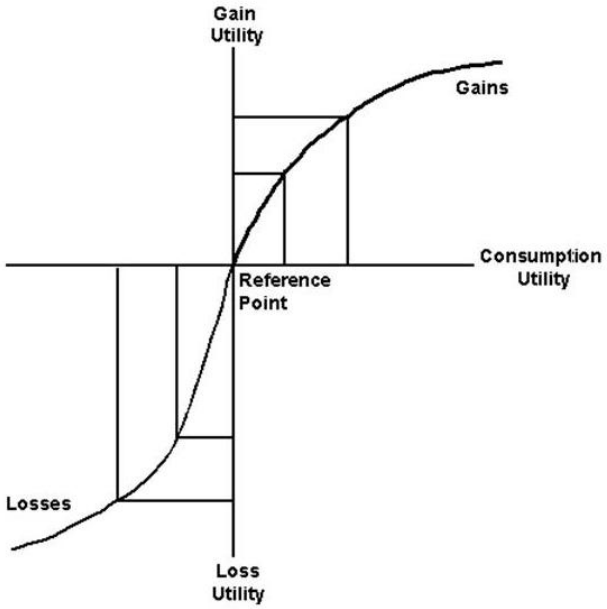
A 3 ***Loss Aversion - Large Stakes.*** *If $y > x \geq 0$, then $\mu(y) + \mu(-y) < \mu(x) + \mu(-x)$.*

A 4 ***Diminishing Sensitivity.*** *$\mu''(x) \leq 0$ for $x > 0$ and $\mu''(x) \geq 0$ for $x < 0$.*

[8] In a discrete setting each realization of x_{it} (with $i = 1, 2, ..., I$ states of the world in t) would be compared to r_t. So, equation (**??**) would reduce to $ERU_t(x_t, r_t) = \sum_{i=1}^{I} p_{it} m(x_{it}) + \sum_{i=1}^{I} p_{it} n(x_{it}|r_t)$.

A?? implies (through equation (??)) that both, $RU_t(x_t, r_t)$ and $ERU_t(F_t, r_t)$, are increasing in x_t and decreasing in r_t. A?? indicates that people have a distaste for losses even when very small losses are compared to very small gains. A?? suggests that the marginal disutility of a loss is strictly greater than the marginal utility of a comparable gain. A?? says that the marginal disutility decreases for further losses and that the marginal utility decreases for further gains.

Figure 1: Model of Gain-Loss Utility



Source: Own Illustration.

Figure ?? shows the gain-loss function $\mu(\cdot)$ fulfilling A?? – A??. Here, we can nicely see the three major properties of gain-loss utility, namely reference dependency, loss aversion and diminishing sensitivity.

4 Measure of Perceived Poverty and Vulnerability

4.1 Concept

As argued above, the utility of an individual in period t is dependent on his consumption x_t in that period as well as how this consumption compares

to his reference level r_t, so that the utility of the individual is $RU_t(x_t, r_t)$. We hence define multi-period poverty as one minus the relation between the utility the individual actually perceived out of his experienced consumption path over time and the utility the individual would have had if he had consumed the consumption level of the poverty line z over all time periods $t = 1, 2, ..., T$. This can be written as

$$M(x_1, x_2, ...x_T; r_1, r_2, ..., r_T, z) = 1 - \frac{1}{T} \sum_{t=1}^{T} \frac{RU_t(x_t, r_t)}{RU_t(z, r_t)} \tag{13}$$

where

$$RU_t(x_t, r_t) = m(x_t) + \mu \left[m(x_t) - m(r_t) \right] \tag{14}$$

which is substituting equation (**??**) into (**??**), fulfilling the axiomatic properties outlined in A1-A4. $M(\cdot)$ can hence be interpreted as a perceived poverty over T time periods. We use the term *perceived* to denote that our measure is build on reference dependent utility which uses a utility function that is mostly based on experimental and empirical evidence on preferences of individuals. We do, however, neither claim nor reject whether such a function should be used for normative purpose.

Similarly, we can define perceived vulnerability $V_t(x_t, r_t, z)$ of an individual at time t as

$$V_t(x_t, r_t, z) = 1 - \frac{ERU_t(x_t, r_t)}{ERU_t(z, r_t)}. \tag{15}$$

Note that both measures are built on the same utility function. The difference is that $M(\cdot)$ is defined over time periods T whereas $V_t(\cdot)$ is defined for a specific point in time t. Moreover, $M(\cdot)$ is calculated over different *observed* consumption outcomes $x_1, x_2, ..., x_T$, whereas $V_t(\cdot)$ is calculated over different *expected* consumption outcomes $x_{1t}, x_{2t}, ..., x_{It}$ with $i = 1, 2, ..., I$ denoting different possible consumption states at time t.

4.2 Parameterization

Before turning to the empirical application, it is necessary to parameterize consumption utility and gain-loss utility. Respectively, we propose

$$m(x_t) = x_t^{\alpha} \tag{16}$$

and

$$\mu(\cdot) = \begin{cases} [m(x_t) - m(r_t)]^{\beta} & \text{iff } m(x_t) - m(r_t) \geq 0 \\ -\lambda |m(x_t) - m(r_t)|^{\beta} & \text{iff } m(x_t) - m(r_t) < 0 \end{cases} \tag{17}$$

where $0 < \alpha \leq 1$, $\lambda > 1$ and $0 < \beta < 1$, which fulfills the axioms specified in A1-A4. α ($\forall \alpha < 1$) refers to diminishing marginal utility of consumption. λ refers to the loss aversion coefficient. As has become common to assume in applications, we set $\lambda = 2$ which also insures monotonicity of the measures. β is a measure for decreasing sensitivity to gains and losses.[9] Under this specification, consumption utility tends to be relatively more important (compared to gain-loss utility) for larger stakes and relatively less important for smaller stakes (see also Koszegi and Rabin, 2006, 2007).

Last, we need to specify the reference point r_t which is crucial for all reference dependent utility functions. We define the reference point as

$$r_t = x_{t-1}. \tag{18}$$

This kind of reference point has already been used in the literature. First, there is some literature on models of habit formation (and its psychological counterpart, adaptation level theory). Here it is argued that consumption is compared to the pre-period's consumption level because one gets used to a certain level of consumption over time and outcomes are evaluated as changes from that state. Hence, any change to that level is perceived as a gain or loss. Although this 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 habit formation (Dynan, 2000), it is an assumption that has often been used within the framework of habit formation (see e.g. Rayo and Becker, 2007).

Second, in the wide literature on choice under certainty and uncertainty, it is argued that outcomes are either compared to a status quo level (Kahneman and Tversky, 1991; Benartzi and Thaler, 1995; Köbberling and Wakker, 2003), hence $r_t = x_{t-1}$ or to one's expectations about that outcome. However, even if the reference point is the expectations about outcomes, r_t might still be equal to x_{t-1}. This is because either one expects to keep the status quo or because r is the mean of expected outcomes under uncertainty (see e.g. Bell, 1985; Loomes and Sugden, 1986; Gul, 1991).

[9] Although Tversky and Kahneman (1992) distinguish in the parameter describing diminishing sensitivity between gains and losses, we assumed β for both, gains and losses. This seems appropriate firstly because the authors find the same diminishing sensitivity coefficient (i.e. 0.88) for gains and losses, secondly, as noted by Köbberling and Wakker (2005), because the function entails several modeling problems if the parameters would differ, and thirdly, because there is mixed evidence how the β for gains and losses differs (for a review of the evidence see Köbberling, Schwieren and Wakker, 2004).

With the reference point being defined as in equation (??) we can now rewrite equation (??) as

$$M(\cdot) = 1 - \frac{1}{T}\sum_{t=1}^{T}\frac{RU_t(x_t, x_{t-1})}{RU_t(z,z)} \tag{19}$$

since the reference point for experienced consumption x_t in time period t is x_{t-1}, whereas the reference point for an individual that had always consumed the consumption level of the poverty line z over all time periods $t = 1, 2, ..., T$ is $z_{t-1} = z_t = z$. As a result we have $RU_t(z,z) = m(z)$. The vulnerability measure $V_t(\cdot)$ (or equation (??)) becomes

$$V_t(\cdot) = 1 - \frac{ERU_t(x_t, x_{t-1})}{ERU_t(z,z)} \tag{20}$$

The numerator in equation (??) denotes the expected reference dependent utility, where all possible consumption outcomes in period t are compared to the consumption of the last period x_{t-1}. The denominator in equation (??) reduces as before to $ERU_t(z,z) = m(z)$. So, $V_t(\cdot)$ measures how vulnerable an individual expects herself to be in period t. Or in other words, it measures how vulnerable an individual is in period t from the perspective of period $t-1$.

4.3 Properties

Before the above measures can be applied we need to discuss their properties. Both, multi-period poverty and vulnerability measures, are a time and risk extension of poverty measures in a static and certain environment, respectively. We therefore relate the discussed properties to a set of axioms that are generally accepted for static poverty measures: monotonicity, scale invariance, transfer sensitivity, focus sensitivity, anonymity, replication invariance and decomposability.[10]

In the following, we extend those axioms to a time dimension t (for multi-period poverty) or an 'uncertain outcome' dimension i (for vulnerability), so that the poverty measure becomes $M = M^T : \mathbb{R}^T \to \mathbb{R}$ and the vulnerability measure becomes $V = V^I : \mathbb{R}^I \to \mathbb{R}$ (see also Foster, 2006 and Calvo and Dercon, 2005 for comparison). As before $M^T(x)$ is measured over a span of T

[10] Another often cited axiom which should be fulfilled by poverty measures is subgroup consistency, which is however a less strong assumption than decomposability. Hence whenever we consider decomposability, subgroup consistency is also fulfilled.

time periods whereas $V^I(x)$ is measured over a range of uncertain outcomes. x is equal to consumption and z refers to the poverty line. Here we only discuss $M^T(x)$ but the same applies for $V^I(x)$, only that 'time periods' have to be replaced by 'uncertain outcomes'.

Monotonicity. *For* $\delta > 0$ *and* $t \in \{1, ..., T\}$*:* $M^T(x_1, x_2, ..., x_t + \delta, ..., x_T) \leq M^T(x_1, x_2, ...x_t, ..., x_T)$. 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 whenever $\lambda \leq 2$.

Scale Invariance. *For* $\alpha, z \in \{\mathbb{R}\}$ *and* $t \in \{1, ..., T\}$*:* $M^T[(x_1, x_2, ..., x_T) \mid z] = M^T[(\alpha x_1, \alpha x_2, ..., \alpha x_T) \mid \alpha z]$. 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 poverty should not change, which is also fulfilled by the proposed measured being normalized to the poverty line.

Transfer Sensitivity. *For* $\delta > 0$ *and* $i, j \in \{1, ..., T\}$*:* $x_i < x_j$*:* $M^T(x_1, x_2, ..., x_T) < M^T(x_1, x_2, ..., x_i - \delta, x_j + \delta, ..., x_T)$. The transfer sensitivity specifies that whenever there is a transfer from a 'poor' ('rich') time period to a 'rich' ('poor') time period, poverty should increase (decrease), which is the case for all $\alpha < 1$. Calvo and Dercon (2007) refer to this transfer sensitivity as 'increasing cost of hardship'. In a vulnerability framework, this means that vulnerability increases (decreases) if the expected volatility of consumption increases (decreases), holding expected mean consumption constant. Hence in a vulnerability framework transfer sensitivity is actually *risk sensitivity*.

Strong versus Weak Focus. *For* $\delta > 0$ *and* $t \in \{1, ..., T\}$*:* $x_t > z$*:* $M^T(x_1, x_2, ..., x_t + \delta, ..., x_T) \neq M^T(x_1, x_2, ..., x_t, ..., x_T)$ *but for* $\bar{x} > z$*:* $M(\bar{x}) = M(\bar{x} + \delta)$. For clarification, going back to poverty measures, the focus axiom requires that an increase (decrease) in consumption for *households* above the poverty line should not have an impact on the level of poverty. Similar, Foster (2006) 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 a household. We refer to this as the strong focus axiom.

However, 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 welfare of a household over time should be affected by the consumption level in all poor and non-poor time periods. This is

the case in our measure. However, after aggregation over the various time periods the vulnerability ?????NICHT KAPIERT for all households above the poverty line should be set equal to zero, which is specified by the second term above. We call this the weak focus axiom.[11]

Path Dependency. *For* $\delta > 0$ *and* $i, j \in \{1, ..., T\}$*:* $x_i = x_j$*:* $M^T(x_1, x_2, ..., x_i + \delta, ..., x_T) \neq M^T(x_1, x_2, ..., x_j + \delta, ..., x_T)$. All discussed measures in section **??** assume anonymity, or in other words, assume that a multi-period measure should be invariant to the time period of a certain consumption outcome (the exception is Calvo and Dercon, 2007, who introduce a time period weighting coefficient β but are not clear about the parameterization of the coefficient). Although we do agree that it should not matter *which* person has a certain consumption level (as in static poverty measures), we think that it should definitely matter *when* a certain consumption level occurs.

So in a dynamic framework we strongly reject the anonymity axiom and rather propose *path dependency*. This means that the multi-period poverty of a household should change whenever we swap consumption levels from one time period to another. In a vulnerability framework this means that the vulnerability of households is not equal across all time periods (as in all measures discussed in section **??**) but should be dependent on t. Path dependency is fulfilled by both, by our proposed multi-period poverty measure as well as by our proposed vulnerability measure.[12]

Decomposability. $M^T(x_1, x_2, ..., x_T) = M^T(\bar{x}) + M^T(|\bar{x} - x_1|, |\bar{x} - x_2|, ..., |\bar{x} - x_T|)$. We think that when moving from a static certain to a dynamic uncertain framework, it is very useful if it is possible to decompose measures of multi-period poverty and vulnerability into a low consumption and a risk induced component. Measures of poverty over time and vulnerability are much more complex and more difficult to interpret than traditional poverty measures as they introduce a complex second dimensions to poverty, time (multi-period poverty) and uncertainty (vulnerability). Hence it is very useful to be able to evaluate whether high multi-period poverty (vulnerability) of households rather stems from low consumption or high consumption variance (risk). In principle this were possible for most discussed measures,

[11] The same applies for vulnerability measures.

[12] Note that path dependency rules out replication invariance (i.e. that the measured level of poverty must be independent of a replication of a given consumption stream) as well as the 'traditional' decomposability (i.e. that multi-period poverty is a weighted average of subperiod poverty). See also Calvo and Dercon (2007).

however only Ligon and Schechter (2003) and Jalan and Ravallion (1998) make an attempt to do so. We will specify the mean, variance and the gain-loss consumption component of our proposed measure in the empirical application in next section.

Table 1: Properties of Poverty and Vulnerability Measures

	Mon.	Scale	Transfer	Focus	Path	Decomp.
			Poverty Measures			
Mc Kay and Lawson (2003)	No	Yes	No	Strong	No	No
Jalan and Ravallion (1998)*	Yes/No	Yes	Yes/No	Strong	No	Yes
Foster (2006)**	Yes/No	Yes	Yes/No	Strong	No	No
Calvo and Dercon* (2007)	Yes	Yes	Yes	Strong	Yes	No
Perceived Poverty	Yes	Yes	Yes	Weak	Yes	Yes
			Vulnerability Measures			
Pritchett et al. (2000)	Yes	Yes	No	Weak	No	No
Ligon and Schechter (2003)	Yes	Yes	Yes	Weak	No	Yes
Calvo and Dercon (2005)	Yes	Yes	Yes	Strong	No	No
Perceived Vulnerability	Yes	Yes	Yes	Weak	Yes	Yes

Notes: *) Monotonicity and transfer sensitivity is only given if $\alpha = 2$. **) Monotonicity and transfer sensitivity is only given if $\alpha = 2$ and $\beta = 1$ (see equation (**??**)).

Table **??** gives an overview of the discussed measures and the properties they fulfill. Note that all measures fulfill scale invariance as all of them are calibrated to the poverty line. Transfer sensitivity and monotonicity is fulfilled by most measures, for Foster (2006) and Jalan and Ravallion (1998) depending on the parameterization of α. All measures apply some form of the focus axiom, with half being consistent with the weak and half being consistent with the strong focus axiom. Path dependency is, as already noted, only considered by Calvo and Dercon (2007). Last, a decomposition into a structural and risk induced component is only done by the measure of Jalan and Ravallion (1998) and Ligon and Schechter (2003).

5 Empirical Application

We apply the proposed measure of perceived poverty and vulnerability to various consumption paths over time and also compare it with other recently proposed measures of multi-period poverty and vulnerability. Table **??** and Figure **??** show illustrative per capita consumption trajectories for

five 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 derivation from the poverty line.

Table 2: Consumption Matrix

	HH 1	HH 2	HH 3	HH 4	HH 5
Year 1	110	60	80	110	70
Year 2	95	75	90	100	95
Year 3	85	90	95	105	135
Year 4	70	100	90	100	130
Mean	90.00	81.25	88.75	103.75	107.50
CV	0.19	0.22	0.07	0.05	0.29

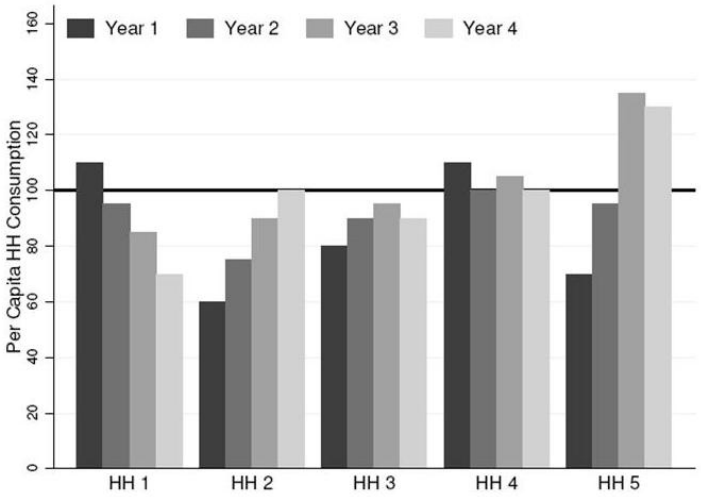
Notes: CV denotes the coefficient of variation.

Household 1 has a higher mean and almost the same variance as household 2 but is on a decreasing consumption path, whereas household 2 finds itself on an increasing consumption path. Household 3 and household 1 have a very similar mean in consumption, but the variance of household 3 is much lower than the one of household 1. Household 4 and 5 have a significant higher mean than households 1-3. However, whereas household 4 has never been poor (but only slightly above the poverty line) household 5 has been poor in two periods and then non-poor in the latest two periods, but considerably above the poverty line.

Table **??** displays the numerical results of existing as well as of our proposed measures of multi-period poverty and vulnerability. The first two columns display the parameterizations for α and β for the various measures, whereas column 3-7 display the measured vulnerability for each household and each measure. α represents the increasing cost of low consumption (implying a concave utility function) for the poverty measures and the magnitude of risk-aversion for the vulnerability measures, respectively.[13] Hence, α specifies the 'transfer sensitivity' of each measure, i.e. the sensitivity of the poverty (vulnerability) measure to a transfer from a 'poor' time spell

[13]Note that specifying a concave utility function in an environment under certainty (multi-period poverty measures) implies an utility function of the expected utility form that has the property of risk-aversion (vulnerability measures).

Figure 2: Consumption Paths



Source: Own Illustration.

(possible state) to a 'wealthy' time-spell (possible state).

β indicates the 'time sensitivity' of the measure. Note that besides our proposed measure of perceived poverty and vulnerability, only Foster (2006) and Calvo and Dercon (2007) incorporate a measure of 'time'. Foster (2006) specifies a 'duration line', which indicates the least number of time spells a household has to be below the poverty line to be considered poo. Calvo and Dercon (2007) apply a 'time multiplier' that either gives more weight to current ($\beta<1$) or past ($\beta>1$) time spells. None of the proposed vulnerability measures incorporates the notion of 'time'. Or in other words, although the proposed vulnerability measures explicitly assume that poverty of households changes over time, they implicitly assume - at least in their empirical applications - that the vulnerability of households does *not* change over time.

In contrast, applying a utility function that incorporates loss aversion to multi-period poverty and vulnerability means a rather strong 'time sensitivity'. Our proposed measure of perceived poverty is not only sensitive to consumption levels at time spells $t = 1, 2, ..., T$ but also to changes in consumption between those time spells, leading to a 'natural' path dependency

Table 3: Applied Poverty and Vulnerability Measures

	α	β	HH 1	HH 2	HH 3	HH 4	HH 5
			Poverty Measures				
McKay/Lawson	–	–	transient	transient	chronic	nonpoor	transient
Jalan/Ravallion	1	–	0.125	0.188	0.113	0.000	0.088
	2	–	0.029	0.058	0.016	0.000	0.023
Foster	1	3	0.125	0.188	0.113	0.000	0.000
	2	3	0.125	0.188	0.113	0.000	0.000
Calvo/Dercon (2007)	1	1	0.125	0.188	0.113	0.000	0.088
	1	0.8	0.141	0.139	0.096	0.000	0.058
	1	1.2	0.115	0.244	0.135	0.000	0.123
Perceived Poverty	0.8	0.5	0.161	0.149	0.088	0.000	-0.079
	0.5	0.5	0.180	0.093	0.053	0.029	-0.069
			Vulnerability Measures				
Pritchett et al.	–	–	0.734	0.843	0.953	0.215	0.450
Ligon/Schechter	0.8	–	3.296	6.189	3.636	-1.185	-2.154
	0.5	–	0.545	1.027	0.584	-0.184	-0.284
Calvo/Dercon (2005)	0.8	–	0.103	0.155	0.091	0.000	0.072
	0.5	–	0.067	0.103	0.058	0.000	0.047
Perceived Vulnerability	0.8	0.5	0.417	-0.044	0.058	0.051	-0.368
	0.5	0.5	0.363	-0.031	0.034	0.062	-0.236

of the measure. The suggested perceived vulnerability measure is not only a function of possible consumption outcomes in $t+1$ but also a function of the current consumption level t, leading to changing vulnerability levels over time.

Based on the numerical results of Table **??**, which are somewhat difficult to interpret[14] - except McKay and Lawson (2003) and Jalan and Ravallion (1998) - the ranking from the poorest/most vulnerable to the wealthiest/less vulnerable household for each measure is then shown in Tables **??** and Table **??**. We first discuss the results of multi-period poverty measures and then turn to the vulnerability measures.

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, all measures - except the measure of Calvo and Dercon (2007) with $\beta < 1$ - consider household 2 poorer (or equally poor) as household 1. The reason

[14] Discuss WHY.

being that household 2 has both a somewhat lower mean as well as higher variance in consumption. In contrast, the measure we propose considers household 1 poorer than household 2, as household 1 experienced several losses (i.e. being on a decreasing consumption path) whereas household 2 experienced several gains (i.e. being on a increasing consumption path) over time.

With regard to household 3, the various measures also come to very different conclusions. The 'spells' approach of chronic and transient poverty (McKay and Lawson, 2003), considers household 3 as the poorest household as it is the only household that has always been poor during the 5 observed time spells. Most other measures consider household 3 less poor than household 1 and household 2, although it has more often been poor than household 1 and 2. However, when being poor, the derivation from the poverty line has not only been smaller than the one of household 1 and 2, but the variance in consumption of household 3 is also much lower than the one of the other two households.

In section **??** we argued that applying a 'strict' focus axiom might be meaningless in a dynamic framework, but which is done by most multi-period poverty measures. By comparing household 4 and household 5 in Table **??** we can see that all existing multi-period poverty measures consider household 4 poorer or (equally poor) than household 5, although household 5 has a significant higher mean in consumption and especially seems to have a much higher consumption when being above the poverty line. A strong focus axiom does however not pay any attention whatsoever to consumption levels above the poverty line. As we apply the weak focus axiom, or in other words only apply the focus axiom after an aggregation over time has taken place, our measure suggests that household 4 is poorer than household 5.

Turning to the welfare rankings based on vulnerability measures in Table **??**, we again observe that the ranking is highly dependent on the measure chosen. On the other hand, also note that the rankings based on vulnerability measures are in general very close to the rankings based on multi-period measures, which stems from the fact that for the empirical application of vulnerability measures we have to get some estimate of expected consumption states and the probabilities thereof, which is almost always taken from past observed consumption levels (REFERENCES HERE).

Assuming that vulnerability measures should be sensitive to risk-aversion,

Table 4: Multi-Period Poverty Rankings

	α	β	HH 1	HH 2	HH 3	HH 4	HH 5
McKay/Lawson	–	–	2	2	1	3	2
Jalan/Ravallion	1	–	2	1	3	5	4
	2	–	2	1	4	5	3
Foster	1	3	2	1	3	4	4
	2	3	2	1	3	4	4
Calvo/Dercon (2007)	1	1	2	1	3	5	4
	1	0.8	1	2	3	5	4
	1	1.2	4	1	2	5	3
Perceived Poverty	0.8	0.5	1	2	3	4	5
	0.5	0.5	1	2	3	4	5

Notes: Ranking for each measure of multi-period poverty. 1 denotes the poorest household in the consumption distribution.

we would expect that all measures show that household 1 is more vulnerable than household 3 as it only has a slightly higher expected mean but a much higher expected variance in consumption. However, both the measures of Pritchett et al. (2000) and Ligon and Schechter (2003) suggest that household 3 is more vulnerable than household 1. Poverty risk, as proposed by Pritchett et al. (2000), actually always implies higher vulnerability with lower expected variance in consumption if the expected mean of consumption is below the poverty line.[15] With regard to the measure of Ligon and Schechter (2003), the risk sensitivity parameter α has to be very low for expected variance dominating expected mean in consumption. In contrast, both the measure of Calvo and Dercon (2005) as well as our measure suggest that household 1 is poorer than household 3.

The probably most striking point is that our proposed measure suggests that household 2 is among the least vulnerable households as of today, whereas all other vulnerability measures indicate that this is the most vulnerable household. The reason is that all so far proposed measures implicitly assume that (i) only the expected *levels* of consumption are of relevance and that (ii) vulnerability of an household does not change over time, i.e. that the vulnerability of a household is the same in $t = 1, 2, ...T$. In contrast, our measure - being based on a theory of loss aversion - is also (but not

[15] A higher variance in consumption with an expected mean of consumption below the poverty line leads to a higher probability of being above the poverty line.

exclusively) (i) interested in the expected *change* in consumption and (ii) assumes that vulnerability is also dependent on the current level of consumption. Expected gains (from the current state of consumption) decrease vulnerability whereas expected losses increase vulnerability (more than gains decrease vulnerability).

Table 5: Vulnerability Rankings

	α	β	HH 1	HH 2	HH 3	HH 4	HH 5
Pritchett et al.	–	–	3	2	1	5	4
Ligon/Schechter	0.8	–	3	1	2	4	5
	0.5	–	3	1	2	4	5
Calvo/Dercon (2005)	0.8	–	2	1	3	5	4
	0.5	–	2	1	3	5	4
Perceived Vulnerability	0.8	0.5	1	4	2	3	5
	0.5	0.5	1	4	3	2	5

Notes: Ranking for each measure of vulnerability. 1 denotes the most vulnerable household in the consumption distribution.

*** ADD MEAN-RISK-GAIN/LOSS DECOMPOSITION

*** BRING CONSUMPTION IN t=1 OF HOUSEHOLD 5 CLOSER TO THE POVERTY LINE TO MAKE THE POINT CLEARER

6 Critical Discussion and Further Research

The objective of this paper was not to propose an ultimate new measure of multi-period poverty and vulnerability. We rather attempted to bring the two strands of literature together in a meaningful way. By doing that we used a reference-dependent utility model that incorporates the biggest behavioral phenomena within reference dependency found for decisions under certainty and uncertainty – loss aversion. We found that incorporating loss aversion helps to get rid of existing shortcomings. For multi-period poverty measures, it allows to introduce path dependency and for vulnerability it allows to formulate an alternative measure that is not based on a framework that has been invalidated by various experiments – classical expected utility theory. We therefore found it worthwhile to replace expected and experienced utility based on a concave function with expected and experienced utility based on a S-shaped function with a kink at the reference point. Unlike other measures,

our measures of perceived multi-period poverty and vulnerability are thus not based on 'shaky' or 'invalidated' utility foundations.

However, as we will discuss in the following, there are several critical points that constrain our application.

So far, experiments on loss aversion have mostly been undertaken in Europe and the US. But in order to apply loss aversion in a setting we proposed here, experiments would be needed in developing countries to clearly understand preferences of 'poor' individuals under certainty and uncertainty. Nevertheless, Dercon (2007) already notes that 'it is well recorded that during crises, such as the 1984-85 famine in Ethiopia, farmers desperately held on to their livestock, rather than selling in time, even at the expense of many of their household members and their own life. The possibility of losing only little, however remote, may induce this risk-seeking behaviour.' Although this might indicate that something like loss aversion might be at work, clearly more evidence is needed in this area.

Another critical feature of our application is the reference point. In order to term our measures *perceived*, a more sophisticated reference point should be developed. Although the literature on reference points is rather sparse, a more sophisticated version would not only take different strengths of reference point adaptation (habit formation) into account[16], but would also use a reference point that is not only intra- but also interdependent (i.e. among individuals in a reference group). Of course, this would clearly complicate the application but we note that it is extendible in this respect.

Since the model we used (Koszegi and Rabin, 2006, 2007) has originally been modeled for choice under both, certainty and uncertainty, we implicitly assumed 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." (Easterlin, 2001 p.474) (for opposing views see for example Kahneman and Krueger, 2006; Kahneman, Wakker and Sarin, 1997; Easterlin 2001) Closely related is the implicit assumption is that the sensation of a loss or gain only occurs during one period, not more and not less. By contrast, projection bias states that "people tend to underappreciate the effects of changes in their tastes, and hence falsely project their current preferences over consumption onto their future

[16] Note that we assumed adaptation takes place period by period. Easterlin (2001) uses a similar assumption in order to explain the relationship between income and happiness over time.

preferences." (Loewenstein, O'Donoghue and Rabin, 2000 p.1) This suggests that people underestimate the extent to which they will adapt to new circumstances (see also Loewenstein and Schkade, 1999). In our context, projection bias, as modeled by Loewenstein, O'Donoghue and Rabin (2000, 2003), would lead to a different experienced utility than we assumed, because the feelings of pleasure and pain for respective gains and losses would not be felt as far into the future (or next period) as we assumed. Despite magnitudes might be affected, the general results of loss aversion still hold.

It might also be argued that poverty and vulnerability should rather be an absolute than a relative (to historical experience) measure. However, we think that if we measure poverty 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.

We think not only poverty levels but also differences between current, past and future poverty is important for an understanding of poverty over time and vulnerability. This is clearly not the case for static measures of poverty which imply certainty. Multi-period poverty does however look at observed past consumption paths which imply the notion of consumption changes. Vulnerability, describes possible shortfalls or, in other words, a possible downward consumption path. Switching from a static to a dynamic framework, it seems hence reasonable that measures do not only evaluate (possible) poverty outcomes but also (possible) poverty changes. Moreover, especially the concept of vulnerability is concerned with the exposure to 'threats' or 'downside risks' (Calvo and Dercon, 2005), thus – apart from experimental evidence – even by the definition itself should losses have a higher weight than gains in the measurement of vulnerability.

Although there are several critical points (as discussed above), this paper shows that it is reasonable to extend individual welfare measures by behavioral components like loss aversion if they show to strongly influence the utility of individuals in systematic ways. Only if the downside impact of income fluctuations on current and life-time individuals' well-being is properly understood, are reasonable policy recommendations – e.g. with regard to insurance mechanisms – possible.

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