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Empirical issues in lifetime poverty measurement

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Abstract Recently there has been increased interest in developing methods for measuring poverty in a way that takes into account the lifetime experience of individuals. We analyze some specific proposals that take the so-called *spells approach* and consider how they differ in the manner in which they address issues of lifetime poverty, most notably the measurement of chronic poverty. Comparing these specific measures by applying them to a US panel data set, we provide important insights for further research in conceptualizing and measuring lifetime poverty.

Keywords Lifetime poverty · Snapshot poverty · Chronic poverty · Early poverty · Poverty measurement

JEL Classification I32

1 Introduction

It has long been recognized that the impact of poverty experienced by an individual for a long and sustained period of time is very different than poverty experienced for one or more relatively short, intermittent periods during a person's lifetime. These two temporal characterizations of poverty have come to be known as chronic and transient poverty, respectively. Clark and Hulme [9] provide a very useful

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background to the historical development of concern about, and progress with, the conceptualization and measurement of individual poverty over time, noting (p. 351) that "breakthroughs in terms of conceptualizing the depth and breadth of poverty were not generally matched by equivalent, systematic advances with regard to time prior to the late 1980s." However, even the terminology of chronic poverty is long-standing. For example, Godley [15, p. 2] describes his concern with the persistent class differences between the "English Protestant aristocracy and middle class, and the Irish Roman Catholic peasantry ... within Ireland ... (*which has resulted in*) chronic anarchy, with its necessary concomitant, chronic poverty (*of the Catholics*)," with italicized text our insertions.

Although important and insightful research on poverty dynamics of both a theoretical and empirical nature has been gaining in quantity and sophistication, development of complete axiomatic characterizations for measuring poverty through time is an area of research in its infancy. The axiomatic foundations of static poverty analysis have been well established for some time.[1] Developing a complementary approach that incorporates sensitivity to the pattern of poverty spells through time can borrow from that literature. However, there are many new challenges in developing an axiomatic characterization that incorporates a temporal perspective. In order to reflect chronic poverty concerns, one must address the manner and extent to which the clumping of poverty spells together or in "nearby periods" should matter. The permanent income approach, although useful empirically, does not distinguish, for example, the difference between someone who experiences poverty in every second period of her lifetime and someone who spends the first half of her life constantly in poverty and the second half out of poverty. Both individuals could have the same permanent income and hence be assigned the same measure of chronic poverty even though one could well argue that the second person suffered more chronic poverty over her lifetime. Other questions that arise when considering how to measure chronic poverty include the extent to which chronic poverty relief results from an interruption of several consecutive periods of poverty with one or two periods of non-poverty. This is especially important when, as is typical, the researcher has access only to a limited segment of say five to ten years of a person's lifetime income experiences. Arranz and Canto [2] find that the specific order of past poverty spells affects future exit and re-entry probabilities of poverty experiences. Duration of poverty in one part of life has implications for future (out of data) spells and so accounting for the timing of poverty in a way that is sensitive to duration can be a way to take into account expected future poverty experiences.

Besides addressing the property of chronic poverty over a person's lifetime, another consideration that has been deemed important in comparing the temporal pattern of poverty is that of the impact of poverty experienced early in life. There is substantial empirical evidence that poverty in earlier stages of life not only affects consumption in later periods but also leaves an inherently deeper mark on lifetime deprivation. Recent research in neuroscience (e.g., see [12]) suggests that children growing up in poor families with low social status not only suffer from inadequate nutrition and exposure to environmental toxins but also suffer from elevated stress hormones that generally impair neural development, including effects on language

[1] See for example the surveys of Zheng [22, 23].

and memory.[2] This suggests at least two channels for adverse effects on the individual later in life. First is a direct lasting impact from poverty early in life in that, due to the vulnerability of children, the physiological and psychological effects noted above reduce their future enjoyment from life for any given future (continuing) stream of consumption levels. Secondly, early poverty worsens an individual's capability to generate higher consumption later in life due to a compromised ability to accumulate human capital and obtain favorable employment opportunities. This second effect is captured implicitly if one includes all future levels of consumption in the measurement of lifetime poverty. However, to account for the first (direct) effect, one may require that any lifetime measure of poverty place greater weight on poverty experienced earlier in life.

We consider three recent alternatives to the development of lifetime poverty measurement, namely those of Bossert et al. [5], Foster [13, 14] and Hoy and Zheng [17].[3] Each of these contributions takes a different conceptual approach to creating a lifetime poverty measure that is sensitive to chronic poverty concerns, and in the case of Hoy and Zheng also to early poverty concerns. We demonstrate through hypothetical examples how these measures reflect a concern with chronic poverty in different ways. We also demonstrate with a simple empirical application using a panel data set what types of results each approach generates and also what kind of challenges arise in performing such an exercise. We believe that by doing so we will enhance future work on this important measurement problem.

In Section 2 we compare the three measures through a series of hypothetical examples. By adopting a common approach to measuring the cost of inequality, we can better demonstrate the commonalities and differences of these three approaches. In Section 3 we apply each approach to the PSID (Panel Survey of Income Dynamics) using US data from 1967 to 1992 in order to develop each measure of lifetime poverty. Doing so provides some understanding of the effect of changing relevant parameters that reflect varying sensitivity to the pattern of poverty over people's lifetimes. We provide some remarks in Section 4 and conclusions in the final section.

2 Comparing measures of lifetime poverty

In this section we describe the three measures of lifetime poverty of Foster [13, 14] (F), Bossert et al. [5] (BCD), and Hoy and Zheng [17] (HZ). We do so without extensive attention to the sets of formal axioms that generate the formulae used in each case. Rather, we use an informal approach along with hypothetical examples to illustrate the differing methodologies implicit in these measures. The formal axioms may be found in the papers indicated above.

These three measures focus on quite different aspects of lifetime poverty. However, all three reflect the so-called *spells approach* and all three can be compared by

[2]Boyden and Cooper [6, p. 290] point out that "research shows that, as a general rule, children are more susceptible to the effects of poverty than are adults, especially during infancy and in terms of physical impacts."

[3]See also Calvo and Dercon [7], Carter and Ikegami [8], Cruces [10], and Grab and Grimm [16].

adopting the popular FGT poverty index used to measure a single spell of poverty, which we will refer to as a *snapshot* measure of poverty.[4] Thus, the measures differ according to how they aggregate these snapshot poverty measures over an individual's lifetime. Focusing on the so-called poverty gap measure within the FGT family for the snapshot poverty measure in each case allows for the sharpest comparison of these methods. The BCD and F measures are primarily or exclusively concerned with the presence of chronic poverty, while the HZ measure requires simultaneous satisfaction of a chronic poverty axiom and an early poverty axiom. On the other hand, the formulae implied by the BCD and HZ approaches are structurally very similar in that they both rely on a measure of lifetime poverty that is formed by a weighted average of snapshot poverty levels where the weights depend on the pattern of spells of poverty experienced over the lifetime. Contiguous poverty spells (or more generally in the case of HZ, the "closeness" of poverty spells) will lead to a higher measure of lifetime poverty than if the same poverty spells are more spread out over time.

The Foster approach, on the other hand, determines that an individual in society is characterized as being chronically poor if he spends at least a specified critical fraction of spells of his life in poverty without concern over how close the poverty spells occur to each other. Those who are not classified as chronically poor but do experience some spells of poverty are essentially ignored in this measure while they do contribute to poverty as measured by the BCD and HZ approaches. Thus, F is exclusively concerned with those who are chronically poor. However, by comparing the resulting measure of poverty for the chronically poor with the analogous measure of poverty for the entire population (i.e., by effectively lowering the identification criteria to anyone who has experienced at least one spell of poverty), Foster's measure can be used to generate a decomposition of total poverty into chronic and transient poverty. This is a useful property since this decomposition exercise has been a focus of the components approach to lifetime poverty measurement.

We offer an interpretation for a decomposition of poverty into chronic and transient components for the BCD measure as well. Such a decomposition does not make sense for the HZ measure since, although it responds to the timing of poverty spells in a manner that makes it sensitive to chronic poverty, it is more generally concerned with the overall pattern of poverty spells, including increased sensitivity to poverty experienced early in life. One can, however, examine how taking into account the overall pattern of poverty experiences affects the HZ measure of lifetime poverty. We illustrate these properties for each measure by using the cost of poverty as determined by the equivalent equally distributed (constant) poverty gap (EDE). As described in detail later, we do this by constructing the EDE first ignoring the pattern of spells and then by taking into account the pattern (for the BCD and HZ measures) or selection criteria used to identify the chronically poor (for the F measure). These two results are then compared in order to determine how the timing of spells affects the measures.

[4]The other main approach, the components approach, is concerned with breaking poverty into chronic and transient components. Good examples of this approach are Jalan and Ravallion [18, 19], Baulch and Hoddinott [4], and Duclos et al. [11]. See also the seminal paper of Rodgers and Rodgers [21].

First, some common notation is useful. Consider an individual who lives through T periods. Each period can be interpreted as a year or as a phase of life such as youth, middle age and old age. In each period t, $t = 1, 2, ..., T$, the individual has a non-negative level of consumption x_t . In each period, the individual's poverty status is determined by comparing his consumption level with the poverty line $0 < z < \infty$ which, for sake of simplicity in this paper, is assumed exogenously given and remains constant throughout the T periods. The individual is poor in period t if and only if his consumption level x_t is strictly less than z. Denote $\mathbf{x} = (x_1, x_2, ..., x_T)'$ the profile of the individual's lifetime consumption; his lifetime poverty level is a function $P(\mathbf{x}; z)$ which maps each consumption profile $\mathbf{x}$ into $[0, \infty)$. For the three approaches we refer to this as P_{BCD}, P_F, and P_{HZ} (subscripts having obvious connotation). For each consumption variable, we also define the censored consumption as $\tilde{x}_t = \min\{x_t, z\}$, the poverty gap as $G_t = z - \tilde{x}_t$, and the normalized poverty gap as $g_t = (z - \tilde{x}_t)/z = 1 - \tilde{x}_t/z$.

If $x_t < z$, the individual has poverty deprivation which is measured by $p(x_t; z)$: $p(x_t; z) > 0$ if $x_t < z$; otherwise he lives out of poverty: $p(x_t; z) = 0$ if $x_t \geq z$. We refer to $p(x_t; z)$ as the "snapshot poverty" of period t. The measurement of poverty deprivation has been well studied in the literature. In general, we assume that $p(x_t; z)$ is continuous, $\frac{\partial p(x_t; z)}{\partial x_t} < 0$ (denoted as $p' < 0$ hereafter) and also in some cases we also impose $\frac{\partial^2 p(x_t; z)}{\partial x_t^2} > 0$ (denoted $p'' > 0$ hereafter) for all $x_t \in [0, z)$. That is, poverty deprivation decreases as consumption increases ($p' < 0$); it is often presumed to decrease, however, at a slower pace as consumption increases ($p'' > 0$) – in part this is to reflect the poverty aversion consideration [23]. For the empirical applications and much of the discussion in this paper, we will adopt the FGT measure for the snapshot poverty index; i.e., $p(x_t; z) = (1 - \tilde{x}_t/z)^{\varepsilon}$ using either $\varepsilon = 1$ or $\varepsilon = 2$. Using $\varepsilon = 1$, the normalized poverty gap measure, leads to satisfaction of the first assumption above, $p' < 0$, with $p'' = 0$. Using $\varepsilon = 2$, the squared normalized poverty gap measure, both assumptions, $p' < 0$ and $p'' > 0$, are satisfied. Later we will concern ourselves with aggregation across individuals. Here we focus on aggregation over time.

It turns out that we can describe quite well the differences in the methods of BCD and HZ by focussing on how they measure a single individual's lifetime poverty depending on the "closeness" of any poverty spells experienced—although they do this in quite different ways. In both it is shown that the axioms imposed imply a specific functional form of $P(\mathbf{x}; z)$; namely one that is additive in the snapshot poverty experiences from each period, $p(x_t; z)$.[5]

2.1 The BCD measure

For the BCD measure (Bossert, Chakravarty, and D'Ambrosio) the property of (or the sensitivity to) the chronic nature of poverty is realized through a set of weights applied to snapshot poverty experiences $p(x_t; z)$ such that a sequence of $k \geq 2$

[5] In HZ there is also an axiom which introduces a term involving the level of poverty taken from the perspective of the individual's "whole life" and is based on the level of average consumption or income should that fall below the poverty line; i.e., it is $p(\bar{x}; z)$. Since in their set-up one can choose a weight of zero for this term, we ignore it for the purpose of this paper.

consecutive spells of poverty receive greater weight than spells that are isolated (i.e., any spell of poverty not immediately preceded by or followed by another poverty spell). The weights for $p(x_t; z)$ within a consecutive string of poverty experiences ($k \geq 2$) are $\gamma^{(k-1)}$, $\gamma \geq 1$. Thus, for $\gamma > 1$, the weight on an isolated spell is always strictly less than the weight for an identical poverty experience that occurs in a string of two or more consecutive poverty spells. Moreover, the weight on any given snapshot poverty experience is higher the more consecutive spells during which that poverty experience occurs (i.e., the higher is k), and the sensitivity (or penalty) placed on consecutive poverty experiences compared to any isolated spells increases in the value of the parameter γ. Therefore, γ can be interpreted as a parameter that measures the sensitivity to chronic poverty. In the case of $\gamma = 1$, all poverty spells are weighted equally (i.e., $\gamma^{(k-1)} = 1$ for $k \geq 1$). Thus, the value $\gamma = 1$ provides a useful benchmark for the BCD measures in that it leads to a measure involving zero sensitivity to the degree of chronic poverty experienced by the individual.

Formally, let the power k be represented by the term $D(p_t, t) - 1$ where $D(p_t, t)$ is the (maximal) number of consecutive periods of poverty (that include the t^{th} period) during which poverty is strictly positive. Thus, in the case of an isolated spell of poverty experience the weight is $\gamma^0 = 1$ while in the case of a poverty experience within a (maximal) number of $k \geq 2$ consecutive periods of poverty, the weight is γ^{k-1}. In the case of a period in which poverty is zero we assume the weight is one although obviously this is not important. Then we can write the BCD measure as:

$$P_{BCD}(\mathbf{x}; z) = \frac{1}{T} \sum_{t=1}^{T} \gamma^{D(p_t, t)-1} p(x_t; z). \tag{1}$$

Suppose $z = 5$, $\gamma = 2$, and we consider two individuals with time profiles for censored incomes of $\tilde{\mathbf{x}} = (5, 1, 1, 5)$ and $\tilde{\mathbf{y}} = (1, 5, 5, 1)$.[6] Assume further we adopt the normalized poverty gap measure from the FGT family; i.e., $p(x_t; z) = (1 - \tilde{x}_t/z)$. In the first case there are two consecutive periods of poverty (in periods 2 and 3) with poverty gaps of 4 in each period and so relative poverty gap of 4/5. Thus, we get $P_{BCD}(\mathbf{x}; z) = [1(0) + 2(4/5) + 2(4/5) + 1(0)] \div 4 = 0.8$ and $P_{BCD}(\mathbf{y}; z) = [1(4/5) + 1(0) + 1(0) + 1(4/5)] \div 4 = 0.4$. Clearly, the fact that the poverty spells in **x** occurred in consecutive periods while those in **y** did not leads to higher measured poverty in distribution **x**. For the choice of $\gamma = 1$ the poverty level in both profiles would be the same at 0.4, illustrating that choosing this value for the parameter provides a benchmark case in which there is no sensitivity for chronic poverty. Also, increasing the value of γ to $\gamma = 3$ leaves the measured level of poverty in profile **y** unchanged while it increases the measured level of poverty in profile **x** to $[1(0) + 3(4/5) + 3(4/5) + 1(0)] \div 4 = 1.2$.

It is useful to create a measure of poverty that has cardinal significance. This would, for example, provide a more meaningful comparison between poverty measures of 0.8 and 0.4 for profiles **x** and **y**, since it is not obvious in what sense this difference implies "twice as much poverty" in **y**. Moreover, in developing explanatory examples and empirical illustrations, it is useful to have a method

[6]Throughout this section we will not use the tilde ($\tilde{\mathbf{x}}$) to represent the censored vector but rather simply use, for example, **x** since we have no need to distinguish these concepts here.

of reporting lifetime poverty that allows for intuitive comparisons between the alternative measures. In this regard, we follow Duclos et al. [11] in defining a money metric cost of poverty as the "equally-distributed equivalent" (EDE) poverty gap; that is, the size of the poverty gap if distributed equally to all persons in all periods of life that would produce the same measure of poverty as for the actual lifetime profiles of poverty experienced across the population.[7] Here we restrict ourselves to a single individual's lifetime profile of poverty. Naturally the EDE poverty gap will depend on both the properties of the snapshot poverty index, $p(x_t, z)$, and the weights (i.e., parameter γ in the case of the BCD measure).

We now explain more formally how to associate various aspects of the temporal pattern of spells such as the degree of chronic poverty on the "overall" cost of poverty. Let $\mathbf{g_x}$ represent the vector of poverty gaps associated with the income vector (profile) $\mathbf{x}$. For the above example $\mathbf{g_x} = (0, 4, 4, 0)$ and $\mathbf{g_y} = (4, 0, 0, 4)$. Let $\overline{\mathbf{g}}_\mathbf{x}$ be the vector formed by inserting the average poverty gap in each period, and so $\overline{\mathbf{g}}_\mathbf{x} = \overline{\mathbf{g}}_\mathbf{y} = (2, 2, 2, 2)$. We use the same symbol, but not in bold (i.e., $\overline{g}_\mathbf{x}$) to refer to the average value of this poverty gap (i.e., $\overline{g}_\mathbf{x} = 2$ for the above example). The EDE (*equivalent constant poverty gap*) for a consumption profile is that (single valued) poverty gap which, if incurred in each period of life, would generate the same poverty level as that for some existing lifetime profile of poverty spells. Let this value be represented by $\widehat{g}_\mathbf{x}$. For the BCD poverty measure one must recognize that in generating this hypothetical profile to compute the EDE, one (in a sense) creates the highest possible penalty for (or sensitivity to) chronic poverty since the profile of the EDEs will have poverty experienced in every period. The intent of the EDE value is to reflect a level of poverty in each period that would be *equivalent to* the measured poverty generated by the actual profile of poverty gaps according to the manner and degree of sensitivity to chronic poverty of the measure used. Thus, rather than use weights that effectively blow up the degree of poverty in the EDE calculation, one could argue that weights that eliminate sensitivity to the chronic nature of poverty should be used. So we consider two ways of computing the EDE. First, in keeping with the spirit of the BCD measure, we use the weights for the EDE inspired profile of poverty gaps that account for the maximal number of consecutive periods of poverty, which would be γ^{T-1} or γ^3 for our hypothetical example. In general, using this measure we obtain the EDE for the BCD measure according to the following two equations:

$$P_{BCD} = \gamma^{T-1} \widehat{p} \tag{2}$$

where $\widehat{p}$ is the per period normalized poverty gap generated by the EDE and P_{BCD} is the poverty level created by some profile of incomes. So the EDE poverty gap for the BCD measure is:

$$\widehat{g} = z \left(\frac{P_{BCD}}{\gamma^{T-1}} \right)^{1/\varepsilon} \tag{3}$$

Unless otherwise stated, we choose $\varepsilon = 1$.

[7] We follow closely the approach developed in Duclos et al. [11], which in turn is based on the idea of the cost of inequality measurement in Kolm [20] and Atkinson [3]. However, we take a very different approach in how we take into account chronic poverty measurement.

Performing this calculation for the examples above, first with $\gamma = 2$, we obtain for profile **x** that $\widehat{p} = P_B/\gamma^{T-1} = 0.8/2^3 = 0.1 \Rightarrow \widehat{g}_x = 0.5$. Similarly, we obtain for profile **y** that $\widehat{p} = P_B/\gamma^{T-1} = 0.4/2^3 = 0.05 \Rightarrow \widehat{g}_y = 0.25$. These numbers imply that, due to the chronic nature of the poverty experienced in profile **x**, the overall cost of poverty in **x** is double that in **y**. If there were no sensitivity to the chronic aspect of poverty (i.e., $\gamma = 1$), then the cost of poverty would be the same for each profile. For the choice of parameter $\gamma = 3$, $\widehat{g}_x = 0.22$ while $\widehat{g}_y = 0.074$ and so the EDE gap for **x** is three times as large as in profile **y**. Thus, using the EDE poverty gap approach provides an intuitive perspective on how varying the sensitivity parameter γ affects the impact of chronic poverty in the measurement of poverty in a given profile or between profiles.

Thus, for profile **x**, in the case of $\gamma = 2$ the sum of the EDE poverty gaps for profile **x** is $4 \times 0.5 = 2$ while for $\gamma = 3$ the sum of the EDE poverty gaps is $4 \times 0.22 = 0.88$.[8] This suggests that increasing concern for chronic poverty has actually reduced the overall cost of poverty. However, the source of this effect is that when computing the EDE in the case for $\gamma = 3$ there is a higher penalty for (or sensitivity to) the chronic poverty that is created through the process of generating the profile for the EDE calculation (i.e., due to the fact that in this hypothetical distribution there is poverty in every period!). However, the EDE calculation for profile **y**, which has no chronic poverty, also falls when increasing γ and the ratio of the cost of poverty in **x** relative to **y** does indeed increase in γ. Thus, the extent to which the BCD measure is (relatively) sensitive to the choice of parameter γ can be assessed using such calculations.

Even though it is evident that, as γ increases, the cost of poverty falls even more for a profile that has no chronic poverty than one that does, one might find the property that increasing sensitivity to chronic poverty reduces the measured cost of poverty an undesirable feature of the EDE as computed above. An alternative approach is to remove the penalty for chronic poverty in the profile created for computing the EDE; that is, rather than using weights γ^{T-1} for each spell of poverty created in the EDE profile, one could instead use weights of $\gamma^0 = 1$ in order to assign an amount of poverty in each period of life just as one would do if the poverty experiences were isolated. Doing so allows one to compute a cost of poverty that can be interpreted as the sum of the poverty gaps spread evenly over time periods (and later also over individuals) without applying any penalty for these gaps occurring consecutively. Such an approach represents an unweighted efficiency cost of poverty. This would mean replacing γ^{T-1} in equations (2) and (3) with $\gamma^0 = 1$. Performing this calculation for the examples above, first with $\gamma = 2$, we obtain for profile **x** that $\widehat{p} = P_B/1 = 0.8 \Rightarrow \widehat{g}_x = 4$, while for profile **y** we have $\widehat{p} = P_B/1 = 0.4 \Rightarrow \widehat{g}_y = 2$. Again, the EDE is twice as high for profile **x** than for profile **y**. For the choice of parameter $\gamma = 3$, $\widehat{g}_x = 6$ while $\widehat{g}_y = 2$. Thus, increasing the sensitivity to chronic poverty through an increase in γ does increase the cost of chronic poverty as reflected in the EDE when calculated in this manner.

It is reassuring that both methods for calculating the EDE give the same relative cost of poverty between any pair of lifetime profiles. This can be seen by noting that

[8] Notice that the raw (unweighted) sum of poverty gaps in both profiles is 8.

for any pair of profiles $\mathbf{x}$ and $\mathbf{y}$ with $P_{BCD}(\mathbf{x}) > P_{BCD}(\mathbf{y})$, the ratio of the gaps as measured by equation (3) is

$$\frac{\widehat{g}_x}{\widehat{g}_y} = \left(\frac{P_{BCD}(\mathbf{x})}{P_{BCD}(\mathbf{y})}\right)^{1/\varepsilon} > 1$$

and this ratio would be the same if $\gamma^0 = 1$ were used in place of γ^{T-1} as in the second method of computing the EDE.

By considering how much poverty persists in some original profile, such as $\mathbf{x}$, that has at least one string of poverty spells at least two periods in length, and comparing the EDE associated with that distribution to the EDE one would obtain by ignoring the penalty or sensitivity of the BCD measure for chronic poverty (i.e., by replacing γ^{T-1} by $\gamma^0 = 1$ or simply choosing $\gamma = 1$ for all time periods, including those in which chronic poverty is experienced), one can decompose "total poverty" into the part due to the chronic nature of poverty experienced and the part due to transient poverty. So, for example, in the case of $\gamma = 3$ above, we found the EDE for profile $\mathbf{x}$ to be 6 while if the sensitivity to the chronic poverty experiences weren't taken into account (i.e., if one simply used all poverty gaps weighted by 1 in the BCD formula), one would get an EDE of value 2. Thus, of the total cost of poverty that is 6, 2 is the transient component and the additional 4 is due to the chronic nature of poverty (i.e., 1/3 of poverty is transient, 2/3 is chronic).

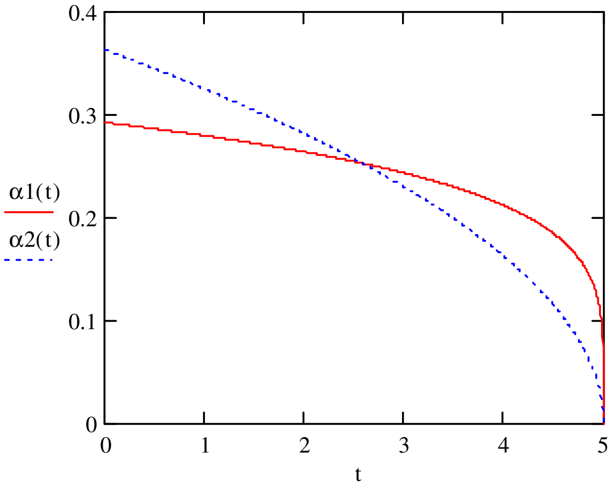
2.2 The HZ measure

The HZ (Hoy and Zheng) measure is also a weighted average of snapshot poverty levels and can be written as follows:

$$P(\mathbf{x}; z) = \sum_{t=1}^{T} \alpha(t, T) p(x_t; z). \tag{4}$$

The weights $\alpha(t, T)$, sometimes referred to as α_t, applied to each poverty spell have mathematical properties that reflect the axioms relating to the way in which this measure accounts for a sensitivity to both chronic and early aspects of the pattern of lifetime poverty experiences. The weights are normalized to sum to one and so this property replaces the need to divide the sum by T. The early poverty axiom simply implies that $\alpha(t, T)$ is falling (nonincreasing) in t while the chronic poverty axiom implies that $\alpha(t, T)$ is concave in t. Concavity of the weights implies that if one moves two spells of equivalent poverty experiences in a person's life farther apart, then lifetime poverty will fall. Thus, for example, the profile $\mathbf{y} = (1, 5, 5, 1)$ has less poverty than the profile $\mathbf{x} = (5, 1, 1, 5)$ for any set of weights $\alpha(t, T)$ that are strictly concave in t. This property is consistent with the BCD measure. However, if one were to switch the poverty spell in period 2 of profile $\mathbf{x}$ to period 1 to obtain profile $\mathbf{x}' = (1, 5, 1, 5)$, the HZ measure would assign more lifetime poverty to $\mathbf{x}'$ than to $\mathbf{x}$ due to the additional early poverty experienced. In other words, the HZ measure accommodates trade-offs between an early poverty concern and a chronic poverty concern. This is in stark contrast to the BCD measure that is only sensitive to chronic poverty concerns. It is also the case that any symmetric spreading out of poverty spells in a person's lifetime, even if they are not contiguous, will reduce the HZ measure of poverty. Thus, distribution $\mathbf{z} = (5, 1, 5, 1, 5)$ has more lifetime poverty

Fig. 1 Normalized weights for $\alpha(t,T) = (1 - \frac{t}{T+1})^{\delta}$ with $\delta = 0.2$ (i.e., $\alpha_1(t)$) and $\delta = 0.5$ (i.e., $\alpha_2(t)$)



according to any HZ measure than would $\mathbf{z}' = (1, 5, 5, 5, 1)$ due to the two poverty spells occurring closer in time in $\mathbf{z}$ (i.e., separated by one year in $\mathbf{z}$ but separated by three years in $\mathbf{z}'$). The BCD measure would assign the same poverty level to both profiles.[9]

One must be careful in using any particular weighting function and in varying any relevant parameter in terms of expectations about changes in how the measure takes into account the pattern of poverty spells in determining the amount of lifetime poverty. The following examples provide some intuition into how both early and chronic poverty can be reflected in different ways by different weighting functions. The functions $\alpha_1(t)$, $\alpha_2(t)$ in Fig. 1 below are generated from the non-normalized weight function $\alpha(t,T) = (1 - \frac{t}{T+1})^{\delta}$, $0 \leq \delta \leq 1$, for the parameters $\delta = 0.2, 0.5$ respectively, with $T = 4$ corresponding to the profiles $\mathbf{x}$ and $\mathbf{y}$ considered above. We will call the overall difference in weights from beginning to end of life (i.e., $\alpha(1,T) - \alpha(T,T)$) the *overall drop in weights* and use it as a crude measure of sensitivity to early poverty conditions. At the value $\delta = 1$, the overall drop in weights is at its maximum possible value while for $\delta = 0$, the overall drop in weights is zero. In moving across the range of permissible values from $\delta = 1$ to $\delta = 0$, we find that the range of values $\alpha(t,T)$ varies from its maximum to its minimum and that the weighting function begins as linear at $\delta = 1$, becomes strictly concave for $0 < \delta < 1$, and then finally becomes linear and flat (equal weights) at $\delta = 0$. Thus, different values of the parameter δ imply different relative sensitivity to early and chronic poverty.

One can also choose a family of weights that allows for a movement in the direction of a lifetime poverty measure that becomes more sensitive to early poverty through parameter changes that imply either a sole concern with the early poverty experience of individuals or a concern with both early and chronic poverty experiences.

[9]The HZ measure also has an additional component relating to a retrospective or "whole life" perspective. This is based on average income or consumption over the lifetime (e.g., such as the permanent income concept). We ignore this feature of this measure here.

A simple example of such a family of weighting functions is the quadratic function $\alpha(t, T) = c_0 - c_1 t - c_2(t-1)^2, c_0, c_1, c_2 \geq 0$, with $c_0 = c_1 T + c_2(T-1)^2 + 1$ to ensure $\alpha_t > 0$ for all t. This function is linear if $c_2 = 0$ but strictly concave for $c_2 > 0$. For the non-normalized weights, $\alpha(1, T) = c_0 - c_1$ and $\alpha(T, T) = 1$ and so the difference $\alpha(1, T) - \alpha(T, T) = c_1(T-1) + c_2(T-1)$ reflects the degree of sensitivity to early poverty. Thus, the overall drop in the set of non-normalized weights is increasing in both c_1 and c_2. The anchor for any set of non-normalized weights for this family is $\alpha(T, T) = 1$. Thus, increasing either c_1 or c_2 will also increase the drop in the set of normalized weights. Increasing c_1 when $c_2 = 0$ leads to a greater sensitivity to early poverty concerns while retaining linearity of the weighting function, implying no sensitivity to chronic poverty. Setting $c_1 = 0$ and increasing $c_2 > 0$ increases sensitivity to early poverty but does so while also reflecting a sensitivity to chronic poverty. Thus, through use of a two parameter family of weights for $\alpha(t, T)$ one can design changes in the weights that are more flexible in terms of how one changes sensitivity to early and chronic poverty concerns.

We now consider the (EDE) poverty gaps generated by some examples of the HZ measure. We use the weighting function $\alpha(t, T) = (1 - \frac{t}{T+1})^{\delta}, 0 < \delta < 1$ and consider values $\delta = 0.5$ and 0.2. The smaller value of δ implies less sensitivity to early poverty as measured by the drop $\alpha(1, T) - \alpha(T, T)$. As always the weights are normalized by dividing by the sum $\sum_{t=1}^{T} \alpha(t, T)$ to create a sum of 1 for the final weights. Again, we use the FGT poverty index $p(x_t; z) = (1 - x_t/z)^{\varepsilon}$, with $\varepsilon = 1$ unless otherwise stated. Consider the same income vectors $\mathbf{x} = (5, 1, 1, 5)$ and $\mathbf{y} = (1, 5, 5, 1)$ as used before. Using α_t for $\alpha(t, T)$, we obtain the following sets of weights for $\delta = 0.5, 0.2$:

$$\delta = 0.5\colon\ \alpha_1 = 0.325,\ \alpha_2 = 0.282,\ \alpha_3 = 0.230,\ \alpha_4 = 0.163 \tag{5}$$

$$\delta = 0.2\colon\ \widetilde{\alpha}_1 = 0.280,\ \widetilde{\alpha}_2 = 0.264,\ \widetilde{\alpha}_3 = 0.244,\ \widetilde{\alpha}_4 = 0.212 \tag{6}$$

Both sets of weights come from a "concave function" and so spreading out the two periods of poverty in a manner described by the chronic poverty axiom will lead to a decrease in lifetime poverty. This can be illustrated by the results that, for $\gamma = 0.5$, $P(\mathbf{x}, z) = 0.40952 > P(\mathbf{y}, z) = 0.39048$ and for $\gamma = 0.2$, $P(\mathbf{x}, z) = 0.40636 > P(\mathbf{y}, z) = 0.39364$. The EDE value for these profiles in terms of the HZ measure will depend on both the parameter ε and δ. Thus, we write the EDE poverty gap as $\widehat{g}_{\mathbf{x}} = \widehat{g}_{\mathbf{x}}(\delta, \varepsilon)$. The extent to which this value differs from the average (raw) poverty gap reflects the impact of the temporal pattern (i.e., both early and chronic poverty concerns) on the HZ measure.[10]

To isolate the effects of the temporal pattern of spells, we first select the equal weights case ($\alpha_t = \frac{1}{T}, \forall t = 1, 2, ..., T$) which eliminates both chronic poverty and early poverty considerations. In terms of our specific weighting function above, this would correspond to initial selection of $\delta = 0$ to reflect equal weights. We then introduce a weighting scheme with sensitivity to timing of poverty spells.

[10]Unlike the BCD measure, the EDE calculation of the cost of poverty for the HZ measure is the same whether one uses the *original* weights chosen or equal weights per period (i.e., assuming no temporal effects regarding the hypothetical EDE consumption profile that has equal poverty gaps in each period). This follows from the normalization of weights, which implies they sum to one.

For the FGT snapshot measure with $\varepsilon = 1$, in conjunction with $\delta = 0$, we obtain $\widehat{g}_{\mathbf{x}}(0, 1) = \widehat{g}_{\mathbf{y}}(0, 1) = \overline{g}_{\mathbf{x}} = \overline{g}_{\mathbf{y}} = 2$. Taking into account the temporal aspects through choice of $\delta = 0.5$ we obtain $\widehat{g}_{\mathbf{x}}(0.5, 1) = 2.048$ and $\widehat{g}_{\mathbf{y}}(0.5, 1) = 1.952$. Compared to equal weighting across time periods, the cost of poverty in profile **x** rises while that for **y** falls. This highlights an important point. In comparison to equal weighting, introducing a concern for time sensitivity can of course lead to a reduction in the measured value of lifetime poverty according to the HZ measure. In conjunction with the use of $\varepsilon = 1$ for the FGT measure, which is neutral in regards to intensity of poverty in any period, note that equal weighting across time periods implies that vectors of poverty gaps $(0, 4, 4, 0)$, $(4, 0, 0, 4)$, and $(2, 2, 2, 2)$ all generate the same amount of lifetime poverty. But once we introduce a concern with chronic poverty - and early poverty - by using a weighting function that is both decreasing and concave in t, the cost of poverty rises above 2 (per period) for the distribution with more chronic poverty and falls below 2 for the profile with poverty spells (more) spread out over time. In one sense profile $\mathbf{y} = (1, 5, 5, 1)$ may seem worse than $(2, 2, 2, 2)$ in that it has an earlier spell of poverty which is deeper. However, the two spells of poverty in **y** are separated by two time periods while for $(2, 2, 2, 2)$ poverty is experienced in any pair of successive years and so no relief from consecutive poverty experiences occurs. Thus, it is not unrealistic to assign a lower value of poverty to profile $(1, 5, 5, 1)$ than to $(2, 2, 2, 2)$, especially given the presumption that intensity of spells in a snapshot sense is irrelevant (i.e., through use of $\varepsilon = 1$ for the FGT measure). Thus, it seems reasonable that the EDE poverty gap can be less than the average (raw) poverty gap.

Similarly, using $\delta = 0.2$, implying a greater degree of concavity of weights, the cost of poverty for profiles **x** and **y** becomes $\widehat{g}_{\mathbf{x}}(0.5, 1) = 2.032$ and $\widehat{g}_{\mathbf{y}}(0.5, 1) = 1.968$. Again, there is more chronic poverty present in profile **x** than in **y**, but the pattern of early poverty is also different. Consequently, it is difficult to determine a priori which of the two weighting functions (i.e., $\delta = 0.5$ or $\delta = 0.2$) will create a bigger difference in the EDEs of these two profiles since it is not really possible to separate the two influences for this weighting function.

To see this more clearly, consider the following example. Starting with profile $\mathbf{y} = (5, 1, 1, 5)$, suppose we create another profile **x** by moving the poverty spell of period 2 in **y** to period 1,thus generating $\mathbf{x} = (1, 5, 1, 5)$. Due to the early poverty axiom, any HZ measure must assign higher lifetime poverty to profile **x** than to profile **y** despite the fact that **y** has more chronic poverty (i.e., the two spells of poverty are contiguous in **y**).[11] Accordingly, for this example the additional early poverty in **x** dominates the additional chronic poverty of **y**. But note that the set of weights determined by $\delta = 0.2$ expresses less concern with early poverty and more concern with chronic poverty compared to that with $\delta = 0.5$ (at least roughly speaking). As a result it is intuitively pleasing that the reduction in the cost of poverty in moving from **y** to **x** is less with $\delta = 0.2$ compared to $\delta = 0.5$. This can be seen as $\delta = 0.2$ implies $\widehat{g}_{\mathbf{x}} = 2.094$ and $\widehat{g}_{\mathbf{y}} = 2.032$, a drop of 0.062, while $\delta = 0.5$ leads to $\widehat{g}_{\mathbf{x}} = 2.22$ and $\widehat{g}_{\mathbf{y}} = 2.05$, a drop of 0.17.

Overall it is evident from the examples above that comparisons of lifetime poverty using the HZ measure can indeed be rather complicated. We suggest that in fact this

[11] This is obviously the case given $a(t, T)$ must be decreasing in t for any HZ measure.

is not unreasonable when considering more than one characteristic of the pattern of poverty spells experienced in a lifetime. Spreading out poverty spells to earlier and later periods in life may in some cases create less chronic poverty but also different patterns of early/late poverty experiences. Despite the complications, however, one can obtain some insights into the different aspects of lifetime poverty comparisons by taking care to use alternative weighting functions to "tease out" relative concerns with early and chronic poverty experiences. We demonstrate this in the empirical applications using the weighting functions based on the family $\alpha(t, T) = c_0 - c_1 t - c_2(t-1)^2$.

2.3 The F measure

We now turn our attention to the F measure (Foster). This measure reflects a different approach to measuring chronic poverty. Unlike the BCD and HZ measures, F does not rely on a set of weights applied to snapshot poverty experiences to reflect a concern with chronic poverty. Rather, the F measure employs a selection criterion in order to identify who is chronically poor. This criterion depends only on the fraction of periods that a person is in poverty throughout his lifetime and not on the particular pattern of poverty spells and in particular not on how close in time the spells occur. So, for example, the two profiles $\mathbf{x} = (5, 1, 1, 5)$ and $\mathbf{y} = (1, 5, 5, 1)$ are treated in an equivalent manner by F since in both cases the person experiences two poverty spells over four years (50% of his lifetime) and the poverty gaps are of equivalent size.

The essential parameter reflecting sensitivity toward chronic poverty for the F measure is τ, the minimum fraction of time a person must have spent in poverty during his lifetime in order to be classified as having been chronically poor, with $0 \leq \tau \leq 1$. Thus, individuals reflected by income profiles $\mathbf{x}$ and $\mathbf{y}$ above would be classified as chronically poor iff τ is chosen to be no greater than 0.5. It turns out that to gain intuition about F one needs to compare sets of income profiles of individuals and aggregate over the number of individuals in each set. The measure F can then be defined by:

$$P_F = \frac{1}{NT} \sum_{i=1}^{N} \sum_{t=1}^{T} p^*_{i,t} \tag{7}$$

where

$$p^*_{i,t} = \begin{Bmatrix} p_{i,t} & \text{if individual } i \text{ is poor in at least } \tau \text{ of the } T \text{ periods} \\ 0 & \text{otherwise} \end{Bmatrix} \tag{8}$$

which implies an EDE poverty gap amount defined by:

$$P_F = \widehat{p} \tag{9}$$

and

$$\widehat{g} = z P_F^{1/\varepsilon} \tag{10}$$

The smaller the value chosen for τ, the more people will be potentially considered as chronically poor and so the more poverty spells are accounted for by F and the greater is P_F. In this sense the sensitivity towards chronic poverty is decreasing in τ. Consider two populations, 1 and 2, each composed of three persons with the following consumption profiles where $\mathbf{x}^{kl}$ represents person l's consumption profile where this person belongs to population k, $k = 1, 2$ and $l = 1, 2, 3$:

$$\text{Population 1:} \quad \left\{\mathbf{x}^{11} = (1, 5, 5, 5); \mathbf{x}^{12} = (1, 1, 5, 5); \mathbf{x}^{13} = (1, 1, 1, 5)\right\}$$

$$\text{Population 2:} \quad \left\{\mathbf{x}^{21} = (1, 1, 5, 5); \mathbf{x}^{22} = (1, 1, 5, 5); \mathbf{x}^{23} = (1, 1, 5, 5)\right\}$$

The examples have been chosen to make comparisons as simple as possible with a focus on the effect of the choice of parameter τ. In general we can write the EDE poverty gap for F as $\widehat{g}(\tau, \varepsilon)$. For the choice $\varepsilon = 1$ it is simply the sum of all the relative poverty gaps experienced by each person who is identified as chronically poor, divided by NT, and then multiplied by the poverty line z. Thus, for $\varepsilon = 1$ we report the values of the EDE for each population as $\widehat{g}^1$ and $\widehat{g}^2$ for the following ranges of τ.

$$3/4 < \tau \leq 1: \ \widehat{g}^1 = \widehat{g}^2 = 0$$

$$1/2 < \tau \leq 3/4: \ \widehat{g}^1 = 1 > \widehat{g}^2 = 0$$

$$1/4 < \tau \leq 1/2: \ \widehat{g}^1 = 5/3 < \widehat{g}^2 = 2$$

$$0 \leq \tau \leq 1/4: \ \widehat{g}^1 = 2 = \widehat{g}^2 = 2$$

One can see how the determination of which population suffers more chronic poverty depends on the choice of τ in an intuitive manner. Population 1 has more chronic poverty for the relatively high range of values for τ since the only person in either population who suffers poverty in three of the four periods of his life is in population 1. Alternatively, for the more moderate range of τ (i.e., $1/4 < \tau \leq 1/2$), we find that population 2 has more chronic poverty due to the fact that three people in population 2 experience poverty in 50% or more of their lifetimes while only one person in Population 1 qualifies under this criterion.

If each person's poverty experiences are included in computing P_F (i.e., in effect using $\tau = 0$ as the selection criterion) the result is a value for total poverty. That is, even people who suffer only one spell of poverty have their poverty experience included. Moreover, unlike the BCD and HZ measures, since spells of poverty for those who are counted as chronically poor are not weighted any differently than for those with only one spell, the F measure for $\tau = 0$ can be argued to effectively measure "total poverty". Thus, for the populations above, the EDE value for total poverty is 2 for each of the populations. We then divide the EDE cost of poverty for a given choice of $\tau > 0$ by the cost of total poverty (i.e., EDE for the case $\tau = 0$). Doing so gives the fraction of poverty ascribed to chronic poverty (CP) for each of the following ranges:

Percentage of poverty due to chronic poverty		
Range of τ	Population 1	Population 2
$3/4 < \tau \leq 1$	0%	0%
$1/2 < \tau \leq 3/4$	50%	0%
$1/4 < \tau \leq 1/2$	83%	100%
$0 \leq \tau \leq 1/4$	100%	100%

2.4 Further remarks on BCD, HZ, F measures

By comparing these three lifetime poverty measures we see quite substantial differences in (i) the attention paid to how chronic poverty is conceptualized, (ii) how one views the impact of changes in the pattern (or frequency) of poverty spells within lifetimes on the measurement of lifetime poverty, and (iii) how one should adjust the sensitivity to chronic poverty within each methodology. In particular, it is interesting to consider how the different measures change as the relevant parameters take their limiting values. For example, for F it is clear that as $\tau \to 1$ (i.e., the measure becomes "least sensitive" to chronic poverty) one becomes concerned only with those who experience poverty in every period of life. For BCD it is essentially the opposite case in that as the parameter which measures sensitivity to the chronic nature of poverty (γ) approaches infinity, the measure 'picks up' only those who are poor in every period of life. This difference reflects the different perspectives on how to measure chronic poverty. F becomes more sensitive to chronic poverty by relaxing the selection criterion for classifying individuals as chronically poor (i.e., reducing τ). BCD becomes more sensitive to chronic poverty by increasing the weight on those poverty spells that occur in contiguous strings of poverty (i.e., increasing γ) and through this process increasingly greater weight is placed on those with longer strings of poverty experience relative to those with shorter strings or those who are only occasionally poor. The HZ measure is interested in both chronic and early poverty concerns and so a straightforward comparison with the other measures in this regard is not generally possible.

To see the above relationships more clearly, note that in the BCD measure as $\gamma \to \infty$ the relative weight on a spell of poverty for someone who experiences poverty in every period of life (i.e., T periods) compared to that of someone who experiences poverty in $T-1$ consecutive periods approaches infinity since $\frac{\gamma^T}{\gamma^{T-1}} = \gamma$. And so intuitively only the person experiencing poverty in each period *matters*.[12] In the case of the weighting function $\alpha(t, T) = (1 - \frac{t}{T+1})^\delta$, $0 < \delta < 1$ for the HZ measure, we cannot allow δ to exceed one since then the weighting function becomes convex and so HZ would violate the chronic poverty axiom. In the case of the two parameter family of weights $\alpha(t, T) = c_0 - c_1 t - c_2(t-1)^2$, recall that, at $c_2 = 0$, increasing c_1 increases sensitivity to early poverty without any concern for chronic poverty while increasing c_2 increases sensitivity to early while maintaining a concern for chronic poverty. By setting $c_1 = c_2 = c$ we find that as $c \to \infty$ the measure is driven entirely by the first period poverty experience of individuals.[13] Thus, not surprisingly, for the HZ measure, considering such limits may lead to exclusive concern with early poverty while ignoring the chronic poverty property altogether.

[12]One can show that if there are two people in a population, with $p_{1,t}$ and $p_{2,t}$ representing poverty of persons 1 and 2, respectively, where person 1 incurs poverty in each of T (consecutive) periods while person 2 in $T-1$ consecutive periods, then as $\gamma \to \infty$ we have $\widehat{g} = z \left(\frac{\sum_{t=1}^{T} p_{1,t}}{2T} \right)^{1/\varepsilon}$.

[13]In particular, we obtain $\widehat{g} = z \left(\frac{1}{N} \Sigma_{i=1}^{N} \Sigma_{t=1}^{T} \frac{3(-T+T^2+(t-t^2)}{T(-3T+1+2T^2)} p_{i,1} \right)^{1/\varepsilon}$; that is, only poverty in the first period *matters*.

It is also instructive to consider what happens to these three lifetime poverty measures in special cases where consumption in a given (critical) period varies from being out of (snapshot) poverty to in (snapshot) poverty. Consider the consumption profile $\mathbf{x} = (5, 1, \kappa, 1)$ where again $z = 5$. For $\kappa = 5$ the F measure suggests zero chronic poverty for any $\tau > 0.5$. However, for $\kappa = 5 - \epsilon$, even for $\epsilon > 0$ arbitrarily small, the F measure suggests some finite level of poverty for any $0.5 < \tau \leq 0.75$. Thus, F is not generally continuous as consumption in a given period approaches the poverty line (from below). For the BCD measure, there is no "penalty" for chronic poverty for any of the poverty spells in $\mathbf{x}$ when $\kappa = 5$ but there is when $\kappa = 5 - \epsilon$. In fact, the BCD measure changes the weights from unity to γ^2 on each poverty spell when κ falls from 5 to below 5. This reflects a different sort of discontinuity. For the HZ measure, there is no discontinuity property since the weights are not determined by the pattern of poverty spells but rather the weighting function is given a priori and simply has the property of being sensitive to chronic poverty according to the concavity of the weighting function. It follows that, when implementing empirical applications of measuring lifetime poverty, one needs to be careful about the implications of measurement error especially for the BCD and F measures. Small changes in the value of consumption close to the poverty line can have substantial effects on results. Varying the poverty line z would provide a useful robustness check not just for the usual reasons suggested with cross-sectional (snapshot) poverty measurement but also to check on the possibility of significant errors resulting from the discontinuity properties described above.[14]

Another interesting (and related) feature of the BCD measure is how it treats a person with a long string of poverty spells compared to someone with a similar string but where in one case consumption rises to the poverty line z. For example, someone in the data set used in this paper could have a maximum of 26 consecutive years of consumption below the poverty line. In fact, three people do. Suppose the poverty line is \$5,000 and that such a (hypothetical) person has a poverty gap of \$100 in each year. Further, suppose there are 1,000 people in the sample and that this one person is the only person to experience any poverty. Now, suppose we measure the EDE poverty gap using the second method discussed in this paper; that is, we use weights of one for each poverty experience in this hypothetical profile. The result is an EDE of approximately \$3,355. That means this one person's contribution to total poverty from a \$100 poverty gap in each year of his life creates as much poverty as in the hypothetical scenario where each of the 1,000 people incurs a poverty gap of \$3,355 in each year of his life but under the measurement assumption of treating these poverty spells as if they were isolated.[15] Now, compare this situation with one in which the only difference is that in year 13 of this sequence, the person experiencing poverty has consumption of \$5,000 and so "just" escapes being poor for one time

[14]Although such a problem may not be important when using sufficiently large data sets, the subsequent example suggests some care is nonetheless worthwhile.

[15]Note that another way to construct a population with the same measured poverty would be to have each person have alternating periods with a poverty gap of double the \$3,355 in every other period with zero poverty (say consumption equal to \$5,000) in the alternate periods. In this scenario, the BCD measure would not assign any penalty due to chronic poverty.

period. This person then would have 12 consecutive periods of experiencing a \$100 poverty gap, followed by one period with no poverty gap, then followed by 13 further consecutive periods of experiencing a \$100 poverty gap. The result in this case is an EDE of approximately \$0.30. The ratio of the cost of poverty between these scenarios is more that 10,000. This ratio is the same whether or not one applies the "penalty" for chronic poverty in the EDE calculation. Hence, we see that the measure in some circumstances is very sensitive to small changes in a single period of consumption. This is also true for the F measure. For any value of $\tau > 25/26$, F would assign no chronic poverty to the second scenario but some chronic poverty to the first. This example points to the need to use robustness checks in any empirical application since the difference between the above profiles could easily be the result of measurement error.

3 Empirical application

In this section we provide a demonstration of the implications and interpretation of results when measuring lifetime/chronic poverty for the PSID data over the years 1967–1993 ($T = 26$). Having 26 consecutive years of data is unusual and provides a useful application for comparing these measures.

We have continuous information on 1,494 households. On the basis of the head of the household, we classify each household as White (W) or Non-White (NW), of which there are 1,047 and 447, respectively. For the HZ measure, we determine age in terms of the head of the household. Since the main reason for adopting the early poverty axiom in the HZ measure is to account for the heightened sensitivity of poverty experienced early in life, we remove those who never have household size greater than 2 (i.e., we remove possible instances of childless couples). Making this restriction leaves 883 W and 397 NW observations. Although we are unable to ascertain the ages of children in the household, it is natural to expect a head of age 20–25 (in 1967) to have younger children than a head aged 40–45.[16]

We then remove anyone greater than 55 in year 1 (1967), which leaves 849 W and 386 NW. We do this in order to have a greatest possible value T that is not driven by a handful of individuals. This represents our sample referred to as "all ages" throughout the rest of the paper. We also create a sample involving those households whose head is aged 20 to 25 in the first year (1967). We do this in order to have a relatively balanced cohort sample for Whites and Non-Whites. This creates a sample that is especially relevant to the theoretical or conceptual approach of the HZ measure. It is also useful to check how the other measures compare two groups with a more balanced cohort since patterns of poverty can be influenced by stage of life and the White and Non-White samples have significant differences in the distribution of the ages of the heads. In 1967, within the White group 2.7% are under age 20 while 82.7% are over 25 while within the Non-White group less than 1% are under age 20 while 92.7% are over 25. The differences in the age distribution is much less for

[16] Admittedly, there may well be households of size greater than two composed only of adults. Again, we can not screen out households on this basis.

the restricted 20–25 age sample with the following table giving the percentage of this sub-sample at each head-of-household age (in 1967):

Age distribution in 20–25 sample						
%	20	21	22	23	24	25
W	10	15.4	15	19.3	17.9	21.4
NW	10.7	10.7	14.3	14.3	28.6	21.4

The four panels of Fig. 2 are the cumulative distributions of the number of periods individuals spend in poverty for the various sub-populations described above. Consider first the top two panels. In the all ages sample 76.0% of Whites do not experience any periods in poverty while this is the case for only 29.5% of Non-Whites. For the sample ages 20–25, the fraction of Whites who do not experience any poverty is 72.9% while the fraction of Non-Whites is 32.1%. Although one can see from the graphs that while the cumulative distribution is still lower (worse total poverty experienced) for Non-Whites in the sample ages 20–25, the difference between Whites and Non-Whites is less stark than for the all ages sample. We find,

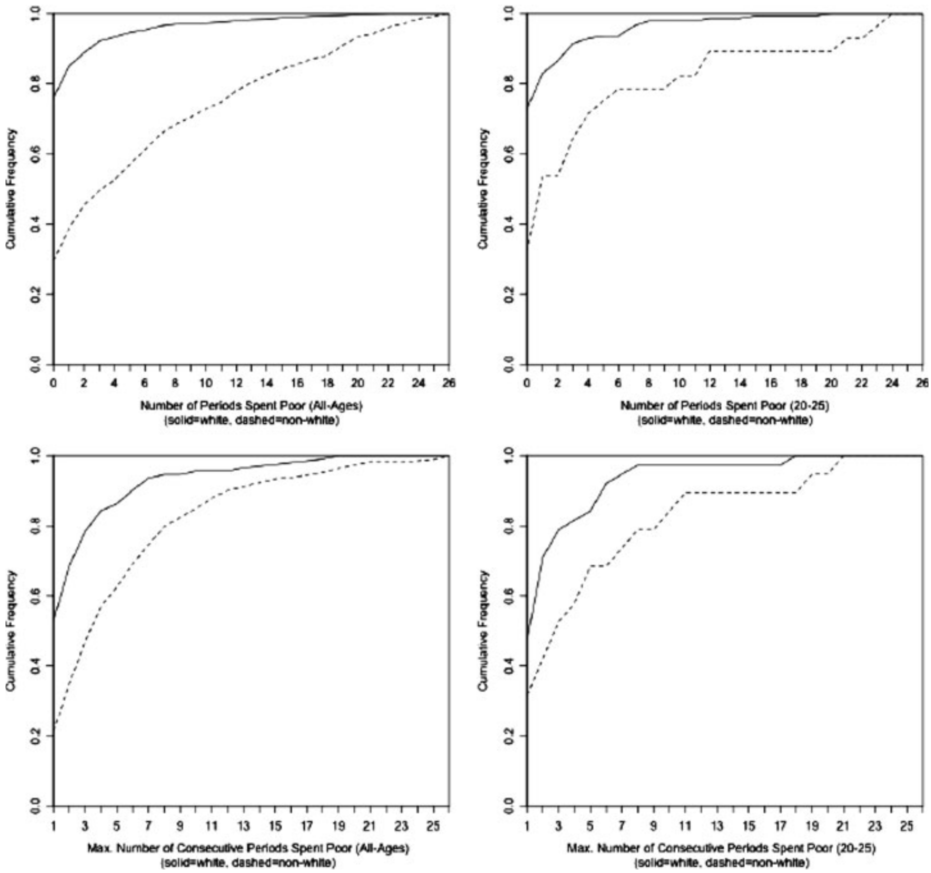


Fig. 2 Cumulative frequencies of poverty spells

for example, that for Whites the fraction of households in the all ages versus age 20–25 samples who experience poverty in at least five years (out of 26) is 6.7% versus 7.1%, with equivalent numbers for being in poverty in at least 10 years being 2.9% versus 2.1%, respectively. For Non-Whites these numbers are 47.4% (all ages) versus 28.6% (aged 20–25) spending at least 5 years in poverty and 29.5% (all ages) versus 21.4% (aged 20–25) spending at least 10 years in poverty.

The bottom two panels in Fig. 2 provide the cumulative distributions for consecutive periods spent in poverty conditional on a person being poor in at least one period of life. In the all ages sample 15.7% of Whites who have been in poverty experience at least 5 consecutive years of poverty while approximately 43.0% of Non-Whites do. The equivalent numbers for the sample 20–25 are 18.4% for Whites and 42.1% for Non-Whites. In terms of both total poverty and chronic poverty, it appears that the difference between the two samples is less for Whites than for Non-Whites. Moreover, these descriptive statistics suggest that Non-Whites in the age/cohort group with heads aged 20–25 in 1967 and so aged 40–45 in 1993 experience less poverty and are less different from the Whites than is the case of the all ages sample. We will see that the measures of lifetime poverty that focus on chronic poverty only (i.e., the BCD and F measures) bear this out.

Importantly, it turns out that the three people from our overall sample who experience poverty in every period of life are from the NW set but not in the ages 20–25 group (i.e., 20–25 cohort). Comparing the two samples (all ages and 20–25 cohort) for all three poverty measures provides us with a sensitivity test as we will see below. There are also important differences between these samples in the percentage of households with average income (i.e., over all periods 1967–1993) falling below the poverty line, with the fraction for Whites and Non-Whites being 0.71% and 13.73% (respectively) in the all ages sample and 0.71% and 2.14% in the 20–25 ages sample. These comparisons demonstrate the importance of paying attention to different cohorts for all three measures.[17]

The HZ measure is more sensitive to poverty the earlier it occurs in life. We computed the relative frequency of poverty spells for the first and second halves of the 26 year period for both samples. In the all ages sample there is somewhat higher poverty experience in the second half of the period (55.7%) than in the first half (44.5%) for Whites and almost no difference for Non-Whites (51.5% in the first half). For the sample with heads aged 20–25 at the beginning of the sample, and so who are aged 45–50 at the end of the 26 years covered in the panel, there is substantially more poverty experience for Non-Whites in the first half of the period (63.9% versus 36.1% in the second half) and also a somewhat higher frequency of poverty experienced by Whites in the first half (56.9%). The early poverty experience of Non-Whites in the 20–25 cohort sample is reflected in the results below for the HZ poverty measure.[18]

[17] The number in the NW sample ages 20–25, however, is only 28, with 140 in the W sample.

[18] This rather crude method of checking for early versus late poverty is likely to provide a more reasonable connection to the HZ measure for the ages 20–25 sample since the relative weights over time are approximately the same due to the closeness of the ages of the families over time. This is not the case for the all ages sample and so one cannot put much confidence in such a descriptive statistic and its relationship to early versus late poverty experience.

The following tables provide the results for the two samples (all ages and 20–25 cohort) for all three lifetime poverty measures (Tables 1, 2, 3, 4, 5, 6, 7 and 8). For each case we use the FGT snapshot poverty measures with $\varepsilon = 1, 2$. For the HZ measure one needs to use adjustments in the time index (t) in order to account for the fact that early poverty is an age-related concern.[19] We use the weighting function $\alpha(t, T) = (1 - \frac{t}{T+1})^{\delta}$, $0 < \delta < 1$ (see Tables 3 and 4) while results for the quadratic weighting function are reported in Tables 5 and 6. Recall that as δ ranges from zero to one this weighting function becomes more sensitive to early poverty and, in the limit $\delta \to 1$ there is no sensitivity to chronic poverty. For the BCD measure (see Tables 1 and 2), the parameter $\gamma \geq 1$ reflects the sensitivity of concern with chronic poverty, and this increases with γ, while for the F measure, the relevant parameter is τ $(0 \leq \tau \leq 1)$ and sensitivity of chronic poverty is decreasing in τ.

We treat as our baseline case the EDE values for $\varepsilon = 1$ when the choice of parameters for these measures are $\gamma = 1$ for the BCD measure, $\delta = 0$ for the HZ measure,[20] and $\tau = 0$ for the F measure. Using these parameter values in each case gives us the average or raw poverty gap over the poverty experiences of all individuals over all periods in the sample. This implies for the all ages sample an average poverty gap of \$69.09 for whites and \$417.21 for non-whites and so the average poverty gap is approximately six times higher for non-whites. In the sample with 20–25 cohort, the average poverty gap for whites (\$77.21) is somewhat higher and substantially lower for non-whites (\$309.57). Thus the ratio for non-whites to whites falls to about 4 for the more balanced cohort.

For any $\gamma > 1$ the BCD measure will rise as long as at least one person has at least one string of poverty experiences involving at least two consecutive spells of poverty. If there is no such instance, then the cost of poverty will simply be the raw poverty gap. We see through increasing γ to two and then three that the EDE cost of poverty rises much faster for non-whites than for whites, with the ratio increasing from 6.04 to 836.22 and then to 17,347 for the all ages sample.[21] The increase in the ratio is much less for the sample with ages 20–25 where this ratio rises from 4.01 to 43.07 to 133.27 (see Tables 1 and 2). One reason for this is that the three individuals in the all ages sample, all of whom are non-white, who experience poverty in each year of the sample period are not in the ages 20–25 sample. If we omit these three persons from the all ages sample, then the ratio increases from 5.77 to 133.53 to 1,585.53. In other words, including these three people adds about 5% more to the ratio in the raw poverty gaps but increases the ratio by about 500% for the case of $\gamma = 2$ and by 1,100% for the case of $\gamma = 3$. This highlights the sensitivity of the BCD measure to the presence of a few people in the sample who experience poverty in every period.

[19] Let A_{it} represent age of person i in year t, $\underline{m} = \min\{A_{i1}\}, \forall i$, the minimum age in year 1 (1967) of all persons, and $\overline{m} = \min\{A_{iT}\}, \forall i$, the maximum age in year T (1992) of all persons. We then make the assignment $\alpha(t, T)$ for person i according to $t = A_{it} - \underline{m} + 1$, $T = \overline{m} - \underline{m} + 1$. In the all ages sample $\underline{m} = 17$ and $\overline{m} = 80$, and so someone who is 30 in year 1 has weight $\alpha(14, 64)$ in year 1 while someone who is 20 in year 1 has weight $\alpha(4, 64)$.

[20] More generally for the HZ measure the baseline case is the the equal weighting case; i.e., $\alpha(t, T) = 1/T$.

[21] Recall that the EDE falls in γ if one uses the actual BCD weights to compute the hypothetical profile of consumption for the EDE calculation which we do in these tables. The reason is that the hypothetical profile has poverty experienced in every period of every person's life and so these poverty gaps attract the maximum possible penalty for chronic poverty.

Table 1 EDE poverty gap (BCD measure). $\widehat{g}(\gamma, \varepsilon), \varepsilon = 1$

	All ages			20–25 cohort		
γ	White	Non-White	Ratio	White	Non-White	Ratio
1	69.09	417.21	6.04	77.21	309.57	4.01
2	0.03	25.64	836.22	0.06	2.53	43.07
3	0.00...	23.73	17,347	0.00...	0.31	133.27
∞	0	21.58	–	0	0	–

Table 2 EDE poverty gap (BCD measure). $\widehat{g}(\gamma, \varepsilon), \varepsilon = 2$

	All ages			20–25 cohort		
γ	White	Non-White	Ratio	White	Non-White	Ratio
1	452.15	1,001.48	2.21	492.77	850.07	1.73
2	8.43	275.09	32.64	13.87	85.44	6.16
3	1.70	266.73	157.34	2.74	30.04	10.96
∞	0	257.46	–	0	0	–

Table 3 EDE poverty gap (HZ measure). $\widehat{g}(\delta, \varepsilon), \varepsilon = 1$

	All ages			20–25 cohort		
δ	White	Non-White	Ratio	White	Non-White	Ratio
0.00	69.09	417.21	6.04	77.21	309.57	4.01
0.25	70.48	420.97	5.93	80.27	327.20	4.08
0.50	71.26	415.53	5.83	81.77	339.03	4.15
0.75	70.44	404.15	5.74	82.19	346.08	4.21
1.00	68.93	389.22	5.65	81.89	349.36	4.27

Table 4 EDE poverty gap (HZ measure). $\widehat{g}(\delta, \varepsilon), \varepsilon = 2$

	All ages			20–25 cohort		
δ	White	Non-White	Ratio	White	Non-White	Ratio
0.00	452.15	1001.48	2.21	492.77	850.07	1.73
0.25	459.59	1005.83	2.19	499.21	873.01	1.75
0.50	461.16	999.10	2.17	500.77	886.86	1.77
0.75	458.72	984.99	2.15	499.06	893.54	1.79
1.00	453.60	966.13	2.13	495.28	894.77	1.81

Table 5 EDE poverty gap (HZ measure: all ages). $\widehat{g}(c_1, c_2, \varepsilon), \varepsilon = 1$

	White			Non-White		
$c_1 \backslash c_2$	0	0.5	1	0	0.5	1
0	69.09	73.57	73.57	417.21	425.08	425.09
0.5	68.94	73.52	73.54	390.06	424.65	424.87
1	68.93	73.46	73.52	389.22	424.23	424.65

Table 6 EDE poverty gap (HZ measure: 20–25 cohort). $\widehat{g}(c_1, c_2, \varepsilon), \varepsilon = 1$

	White			Non-White		
$c_1 \backslash c_2$	0	0.5	1	0	0.5	1
0	77.21	84.76	84.78	309.57	358.34	358.42
0.5	81.61	84.70	84.74	347.02	358.18	358.34
1	81.89	84.64	84.71	349.36	358.03	358.26

Although this may be a desirable normative property, one must be cautious about the possibility of measurement error. Also, a relatively small change in the poverty line could affect the number of people with such consistent poverty experiences and significantly affect the overall comparisons.

For the HZ measure an increase in δ leads to almost no change in the EDE cost of poverty for Whites in the all ages sample and also only a modest decrease for Non-Whites in the all ages sample. The ratio changes very little over these values of δ. This means that the actual pattern experienced, including both early poverty and chronic poverty experiences, does not have important effects on the cost of poverty for this particular weighting function. There is a more substantial change in the measured cost of poverty however, as one changes δ in the sample with 20–25 cohort. In this case the EDE cost of poverty rises by about 13% for non-whites as one varies δ from zero to one, and 6% for whites, leading to a ratio of 4.01 at $\delta = 0$ and 4.27 at $\delta = 1$. Note that, at both of these extreme values of δ, the weighting function is linear, hence expressing no sensitivity to chronic poverty. Thus the difference between the cases is simply that at $\delta = 0$ there is no sensitivity to early poverty concerns while at $\delta = 1$ there is. This is a particularly relevant comparison to make for the group of heads of households aged 20–25 in 1967 (and so 45–50 in 1993) given that one expects there are young children in most, if not all, of these units at the beginning of the time period. A concern with early poverty implies a bigger increase in the cost of poverty for non-whites compared to whites.

In Tables 5 and 6, we report the results for the case of $\varepsilon = 1$ for the two-parameter family of weighting functions for the HZ measure, $\alpha(t, T) = c_0 - c_1 t - c_2 (t-1)^2$, which was introduced in Section 2.2.[22] Recall that while increasing either of c_1 or c_2 leads to an increase in sensitivity to early poverty, each has a different implication regarding sensitivity to chronic poverty. It is of particular interest to look at the borders of the results matrix. In Table 5 (all ages), for Whites, starting with a value of $c_2 = 0$, an increase in c_1 leads to a small reduction in the (EDE) cost of poverty while an increase in c_2 (with $c_1 = 0$) leads to a somewhat higher increase in lifetime poverty. For Non-Whites, the same direction of effects is evident, although the extent is more significant. Therefore, for the all ages case and for both Whites and Non-Whites, it appears that early poverty is not an important property of aggregate lifetime poverty but chronic poverty is (albeit in a more significant fashion for Non-Whites). For the 20–25 cohort, however, increasing sensitivity for both chronic and early poverty leads to increases in the cost of poverty, again more significantly for Non-Whites (i.e., when increasing c_2 with $c_1 = 0$ and comparing to the reverse case). These results demonstrate that, for the HZ measure, it is helpful to use alternative weighting functions that reflect in different ways the effects of early and chronic poverty concerns.

For the F measure, as τ rises from zero (everyone included as being in chronic poverty) to one (nobody included in chronic poverty) the cost of poverty must fall (or at least not rise). We see (Tables 7 and 8) for both samples that this cost falls less quickly for non-whites than for whites (i.e., the ratio NW to W is increasing in τ).[23]

[22]The results with $\varepsilon = 2$ are qualitatively similar and so are not reported.

[23]At $\tau = 1$ chronic poverty is present only for non-whites in the all ages sample. Recall, there are no cases of persons being poor in each period in the white (all ages) group nor in the non-white ages 20–25 group.

Table 7 EDE poverty gap (F measure). $\widehat{g}(\tau, \varepsilon)$, $\varepsilon = 1$

	All ages			20–25 cohort		
τ	White	Non-White	Ratio	White	Non-White	Ratio
0.00	69.09	417.21	6.04	77.21	309.57	4.01
0.25	37.18	369.63	9.94	42.45	249.10	5.87
0.50	23.22	282.64	12.17	19.54	171.61	8.78
0.75	10.31	151.85	14.72	15.76	171.61	10.89
1.00	0	21.58	–	0	0	–

This means that as the criterion for selecting those who are chronically poor becomes more selective (i.e., requiring people to be poor for a larger fraction of their lives), the cost of chronic poverty for non-whites becomes increasingly important relative to whites. We can conclude that non-whites suffer more than do whites from more extreme experiences of chronic poverty according to both the BCD and F measures even though these two methodologies approach the measurement of chronic poverty in very different manners.

Results using $\varepsilon = 2$ for the FGT snapshot poverty measure are also included (see Tables 2, 4, and 8). The implication is to emphasize the depth of poverty spells since the relative poverty gap is squared in each spell that poverty occurs. For the baseline case of equal weighting for all poverty spells experienced by all individuals, the EDE cost of poverty rises in all cases. However, it is also true for all cases that the relative increase in the cost of poverty is greater for whites than for non-whites. The ratio of the NW to W cost of poverty is lower and less sensitive to changes in the parameter that reflect sensitivity to chronic poverty for the BCD and F measures and also to the parameter that reflects the temporal pattern of early/chronic poverty for the HZ measure in all cases.

It is also interesting to investigate the decomposition of total poverty into chronic and transient poverty for the F measure. Recall that at $\tau = 0$ the F measure includes all individuals and all poverty experiences, including for those with only one spell of poverty over the 26 years, in the calculation. For any other value of $\tau > 0$ the selection criterion for who is to be defined as chronically poor is more stringent and so the amount of poverty is nonincreasing in τ. For example, since the cost of poverty from those Whites who are defined as chronically poor in Table 7 at $\tau = 0.5$ is 23.22 while total poverty (i.e., for $\tau = 0$) is 69.09, we say that 54% of poverty (i.e., $\frac{23.22}{69.09}$) is due to chronic poverty while the rest (46%) is due to transient poverty. The full

Table 8 EDE poverty gap (F measure). $\widehat{g}(\tau, \varepsilon)$, $\varepsilon = 2$

	All ages			20–25 cohort		
τ	White	Non-White	Ratio	White	Non-White	Ratio
0.00	452.15	1,001.48	2.21	492.77	850.07	1.73
0.25	311.33	945.18	3.04	332.05	774.56	2.33
0.50	242.98	831.61	3.42	234.40	657.19	2.80
0.75	165.84	623.96	3.76	224.56	657.19	2.93
1.00	0	257.46	–	0	0	–

Table 9 Percentage of total poverty due to chronic poverty (F measure). $\widehat{g}(\tau, \varepsilon)$, $\varepsilon = 1$

	All ages			20–25 cohort		
τ	White	Non-White	Ratio	White	Non-White	Ratio
0.00	100	100	1	100	100	1
0.25	54	88	1.63	55	80	1.45
0.50	34	68	1.26	25	55	2.2
0.75	15	36	2.4	20	55	2.75
1.00	0	5	–	0	0	–

set of these values is presented in Tables 9 and 10. Notice that not only is the cost of poverty always greater for non-whites than whites, it is also always the case that the percentage of poverty due to chronic poverty is higher for non-whites.

4 Remarks

The three measures of lifetime poverty that we have compared in this paper take different conceptual approaches concerning how the pattern of poverty experiences over a lifetime should impact on the level of lifetime poverty. The methods due to Foster [13, 14] (F) and Bossert et al. [5] (BCD) address the concern with chronic poverty while the measure due to Hoy and Zheng [17] (HZ) addresses both chronic and early poverty concerns. Both BCD and HZ adopt a lifetime measure that is a weighted average of snapshot poverty experiences. The choice of weights or the parameters that determine these weights turn out to be crucial for both approaches. Measure F extracts from a sample those persons who are poor for a given fraction τ (or more) of their lifetimes, with τ ranging from zero to one. Naturally, results for the F measure will depend crucially on the value of its chosen parameter τ. In each case the choice is subjective. However, research that studies the relative importance in physical and mental well-being of alternative patterns of poverty experiences over time can inform these choices. In particular, the measures are all sensitive to different perspectives of chronic poverty experiences and the HZ measure also incorporates an early poverty consideration. Looking at how dimensions of well-being such as various health characteristics and longevity are affected by the presence of chronic poverty and poverty experienced earlier in life could inform such choices.

The hypothetical examples and the empirical application explored in this paper demonstrate that, for any of the measures investigated here, one should be cautious in choosing parameters and perform sensitivity tests of various sorts. For the BCD and HZ measures, the length of time period covered in the sample interacts (in different ways) with the parameters of the weighting functions. The BCD approach

Table 10 Percentage of total poverty due to chronic poverty (F measure). $\widehat{g}(\tau, \varepsilon)$, $\varepsilon = 2$

	All ages			20–25 cohort		
τ	White	Non-White	Ratio	White	Non-White	Ratio
0.00	100	100	1	100	100	1
0.25	69	94	1.36	67	91	1.36
0.50	54	83	1.54	48	77	1.60
0.75	37	62	1.68	46	77	1.67
1.00	0	26	–	0	0	–

applies a weight γ^k, $\gamma \geqq 1$, to each snapshot poverty measure experienced in a string of k consecutive spells. We saw that if the data set covers a large number of periods (T) then the BCD measure can become very sensitive to the size of γ especially if even only a handful of individuals experience poverty in many consecutive spells. The measure is also sensitive to measurement error since it is important whether or not one is poor in a given period of a string of (otherwise) consecutive poverty spells. One safeguard is to use a range of poverty lines that would indirectly test the robustness of how such individuals contribute to lifetime poverty. Also, the range of the parameter γ that one might consider sensible may well be different for different values of T.

Any weighting function for the HZ measure is also sensitive to the number of periods covered by the data set (T). Moreover, it can be challenging to disentangle the implications of early poverty from chronic poverty inherent in the HZ approach. As a result, it is useful to use a variety of different weighting functions or one with two parameters such as the quadratic function explored in this paper. This allows one to consider changing weights in a way that takes into consideration only early poverty through a series of increasingly steep linear weights or also changing the curvature (degree of concavity) of the weighting function to explore the impact due to chronic poverty.

A further concern with the HZ measure is the extent to which (or stage of life over which) early poverty actually affects individuals' lifetime well-being. Although medical research suggests that poverty in childhood is especially crucial to the ultimate lifetime health and well-being of an individual, it is not clear that one should apply the early poverty axiom over people's full lifetimes. In the empirical section we created a cohort of families that would contain young children at the outset (1967) who would become young adults at the end of the sample period (1993). The early poverty axiom seems a reasonable consideration for this stage of people's lives. Moreover, the approach of HZ can be applied in a more flexible manner. One can generalize the early poverty axiom by breaking up lifetimes into various age ranges say, for example, by generating a set of weights that are decreasing in t only for a set of consecutive periods through childhood (say $t = 1, 2, ..., T_1$) and, if poverty late in life is also a concern, weights could increase in t for a second set of consecutive periods late in life (say $t = T_2, T_2 + 1, ..., T$, with $T_2 \geq T_1$).

5 Conclusion

The three measures of lifetime/chronic poverty compared in this paper were applied to the PSID household panel data covering 26 consecutive years, splitting the sample into Whites and Non-Whites, and also using all ages as well as a more balanced cohort. The findings for both the F and BCD measures are similar in that both measures identified greater poverty for Non-Whites and this became increasingly so the more sensitive was each measure to greater chronic poverty experiences. For F, this increased sensitivity to "deeper" chronic poverty is realized by increasing the parameter τ that restricts the sample to those who have experienced at least that fraction (τ) of spells of poverty during their lifetimes. For BCD, sensitivity to poverty increases according to the parameter γ which essentially increases the penalty on chronic poverty experiences as defined by contiguous spells of poverty compared to isolated spells. The HZ measure, on the other hand, while sensitive to chronic poverty as defined by temporal closeness of poverty experiences, is also concerned with early poverty. By using alternative functional forms for its associated weighting function one can change the relative sensitivity of the HZ measure to early and chronic poverty experiences.

We have shown that looking at a sample with more balanced cohorts across two subpopulations (Whites and Non-Whites in this paper) can be an important consideration. This is especially so for the HZ measure which is explicitly concerned with the specific ages of each person or household due to its concern with early poverty. Thus, if one group in a sample has significantly more young persons in it than another, then this group gets higher weight on each snapshot poverty experience that would occur in a given year of the data. But this is also an important consideration for the F and BCD measures since the extent to which chronic poverty differed between Whites and Non-Whites was substantially different for the restricted cohort sample (aged 20–25 in 1967) compared to the all ages sample.

We believe that the further development of concepts of lifetime poverty has been enlightened by our comparison of the three measures reviewed in this paper. Some properties of one measure could be adopted by another. For example, one could incorporate an age-based weighting scheme—as suggested by the HZ method—for the BCD measure by allowing γ to be age dependent. This would create a measure that allows for greater impact of chronic poverty on young children. One could combine the approaches of BCD and F by using the selection criterion of F and then applying the weighting function from BCD to that subpopulation. There are other unexplored issues that also deserve attention, such as whether the level of income experienced in non-poverty spells should be treated as having compensatory effects on lifetime poverty. None of the measures discussed in this paper allow for such an effect. For further discussion on this and other issues, see Addison et al. [1] and Calvo and Dercon [7], and elsewhere.

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Appendix

Table 11 Poverty lines (in 1983 dollars) and implied equivalence scales

Family size	Poverty line	Implied equivalence scale
1	5,047.59	1.00
2	6,483.79	1.28
3	7,942.48	1.57
4	10,176.61	2.02
5	12,030.04	2.38
6	13,568.20	2.69
7	16,775.38	3.32

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