the review of income and wealth

Review of Income and Wealth
Series 58, Number 2, June 2012
DOI: 10.1111/j.1475-4991.2011.00458.x

MEASURING POVERTY ACCOUNTING FOR TIME

by Carlos Gradín,* Coral del Río

Universidade de Vigo

and

Olga Cantó

Instituto de Estudios Fiscales and Universidade de Vigo

In this paper we make a methodological proposal to measure poverty accounting for time by proposing a new family of intertemporal poverty indexes that aims at reconciling the way poverty is measured in a static and a dynamic framework. Our index is able to consider the duration of the poverty spell and the social preference for equality in well-being given that, in contrast with others that have been previously proposed, it is sensitive to the level of inequality between individual complete poverty experiences over time. Moreover, other indices in the literature can be interpreted as special cases of our more general measure. An empirical illustration shows the relevance of considering the distribution of poverty experiences among the population in an international analysis.

JEL Codes: D31, D63, I32

Keywords: intertemporal poverty, duration, equality, poverty measurement

Introduction

During the twentieth century the literature on the measurement of poverty has constructed a sound analytical framework in which there is a large consensus on the set of properties that poverty indices should satisfy. The seminal work by Sen (1976) focused the discussion on the three main dimensions of poverty—incidence, intensity, and inequality—and drew the path through which subsequent research has followed. In those first stages poverty measurement was generally linked to a static view of the poverty phenomenon because most of the data was of a cross-sectional nature. The increasing availability of longitudinal data in a variety of countries has stimulated advances in undertaking a more dynamic view of the issue.

The first approaches to considering the time dimension in poverty measurement were centered on analyzing poverty transitions and the duration of poverty spells. All these contributions put forward the importance of flows into and out of poverty and the significant heterogeneity in the poverty dynamics pattern of different populations. More recently, there has been increasing research interest in developing new methodologies that take into account individual income profiles

Note: The authors gratefully acknowledge financial support from the Ministerio de Ciencia e Innovación (ECO2010-21668-C03-03/ECON) and Xunta de Galicia (10SEC300023PR).

*Correspondence to: Carlos Gradín, Universidade de Vigo, Facultade de Económicas e Empresariais, Campus Lagoas-Marcosende s/n, 36310-Vigo, Spain (cgradin@uvigo.es).

along time in constructing a consistent aggregate indicator. The proposals in the literature aiming to construct a desirable indicator can be classified into two main approaches, the *components approach* and the *spells approach*. The first of these approaches contributed to underlying the relevance of permanent income in poverty analysis and is strongly related to the possibility of compensating low and high income periods. The use of a permanent income concept allows this approach to easily adapt the standard poverty measurement tools to a dynamic setting. In contrast with this method, the spells approach is able to incorporate duration as a poverty dimension while considering incidence in the aggregate poverty indicator. Also, recent contributions have permitted the consideration of poverty intensity within this aggregate poverty measure, considering not only the poverty gap but also taking into account that the concatenation of poverty periods may aggravate poverty. In this context, and despite the many advances in the literature on poverty dynamics, there is still no consensus on a measure of poverty that adequately summarizes the information provided by a panel of individuals.

From our point of view, these recent contributions within the spells approach allow us to adequately include both the incidence and the intensity of poverty dimensions in a dynamic framework. In particular, the incidence of poverty in a dynamic setting is based in a double cut-off approach where, apart from the poverty line, a certain number of periods below the poverty threshold are necessary to identify those who are longitudinally poor. In the case of intensity it is not only a larger poverty gap that increases poverty but also the concatenation of periods below the poverty threshold could make poverty more severe. This considers the importance of poverty spell duration.

Regarding the third relevant dimension in the measurement of poverty, the inequality of poverty experiences has also been partially incorporated in the aggregate intertemporal poverty indicators. A way to include inequality is through indices that are sensible to the equalization of individual per-period poverty gaps; however we believe that the way in which this has been implemented up to now can be significantly improved by considering an index that takes into account the inequality between complete individual poverty patterns in time. This, together with spell duration, leads us to rule out what in the literature is known as *path independence*. Path independence implies that aggregating first across individuals and then across time periods should be equivalent to aggregating in the reverse order (i.e. first across time periods for each individual and then across the population). In our view, given that inequality should be evaluated across individuals, it is necessary that we first summarize the complete individual information in time and then construct an aggregate index that takes into account a social preference for equality among individuals. In this way we move a step forward in the direction of constructing an integrated framework in the measurement of poverty which is consistent for both a static and a dynamic setting. Therefore, we can incorporate time into all Sen's (1976) three dimensions while cross-sectional poverty could be understood as a particular case of a more general dynamic framework.

The aim of the paper is first to discuss the relevant properties that we believe an aggregate intertemporal poverty index should satisfy to be consistent with our view of longitudinal poverty, and then to propose a new index that, while strongly

rooted in the previous literature, satisfies these properties. In fact, some of the other intertemporal poverty indices recently proposed can be viewed as special cases of our index.

The structure of the paper is as follows. The first section presents the different approaches in the literature to measuring poverty, accounting for time. The second section details the relevant properties an aggregate intertemporal poverty index should satisfy and discusses the way in which they are fulfilled by previous indices. The third section introduces a new aggregate intertemporal poverty index that is consistent with these relevant properties. In the fourth section we apply the new measure in an empirical exercise for illustrative purposes. The last section summarizes the main contribution of the paper.

1. Poverty and Time: The Different Approaches in the Literature

Poverty dynamics has experienced a large development in income distribution analysis in recent years. Two main approaches to modeling intertemporal poverty dynamics can be distinguished as noted by Yaqub (2000). The first has been labeled the *components approach* and focuses on estimating the permanent and transitory components of poverty. The second has been labeled the *spells approach* and focuses on poverty spell duration and transitions into and out of poverty. Throughout this paper, following Bane and Ellwood (1986), we will consider a poverty spell as the set of consecutive periods during which income falls below the poverty line. The crucial distinction between these approaches in the study of intertemporal poverty is that the components approach assumes compensation between low and high income periods and then the identification of who is poor each period of time becomes unnecessary, while in the spells approach no compensation is allowed and one needs to identify who is poor each period.

More specifically, an important part of this literature has aimed to find a way to summarize all individuals' income patterns along a time interval into an aggregate intertemporal poverty index. The way this index has been constructed can be generally interpreted as following a two step procedure. A first step aims to obtain an inter-temporal wellbeing (or lack of) indicator for each individual based on her income profile, while a second step aggregates all these in a single inter-temporal poverty index for the society as a whole. In implementing this two-stage procedure, each of the aforementioned approaches follows a different strategy.

In the components approach the individual intertemporal wellbeing indicator is constructed in order to capture the permanent component of income. This indicator can be used to identify who is chronically poor (those individuals for whom its value is below the poverty line). To approximate this permanent component, Jalan and Ravallion (1998), for example, average individual income-to-needs ratios (income relative to the per period poverty line) over the complete period of analysis, while Duncan and Rodgers (1991) calculate an income-to-needs ratio for the whole period by summing up incomes and poverty lines in time. Alternatively Duncan and Rodgers (1991) and Gaiha and Deolalikar (1993) approximate the permanent component by the predicted income (or income-to-needs) estimated using a fitted econometric model, and Rodgers and Rodgers (1993) use the maximum sustainable annual consumption level that the agent

could achieve with her actual income stream over the years if she could save and borrow at a constant interest rate. The components approach generally implies assuming a perfect substitution of income over time and is insensitive to the number of periods that individuals spend below the poverty line. Thus a single period of high income either at the beginning or at the end of the observed time span can offset several periods below the poverty line, which could be reasonable to assume only in absence of liquidity constraints.[1] The assumption of a perfect substitution of income in time was recently relaxed by Foster and Santos (2009) and Porter and Quinn (2008): the former by using a parameterized generalized mean that allows for a whole range of alternative and explicit degrees of income substitutability between time periods; the latter by assuming an increasing elasticity of substitution using a linear combination of constant elasticity of substitution functions.

In the second step, the components approach typically calculates an aggregate intertemporal poverty index over the distribution of individual indicators: the headcount ratio (Duncan and Rodgers, 1991; Gaiha and Deolalikar, 1993), the squared poverty gap index of Foster *et al.* (1984) (Rodgers and Rodgers, 1993; Jalan and Ravallion, 1998), or the Clark *et al.* (1981) index (Foster and Santos, 2009). These last two indices, as in the static approach to measuring poverty, take all three dimensions of poverty into account: incidence, intensity, and inequality among the poor. Therefore, in essence, this approach constructs an intertemporal income measure over which a poverty index satisfying the standard axioms is then computed.

In the spells approach, the first step consists of computing an individual intertemporal poverty index with desirable properties based on the per-period individual poverty indicators. Then, in the second step, an aggregated index is obtained averaging these over the whole population. In general, per-period poverty indicators are based on each period individual poverty gap. In the earliest and most simple examples of this method, such as Duncan *et al.* (1984), Duncan and Rodgers (1991), Duncan *et al.* (1993), or Gaiha and Deolalikar (1993), the intertemporal (chronic) poverty index takes the value 1 if the number of periods below the poverty line exceeds a certain number out of the total periods of observation. These papers do not take into account per-period poverty intensity or intertemporal variability (inequality of per-period individual poverty gaps along time). More recently, Foster (2007, 2009) generalizes this approach, presenting a new family of chronic poverty measures based on the classical Foster–Greer–Thorbecke (FGT) family of poverty indices constructed over the per-period normalized gaps of the chronically poor. This group is identified using a dual cut-off approach: an individual is considered to be chronically poor if the percentage of time she spends below the poverty line exceeds a certain threshold. This approach, in our view, is equivalent to constructing an individual intertemporal poverty measure using an FGT index on each individual income profile and then computing the arithmetic mean over the population. Note also that this last method satisfies a path independence property. This means

[1]Some authors (Rodgers and Rodgers, 1993; Slesnick, 2001) maintained that poor individuals can smooth consumption by borrowing and saving over time. However, Jappelli (1990) showed the existence of liquidity constraints affecting mostly low income households, while others (Kempson, 1996; Azpitarte, 2011) showed that there is a significant correlation between income and assets.

that once individuals are identified as chronically poor, all their per-period observations are assumed to be independent from each other. This derives from the fact that Foster's index is the mean of the elements of a matrix with column vectors listing individuals and row vectors listing years, where the typical element is the normalized gap to the power of the poverty aversion parameter when the individual is chronically poor and zero otherwise.

Obviously, when aiming to compare two individuals' levels of poverty over time, results will depend on the role assigned to poverty persistence. Since Bane and Ellwood (1986) it appears clear in the literature that the longer a person has been poor the less likely it is that she will escape poverty.[2] Foster (2007) underlines that his approach rules out the possibility that those continuous periods below the poverty line create greater harm than the same periods in poverty interspersed with non-poverty periods. He actually says that it is not entirely clear whether and how the time-ordering of income should impact in aggregation or identification of chronic poverty and he decides to take the extreme position by ignoring the time-orderings entirely. Most recently, a variety of papers such as Calvo and Dercon (2009), Hoy and Zheng (2008), Bossert *et al.* (2010), or Mendola *et al.* (2009) have incorporated the sensitivity to poverty persistence within the individual intertemporal poverty index in different ways. These papers propose a list of desirable properties for measuring poverty across time, focusing on trajectories of poverty rather than on the set of periods of poverty at different points in time.[3]

It is important to note that papers within the spells approach, unlike those within the components approach, generally construct the aggregate poverty index in a way that is inconsistent with the classical approach to measuring poverty. This is because computing a mean of individual intertemporal poverty indicators does not make the aggregate index sensitive to the distribution across individuals. The only exception to this inconsistency that we know of is Hoy and Zheng (2008), who discuss the possibility that individual lifetime poverty measures are aggregated using a function reflecting society's preferences for equality of individual poverty deprivations, in a similar way to other social welfare measures. This is in line with what has been done, not only in the measurement of poverty and inequality but also in the measurement of another form of deprivation such as unemployment (Paul, 1992; Riese and Brunner, 1998; Borooah, 2002; Sengupta, 2009; Shorrocks, 2009a, 2009b). Reconciling the properties of the aggregated intertemporal poverty experiences within the spells approach with those widely accepted for static poverty measures is precisely our main aim in this paper. Using the spells approach to construct a time-sensitive poverty measure is advantageous in order to incorporate to this measure sensitivity to individual poverty trajectories and to the duration of poverty spells, which is not easily captured by the components approach.

[2]Even if a part of this result may come about due to individual heterogeneity, it is also likely that poverty itself makes it more difficult to leave. This last effect is generally referred to in the literature as *true state dependence*.

[3]Calvo and Dercon (2009) apply discount factors to incorporate sensitivity to the income trend in their measures and they also introduce poverty duration sensitivity, taking into account the impact of the poverty gap the previous year. Hoy and Zheng's (2008) measure of lifetime poverty increases with poverty spells experienced at the early stages of life and with the accumulation of poverty periods in time (not necessarily consecutive). Bossert *et al.* (2010) propose a measure of poverty that increases with the duration of poverty spells in time.

2. Relevant Properties in the Measurement of Poverty Accounting for Time

2.1. *Preliminary Notation and Definitions*

Consider a society consisting of N individuals observed T periods of time represented by an NxT matrix Y, whose elements are per-period individual equivalent income (or consumption). For each individual i we can denote the raw vector $\boldsymbol{y}_i = (y_{i1}, y_{i2}, \ldots, y_{iT})$ as representing her non-negative income profile in time. Matrix Y may be written as:

$$Y = \begin{pmatrix} y_{11} & y_{12} & \cdots & y_{1T} \\ y_{21} & y_{22} & \cdots & y_{2T} \\ \cdot & \cdot & \cdots & \cdot \\ \cdot & \cdot & \cdots & \cdot \\ \cdot & \cdot & \cdots & \cdot \\ y_{N1} & y_{N2} & \cdots & y_{NT} \end{pmatrix}.$$

An individual i is poor in period t if and only if her income falls below the corresponding poverty line z_t.[4] Let $\boldsymbol{g}_i^{\gamma} = \left(g_{i1}^{\gamma}, g_{i2}^{\gamma}, \ldots, g_{iT}^{\gamma}\right)$ be the raw vector of normalized poverty gaps[5] to the power of γ (where $\gamma \geq 0$) for individual i, whose elements are given by:

$$g_{it}^{\gamma} = \begin{cases} \left(\dfrac{z_t - y_{it}}{z_t}\right)^{\gamma} & \text{if} \quad y_{it} < z_t \\ 0 & \text{otherwise} \end{cases}. \tag{1}$$

Let us define a poverty (non-poverty) spell to be a set of consecutive periods during which income is lower (greater or equal) than the poverty line. Let s_{it} be the number of periods of the particular (poverty or non-poverty) spell the i-th individual is in at period t, and $q_i(\boldsymbol{y}_i; \boldsymbol{z})$ the total number of time periods that individual i is poor ($g_{it}^{\gamma} > 0$), being $\boldsymbol{z} = (z_1, z_2, \ldots, z_T)$.

An individual intertemporal poverty index is a function $p_i(\boldsymbol{y}_i; \boldsymbol{z})$ that maps each income profile $\boldsymbol{y}_i$ into $\Re_+$ (where $\Re_+$ is the non-negative real number set) for a given poverty line vector $\boldsymbol{z} = (z_1, z_2, \ldots, z_T)$. Thus, p_i is a function whose value indicates the degree of intertemporal poverty level of individual i, associated with her income profile in time, $\boldsymbol{y}_i$, and $\boldsymbol{z}$. Let $\boldsymbol{p} = (p_1, p_2 \ldots, p_N)$ denote the vector of individual intertemporal poverty indicators for the society, and $\tilde{\boldsymbol{p}} = (\tilde{p}_1, \tilde{p}_2, \ldots, \tilde{p}_N)$ the vector of ordered individual intertemporal poverty experiences, where $\tilde{p}_1 \geq \tilde{p}_2 \geq \ldots \geq \tilde{p}_N$, being $q \equiv q(\boldsymbol{p})$ the number of intertemporally poor individuals ($p_i > 0$).

An intertemporal aggregate poverty index is a function $P(Y; \boldsymbol{z})$ which given the poverty lines vector $\boldsymbol{z}$ maps each income matrix $Y = (\boldsymbol{y}_1, \boldsymbol{y}_2, \ldots, \boldsymbol{y}_N)'$ into $\Re_+$. The value of $P(Y; \boldsymbol{z})$ represents the aggregate poverty level of a particular society accounting for time.

[4]This poverty line may be constant over time, as it is common in the measurement of absolute poverty.

[5]The normalization of poverty gaps is not essential in our framework. Non-normalized poverty gaps could also be used.

2.2. *Desirable Properties of an Aggregate Intertemporal Poverty Index*

Given that within the spells approach the index is constructed in two steps, in order to discuss the desirable properties of the aggregate intertemporal poverty index P, we need, in a first stage, to discuss the desirable properties of the individual intertemporal poverty indicator p_i.

2.2.1. Properties of an Individual Intertemporal Poverty Index

It is reasonable to assume that p_i should satisfy the equivalent continuity, focus, monotonicity, and scale invariance axioms that are usual in the standard poverty measurement case.[6] Now, however, these properties refer to time observations of the same individual instead of referring to different individuals at the same moment in time.

The *intertemporal continuity axiom* requires that p_i $(\boldsymbol{y}_i; \boldsymbol{z})$ is a continuous function of $\boldsymbol{y}_i$ for any given $\boldsymbol{z}$. The *intertemporal focus axiom* requires that any increase in income at a period in which the individual is non-poor should not affect the measured level of her individual intertemporal poverty. Accepting this property implies assuming that it is not possible to compensate poverty gaps with incomes over the poverty threshold at periods when the individual is out of poverty, something common within the spells approach. The *intertemporal monotonicity axiom* requires that a decrease in the income at any period in which the individual is below the poverty line should lead to an increase in the measured level of intertemporal poverty. The *intertemporal scale invariance axiom* requires that if both the poverty line vector and every income are scaled up or down by the same factor, the intertemporal poverty level should remain unchanged.[7]

However, in our view p_i should not satisfy the time version of the anonymity or symmetry axiom, and the transfer axiom should not be directly incorporated in this setting given that both are, in some cases, incompatible with a relevant property pointed out by the literature within the spells approach. Indeed, given that longer poverty spells reduce the probability of a poverty exit, we want the measure of individual intertemporal poverty to be sensitive to poverty spells duration. We propose an *intertemporal poverty spell duration sensitivity axiom* that requires that given any two poverty spells (a certain number of concatenated periods of poverty), the index should be higher when both of the spells are consecutive, ceteris paribus. Thus, the concentration of periods of poverty in a fewer number of poverty spells will increase the individual intertemporal poverty index.[8]

[6]See Zheng (1997) for a formalization of these properties in the context of cross-sectional poverty measurement.

[7]Note that this last property only makes sense in the measurement of relative poverty.

[8]A similar idea has been recently suggested by Bossert *et al*. (2010) who proposed decomposability properties across and within spells in order to penalize longer spells, ceteris paribus. A more general property was proposed by Hoy and Zheng (2008), called the *chronic-poverty axiom*, which implies that the closer two spells are from one another, the greater lifetime poverty is. Along the same lines Mendola *et al*. (2009) defended that poverty should be decreasing in the time distance between spells. Hojman and Kast (2009) considered that it would also be desirable that poverty should reflect a preference for improving sequences of outcomes.

For illustrating this property let us consider a simple example with $z_t = 5$ for all t and the income vectors for two individuals $\boldsymbol{y}_i = (6, 0, 6, 0, 6)$ and $\boldsymbol{y}_j = (6, 6, 0, 0, 6)$. This property requires the individual intertemporal poverty index to be larger for the individual j because even if having the same incomes as individual i, her two poverty periods are consecutive.

Assuming an equivalent transfer axiom (defined as is usual in the standard poverty analysis) in this intertemporal setting would imply that an income transfer between two periods in which the individual is poor would always increase poverty if the income loss takes place in the period with a lower income level. This would happen whatever the length of the poverty spell in which each period is inserted. Clearly, this becomes a problem if we want to assume the intertemporal poverty spell duration sensitivity axiom in the case that the income loss takes place in a shorter spell compared to that of the income gain. This is because the regressive transfer is increasing the poverty gap of a period in which the individual is further away from the poverty line which should increase poverty but, at the same time, this period is inserted in a shorter poverty spell which should decrease poverty. Thus it is not clear if, in this particular case, intertemporal poverty should always increase. Therefore, we propose an *intertemporal regressive transfer axiom* that implies that if the previous regressive transfer reduces the income in a period inserted in an equal or larger spell compared to that of the income gain, then poverty should increase. In order to clarify the implications of this property, let us consider the following example with $z_t = 5$ for all t and the income vectors for three individuals $\boldsymbol{y}_i = (6, 1, 3, 6, 2, 6)$, $\boldsymbol{y}_j = (6, 0, 3, 6, 3, 6)$, and $\boldsymbol{y}_h = (6, 1, 4, 6, 1, 6)$. According to this property, intertemporal poverty for individual j should be higher than for individual i because the second vector can be obtained from the first one through a regressive transfer from $t = 2$ to $t = 5$, with the latter involving a shorter poverty spell. However, the property does not allow one to determine whether i or h has more individual intertemporal poverty. This is so, because despite the fact that the vector of individual h can be obtained from the vector of individual i though a regressive transfer from $t = 5$ to $t = 3$, the income that increases belongs to a larger spell. Thus, it is not obvious in which direction the individual intertemporal poverty index should go.

We believe that in our setting it is not interesting that an individual intertemporal index satisfies the equivalent to the anonymity axiom. Accepting this axiom would imply that permutations of per-period incomes across time would not affect intertemporal poverty. As far as one believes that the intertemporal poverty index should be sensitive to the individual poverty profile or trajectory across time (for example, to the length of the poverty spells), anonymity should not be imposed because permutations may affect trajectories in a way that they may aggravate or alleviate intertemporal poverty. We also propose to discard the replication invariance axiom because we believe that it is meaningless in a dynamic framework where comparisons seem to only make sense over distributions with the same number of periods. Note that the magnitude of intertemporal poverty in a panel of individuals depends on the length of the time span considered (T). For example, given a population, the higher T is, ceteris paribus, the smaller the probability to find individuals who are always poor and the larger the probability to find

individuals who are ever poor.[9] Thus, taking into consideration the sensitivity of individual intertemporal poverty to spells' duration makes any comparison between indexes obtained from a different number of time periods much less obvious. Then, if one needs to compare poverty for two distributions with a different number of periods, $T_1 < T_2$, the most reasonable strategy, in our view, would be to select a subsample of T_1 periods for the second distribution in order to compare their measures of poverty accounting for time.

2.2.2. Properties of an Aggregate Intertemporal Poverty Index

In the second stage, an aggregate intertemporal poverty measure $P(Y; \boldsymbol{z})$ is defined to be a function of individual intertemporal poverty indices reflecting society's preference about the distribution of intertemporal poverty deprivations and can be written as:

$$P(Y; \boldsymbol{z}) = f(p_1(\boldsymbol{y}_1; \boldsymbol{z}), \ldots, p_N(\boldsymbol{y}_N; \boldsymbol{z})).$$

In general we would like P to be consistent with the desirable properties of static poverty measures. Thus the function f must satisfy the following properties. The *continuity* property requires that the P index is a continuous function of p_i. The *Anonymity* or *symmetry* property implies that the P index remains unchanged after whichever permutation of p_i (which corresponds to permutations of row vectors in matrix Y). The *replication invariance* property requires that the P index remains unchanged under r replications of the original population where the dimension of the new matrix will be $(rN)xT$, thus allowing for the comparison of populations with different sizes. *Monotonicity* imposes that P increases whenever there is an increase in p_i. *Preference for intertemporal poverty equality among poor individuals* requires that P decreases whenever there is an equalization of p_i's. This is equivalent to the Pigou–Dalton principle of transfers used in the inequality and welfare analysis of income distributions, and commonly required in the measurement of cross-sectional poverty in line with Sen's (1976) seminal discussion of poverty dimensions. This property in our case can be formalized as follows. Let $\boldsymbol{p}$ and $\boldsymbol{p}'$ be two individual intertemporal poverty vectors respectively associated to the income matrices Y and Y' of equal size NxT. If $\boldsymbol{p}'$ is obtained from $\boldsymbol{p}$ such that there are two individuals i and j so that:

$$p_i > p_i' > p_j;\ p_i' + p_j' = p_i + p_j;\ p_s' = p_s \text{ for all } s \neq i, j;$$

where, at least, individual i is intertemporally poor, then $P(Y'; \boldsymbol{z}) < P(Y; \boldsymbol{z})$. For a numerical illustration of this property, see Examples 1 and 2 in Section 2.3.[10]

[9]To illustrate this point we use the data from the balanced panel for the six European countries (as in the empirical illustration in Section 4) and calculate the percentage of people who are found to be always poor or ever poor in each country when we consider the information on poverty for a different number of periods. For all countries, results show that, if we consider only three years, the percentage of always poor individuals turns out to be more than double than when we consider all seven years (from 7.1 to 3.0 on average). Also, in all countries the percentage of those who were poor at least one year when the number of periods considered increases from three to seven goes up from 25.8 to 36.7 percent on average.

[10]Foster (2007, 2009) proposed a transfer axiom to consider inequality among the poor with different implications in comparison with our proposal, as will be discussed in Example 2 in the next section.

We consider this set of axioms as the minimum requirement for an aggregate intertemporal poverty measure. Obviously, satisfying other properties could be of interest. For instance, we could require the index to be normalized, to range between zero and one, or to be additively decomposable by population subgroups.

2.3. *Properties of Previous Aggregate Intertemporal Poverty Indicators*

After detailing the desirable properties with which a measure of aggregate intertemporal poverty should comply, it is interesting to analyze to what extent the indices that have been proposed in the literature satisfy them so far. The literature following the components approach does not properly capture the relevance of poverty duration. In particular this approach leads to the violation of the intertemporal focus, spell duration, and regressive transfer axioms because periods with income above the poverty line can compensate poverty gaps. Within the spells approach the earliest and most simple contributions do incorporate the relevance of duration in the measurement of longitudinal poverty but fail to capture other important dimensions such as intensity of poverty experiences and their distribution across the population. This implies that, in general, measures that have been proposed within this approach do not fulfill either the intertemporal monotonicity axiom or the intertemporal transfer axiom.

The most recent contributions within the spells approach have proposed indices that take better account of the different dimensions of intertemporal poverty. One seminal contribution that centered the main issues on the measurement of poverty in a longitudinal setting was Foster's (2007, 2009) intertemporal poverty index, which can be rewritten in our notation as:[11]

$$K_\gamma(Y;z)=\frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}g_{it}^{\gamma}\quad \gamma\geq 0.$$

This index for $\gamma > 1$ satisfies most of the properties we have previously discussed. However, it fails to satisfy some axioms such as the preference for intertemporal poverty equality and intertemporal poverty spell duration sensitivity.

The first axiom is not satisfied because Foster's index does not take into consideration the whole income profile of individuals (once they are identified as chronic poor). Let us consider the following example with two income matrices and their corresponding normalized poverty gap matrices (for the sake of simplicity, the poverty line is constant for all t, $z_t = 5$):

Example 1

$$Y=\begin{pmatrix}0&4&6&6\\4&0&6&6\end{pmatrix}\Rightarrow Y'=\begin{pmatrix}0&0&6&6\\4&4&6&6\end{pmatrix}$$
$$g^1=\begin{pmatrix}5/5&5/5&0&0\\1/5&5/5&0&0\end{pmatrix}\Rightarrow g^{1\prime}=\begin{pmatrix}5/5&5/5&0&0\\1/5&1/5&0&0\end{pmatrix}.$$

[11]Foster's (2007, 2009) index is actually a measure of chronic poverty. For this reason a person will be considered (chronically) poor if spending a minimum proportion τ of the total time of observation below the poverty line. In the subsequent discussion of the properties of this index we will leave this out for simplicity, thus assuming that $\tau = 1/T$.

where in the first row of the Y and Y' matrices we have the income of individual i, and in the second row we have the income of individual j, both during four periods of time (both being considered chronic poor). The Y' matrix can be obtained from Y by a simple permutation of incomes of both individuals in the second period. Foster's index will remain constant after this permutation. However, it seems reasonable to consider that aggregate intertemporal poverty has increased as long as one cares about equality between the different individual poverty experiences. This is because after the permutation, intertemporal poverty is more concentrated in individual i (first row in matrix Y and Y').

Foster (2007) proposed a transfer axiom in the measurement of intertemporal poverty to take into account the sensitivity to inequality among the poor pointed out by Sen (1976) in a cross-sectional setting. This axiom roughly says that a per-period equalization of all poverty gaps among (chronic) poor individuals should reduce intertemporal poverty. This seems reasonable but does not embrace all possible equalizations between two given individuals (as we will see in Example 2). On the other hand, Foster's index (when $\gamma > 1$) satisfies a more general property, according to which any equalization of poverty gaps g^1_{it}'s (of any individual and period) reduces intertemporal poverty. The reason why we do not consider this general property as desirable is because it implies a decrease in poverty, regardless of the profile of poverty gaps of the individuals involved in the income transfer. In particular it ignores any information about the poverty gaps they experienced in any of the other periods. Let us consider the following example:

Example 2

$$Y = \begin{pmatrix} 1 & 4 & 6 & 4 \\ 4 & 1 & 6 & 1 \end{pmatrix} \Rightarrow Y' = \begin{pmatrix} 2 & 4 & 6 & 4 \\ 3 & 1 & 6 & 1 \end{pmatrix}$$

$$g^1 = \begin{pmatrix} 4/5 & 1/5 & 0 & 1/5 \\ 1/5 & 4/5 & 0 & 4/5 \end{pmatrix} \Rightarrow g^{1\prime} = \begin{pmatrix} 3/5 & 1/5 & 0 & 1/5 \\ 2/5 & 4/5 & 0 & 4/5 \end{pmatrix}.$$

Here the Y' matrix can be obtained from Y by a transfer from individual j (second row in matrix Y and Y') to individual i (first row in matrix Y and Y') in the first time period so that incomes in that period are equalized. This transfer implies a decrease in Foster's intertemporal poverty index K_γ for $\gamma > 1$. In our example $K_2(Y; z) = 0.255$ while $K_2(Y'; z) = 0.235$. However, this index does not take into account the information contained in the matrices regarding other time periods different from those involved in the regressive transfers (the first one in this example). In this particular example it would be reasonable to consider the donor, j, as intertemporally poorer than the receiver, i, despite being less poor in the first period. This is because they are both poor the same number of periods, while j has a lower total income in poverty periods. In this setting we would expect the aggregate intertemporal poverty index to increase.

The violation of the second axiom, regarding intertemporal poverty spell duration sensitivity, comes from the fact that Foster's index does not take into account the length of the spell to which each period belongs. Let us consider the following example:

Example 3

$$Y = \begin{pmatrix} 0 & 0 & 6 & 0 \\ 6 & 6 & 6 & 6 \end{pmatrix} \Rightarrow Y' = \begin{pmatrix} 0 & 0 & 0 & 6 \\ 6 & 6 & 6 & 6 \end{pmatrix}$$

$$g^1 = \begin{pmatrix} 5/5 & 5/5 & 0 & 5/5 \\ 0 & 0 & 0 & 0 \end{pmatrix} \Rightarrow g^{1\prime} = \begin{pmatrix} 5/5 & 5/5 & 5/5 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

In this case, the Y' matrix is obtained from Y by joining the two poverty spells of individual i with durations of two and one periods into a three-period single poverty spell. Again, Foster's index does not change after this concatenation of spells, while if one agrees that longer spells aggravate poverty, as a substantial part of the literature on poverty dynamics does, then the aggregate intertemporal poverty index should increase.[12] This problem will be shared by all other indices that do not incorporate sensitivity to spell duration.

Bossert *et al*. (2010) improved the existing proposals by introducing an index that is sensitive to the duration of poverty spells. Their proposal weights each individual per-period poverty by the length of the spell to which that period belongs.[13] Their aggregate intertemporal poverty measure P^* is an average of individual intertemporal poverty indices P_i^*, and in the case of using the FGT index as the per-period poverty indicator, it can be rewritten (in our notation) as:

$$P^* = \frac{1}{N}\sum_{i=1}^{N} P_i^* = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T} g_{it}^{\gamma} s_{it} \quad \gamma \geq 0.$$

In the case of Example 3, this index increases after joining the two spells, as our intertemporal poverty spells duration sensitivity axiom requires, because it weights each period in the new and longer spell more than it did in the original spells. However, this index fails to solve the counterintuitive result of Foster's index in Examples 1 and 2. Given that in these examples the length of the poverty spells of both individuals is the same in both matrices, the permutation in the first example does not modify the aggregate index while poverty is reduced by the partial equalization in the second one from a value of P^* for $\gamma = 2$ of 0.425 for matrix Y to 0.385 for matrix Y'. This result is due to the fact that this index does not consider individuals' complete intertemporal profiles; thus it ignores the concentration of poverty in one individual (Example 1) or her lower income in the remaining periods below the poverty line (Example 2). This will be a common feature of those indices that construct an aggregate intertemporal poverty measure averaging over either individual or per-period indicators.

Therefore, in order to obtain an aggregate intertemporal poverty index that fulfills all the properties discussed above, we need an indicator that is constructed taking into consideration the individuals' complete time profile.

[12]Note that, as mentioned before, Foster (2007, p. 17) took an extreme position adopting his time anonymity axiom as it was not clear to him whether and how the time-ordering of incomes should impact the aggregation of poverty.

[13]This is not the only case of a spell duration sensitive measure. Calvo and Dercon (2009) have previously proposed an index of intertemporal poverty where the contribution of a period of poverty is larger if that period is followed after another period of poverty. Mendola *et al*. (2009) have alternatively proposed an index that accounts for the relative distances between poverty periods.

3. A New Distribution-Sensitive Aggregate Intertemporal Poverty Measure

Our main aim in this paper is to reconcile the way of measuring poverty in a cross-section and a panel, thus taking the individual as the reference. In order to do this it appears most reasonable to follow the two-step procedure mentioned above. First, we construct an individual intertemporal poverty indicator aggregating per-period poverty. Second, our aggregate intertemporal poverty measure is based on the distribution of these individual indicators.

In the first stage we define the individual intertemporal poverty indicator p_i as being a modified FGT index defined over time:

$$p_i(\boldsymbol{y_i}; \boldsymbol{z}) = \frac{1}{T}\sum_{t=1}^{T} g_{it}^{\gamma} w_{it}, \tag{2}$$

where γ is the usual FGT parameter. As far as $\gamma > 1$ this parameter introduces here the sensitivity of the individual intertemporal poverty index to higher inequality of poverty experiences over time. Thus, for any given time-averaged poverty gap, a higher variability of the normalized gaps over time increases individual poverty. Each poverty gap (to the power of γ) is further weighted according to the duration of the corresponding poverty spell in which that period is involved. In particular, weights w_{it} can be expressed as:

$$w_{it} = \left(\frac{s_{it}}{T}\right)^{\beta},$$

where as far as $\beta > 0$, this parameter increases the relative weight of larger spells consistently with the idea that the continuous accumulation of poverty periods aggravates the individual poverty experience. This is a generalization of weights proposed by Bossert *et al.* (2010), allowing for different degrees of sensitivity to duration, given that we believe that this is a value judgment, not different to, for example, the sensitivity to inequality in poverty indices.

In a second stage, unlike most of the previous literature, we summarize individual intertemporal poverty indices over the whole population by constructing an aggregate intertemporal poverty measure P, which is consistent with the way that poverty is usually measured in a cross-section of individuals:

$$P(Y; \boldsymbol{z}) = \frac{1}{N}\sum_{i=1}^{N} p_i^{\alpha}, \tag{3}$$

where

$$p_i^{\alpha} = \begin{cases} (p_i)^{\alpha} & \text{if} \quad p_i > 0 \\ 0 & \text{if} \quad p_i = 0 \end{cases}.$$

If $\alpha > 1$, this parameter allows for sensitivity of the aggregate intertemporal poverty index to the distribution of intertemporal individual poverty experiences among poor individuals. Thus, a higher inequality of poverty experiences over the poor population will increase aggregate poverty. This would be consistent with a version of the "equality-preferring axiom" by which the society prefers the indi-

vidual poverty deprivations to be equally distributed, as pointed out by Hoy and Zheng (2008). This is in line with Shorrocks (2009a, 2009b), who proposed a normative framework to measure a deprivation dimension such as unemployment in an intertemporal context.[14] We believe that intertemporal poverty is another form of deprivation, and therefore it should be measured within the same inequality-sensitive framework.

The complete expression for the aggregate intertemporal poverty index integrating expression (2) in (3) is the following:

$$P(Y;\boldsymbol{z}) = \begin{cases} \dfrac{1}{N}\sum_{i=1}^{N}\left(\dfrac{1}{T}\sum_{t=1}^{T} g_{it}^{\gamma}\left(\dfrac{s_{it}}{T}\right)^{\beta}\right)^{\alpha} & \textit{if} \quad \alpha > 0 \\ \dfrac{q}{N} & \textit{if} \quad \alpha = 0 \end{cases}. \tag{4}$$

One of the advantages of our framework is that it encompasses some of the previous literature within the spells approach. For example, Foster's (2007, 2009) measure can be obtained as an extreme case of our measure when $\beta = 0$ and $\alpha = 1$, that is, when normalized poverty gaps are not weighted by the poverty spell duration and the aggregate intertemporal poverty index is simply the average of individual intertemporal indicators over the population, and therefore insensitive to the indicators' distribution.[15] Bossert *et al.*'s (2010) index can be expressed as a scalar transformation (by T) of our index by fixing $\beta = \alpha = 1$, that is, when normalized poverty gaps are weighted proportionally to spell duration and the aggregation over the population is also an average. Moreover, $P(Y; \boldsymbol{z})$ can be viewed as a generalization of the popular FGT measure to the dynamic framework, given that the latter can be obtained from the former when $T = 1$ and $\gamma = 1$.

It is easy to check that our individual intertemporal poverty measure p_i defined in (2) satisfies all desirable properties discussed in Section 2.2 as far as $\gamma > 1$ and $\beta > 0$. This is so because since it is a modified version of the FGT it inherits its properties. In particular, the fulfillment of the intertemporal focus and monotonicity axioms is straightforward from the definition of the poverty gaps. The intertemporal scale invariance axiom is satisfied as a consequence of the normalization of the poverty gaps. As far as $\beta > 0$, concatenated spells increase individual poverty, thus satisfying the intertemporal poverty spell duration sensitivity axiom. The higher the β, the larger the penalty to longer spells, ceteris paribus. Therefore, β can be understood as a parameter reflecting the degree of aversion to poverty spell duration, which was implicit in other proposals. Similarly, $\gamma > 1$ guarantees the fulfillment of the Pigou–Dalton principle of transfers adapted to the intertemporal framework (the intertemporal transfer axiom). In the case where $\gamma = 1$, p_i depends on the individual time-averaged normalized gap (weighted by spell duration) and not on its distribution within spells, while when $\gamma = 0$, p_i depends on the proportion of periods the individual spends below the poverty threshold (weighted by spell duration), but neither on the average magnitude of poverty gaps nor on

[14]Other authors who made proposals for measuring unemployment in a similar way were Paul (1992), Riese and Brunner (1998), Borooah (2002), and Sengupta (2009).

[15]This is true provided that $\tau = 1/T$. Note that higher values of τ could be easily accommodated in our framework.

their distribution over time. For values of γ higher than one, the parameter reflects the aversion to inequality of poverty gaps over time when measuring individual intertemporal poverty. Additionally, p_i is normalized to lie between 0 and 1, taking the lowest value when an individual is never poor, and the largest when she is always poor with zero income. Similarly it is immediate to verify that p_i does not satisfy an individual version of the time anonymity axiom proposed by Foster (2007), according to which the individual index should be invariant to permutations of incomes across time. Note also that p_i does not satisfy the direct translation to the time dimension of the replication invariance property usually required in cross-sectional poverty measurement, which, we believe, is not a problem (see Section 2.2.1)

Our aggregate measure P, which is an FGT defined over individual intertemporal poverty indices instead of over normalized poverty gaps, inherits its well-known properties. In particular, it is also normalized to lie between 0 and 1, taking the lowest value when nobody in the population is ever poor, and taking the largest value when everybody is always poor and their income is always zero.[16] Further, it fulfills all the axioms that were also discussed in Section 2.2 as far as $\gamma > 1$, $\beta > 0$, and $\alpha > 1$, including the preference for intertemporal poverty equality which is generally not satisfied by other indices that have been proposed in the literature so far. This property is the consequence of the parameter α being greater than one. Then α can be understood as a parameter reflecting the extent of aversion to inequality of intertemporal poverty across individuals. Note that a consequence of this property and the weighting scheme w_{it} is that P does not satisfy the path independence axiom. This is consistent with our view that time periods and individuals are not symmetric dimensions as far as we give relevance to the role played by poverty persistence and to social preference for equality between individual intertemporal poverty experiences.[17] While persistence was already taken into account by other approaches (e.g. Calvo and Dercon, 2009; Mendola *et al.*, 2009; Bossert *et al.*, 2010), equality of individual complete profiles has not been considered so far. It is important to underline that the three parameters in expression (4) make the inevitable value judgments about measuring longitudinal poverty explicit, i.e. by choosing each parameter value they allow one to choose to what extent to penalize: the variability of individual well-being over time, the duration of poverty spells, and the inequality of intertemporal poverty across the population.

Moreover, the P index also satisfies the additive decomposability by subpopulations property, which is of particular interest for empirical analysis. Let $Y = (Y^1, Y^2, \ldots, Y^K)'$ be an exhaustive partition of the population into K mutually exclusive demographic groups, with $\boldsymbol{\pi} = (\pi^1, \pi^2, \ldots, \pi^K)'$ their respective population shares, then:

[16]Note that in the case of non-normalized poverty gaps the index takes its maximum value at $z^{\gamma\alpha}$, which is in line with the maximum value the conventional FGT index takes in a cross-section of individuals, z^{α}.

[17]Note that both parameters γ and α do not need to take the same value because they are capturing different features of intertemporal poverty. For example, one could be interested in analyzing the distribution (then $\alpha > 1$) of the percentage of time spent in poverty by a given population (thus fixing $\gamma = 0$).

$$P(Y;z)=\sum_{k=1}^{K}P(Y^k;z)\pi^k.$$

Further, parallel to the traditional decomposition of the FGT index into incidence, intensity, and inequality components (Foster *et al.*, 1984), P when $\alpha=2$ can also be decomposed as:

$$P(Y;z)=H\left[I^2+(1-I)^2C^2_{1-p}\right]=H\left[I^2+V_p\right],$$

where $H=q/N$ indicates the proportion of ever poor, and $I=\bar{p}=\frac{1}{q}\sum_{i=1}^{q}p_i$ and V_p respectively indicate the average and variance of individual intertemporal poverty indicators across the ever poor population. Further, $V_p=\frac{1}{q}\sum_{i=1}^{q}(p_i-\bar{p})^2=(1-I)^2C^2_{1-p}$, with C^2_{1-p} being the coefficient of variation of $1-p_i$. More generally, for any $\alpha\geq 0$ (see Shorrocks, 2009b):

$$P(Y;z)=HI^{\alpha}\left[1+E^{\alpha}_{p}\right], \tag{5}$$

where $E^{\alpha}_{p}=\frac{1}{q}\sum_{i=1}^{q}\left[\left(\frac{p_i}{\bar{p}}\right)^{\alpha}-1\right]$ is related to the well-known family of generalized entropy inequality indices.[18]

Finally, our aggregate indicator P is consistent with a partial ordering that comes from dominance criteria based on modified TIP (three I's of poverty) curves defined over the vector of ordered intertemporal individual poverty experiences $\tilde{\boldsymbol{p}}=(\tilde{p}_1,\tilde{p}_2,\ldots,\tilde{p}_N)$ where $\tilde{p}_1\geq\tilde{p}_2\geq\ldots\geq\tilde{p}_N$, instead of over that of ordered individual poverty gaps as in Jenkins and Lambert (1997). Then our intertemporal TIP curve (ITIP) for each value of $\pi=\frac{m}{N}$ can be expressed as:

$$ITIP_{\pi}(\tilde{\boldsymbol{p}})=\sum_{j=1}^{m}\frac{\tilde{p}_j}{N},$$

where m is any integer number such that $m\leq N$. $ITIP(\tilde{\boldsymbol{p}})$ accumulates intertemporal individual poverty levels, from higher to lower intertemporal poverty, divided by N. Similar to conventional TIP curves, $ITIP(\tilde{\boldsymbol{p}})$ shows (i) the *incidence* of intertemporal poverty (the proportion of ever poor); (ii) the *intensity* of intertemporal poverty experiences (that for each individual depends on the level and distribution over time of normalized poverty gaps and on spells duration); and (iii) the *inequality* of intertemporal poverty across the population. The dominance in these curves (i.e., when the curve of a distribution is always equal to or below that of another one) allows for the identification of partial orderings in aggregate intertemporal poverty which are robust to the choice of a particular aggregate poverty indicator satisfying our set of axioms defined over the p_i's.

[18]More specifically, for any $\alpha>1$ the generalized entropy index is $GE^{\alpha}_{p}=\alpha(\alpha-1)E^{\alpha}_{p}$.

4. An Empirical Illustration

In order to illustrate the properties of the new family of intertemporal poverty measures proposed in the previous section, we use longitudinal data on six EU countries: Spain, Germany, Denmark, France, Portugal, and the U.K. The information comes from the European Community Household Panel (ECHP) for the period 1994–2001. The dataset was designed in order to obtain country-comparable statistics on many demographic and socioeconomic aspects of the European population. The panel has been constructed in a way that demographic and income information is contemporaneous.[19] As a consequence the data used is a balanced panel for six countries during seven waves. For the purposes of our research, we use the standard EU definition of poverty so that an individual is classified as poor if per-equivalent income in the household she lives in is below 60 percent of the contemporary median in her country (using the OECD modified equivalent scale).

Our aim is to evaluate the sensitivity of intertemporal poverty indices to differences in poverty gaps and their intertemporal distribution for each individual (reflected in the value of parameter γ), spell duration (reflected in the value of parameter β), and inequality in individual complete poverty experiences over time (reflected in the value of parameter α). For a best illustration of the performance of the aggregate intertemporal poverty measure we will present results for a variety of parameter values.

Considering the most straightforward case when $\gamma = \beta = 0$ allows us to isolate the effect of changes in parameter α in an easy way when neither the magnitude of poverty gaps nor the duration of spells are taken into account in measuring aggregate intertemporal poverty. Note that in this simple case our individual intertemporal poverty indicator equals the proportion of time each person spends in poverty $p_i = q_i/T$. In fact, if we calculate the percentage of individuals in each country who spend different fractions of time below the poverty threshold (Figure 1), we can conclude that the duration pattern of each of the six countries is varied. In the case of Denmark the percentage of individuals sharply falls as duration increases. In contrast, in the case of Portugal the proportion of individuals with large poverty durations is outstandingly high.

Results in Figure 2 depict, for each value of α, every country's aggregate poverty index relative to the unweighted average of the measure across countries (all countries weighting the same regardless of their population size). In the case of Portugal, a country with a large share of individuals ever poor ($\alpha = 0$), the difference between its intertemporal poverty and the intertemporal poverty mean across countries increases when α changes from zero to one (thus when incorporating sensitivity to the average duration of poverty to the index). This difference continues to increase when incorporating a progressively higher sensitivity to inequality of time spent in poverty across individuals (as α grows from one to higher values). This follows from Portugal presenting not only a higher proportion of population ever poor, but also a higher average and inequality of duration (see first four columns in Table 1). The opposite is true for Denmark, a country with a small

[19]For more details of the construction of the panel, see the appendix in Arranz and Cantó (2010).

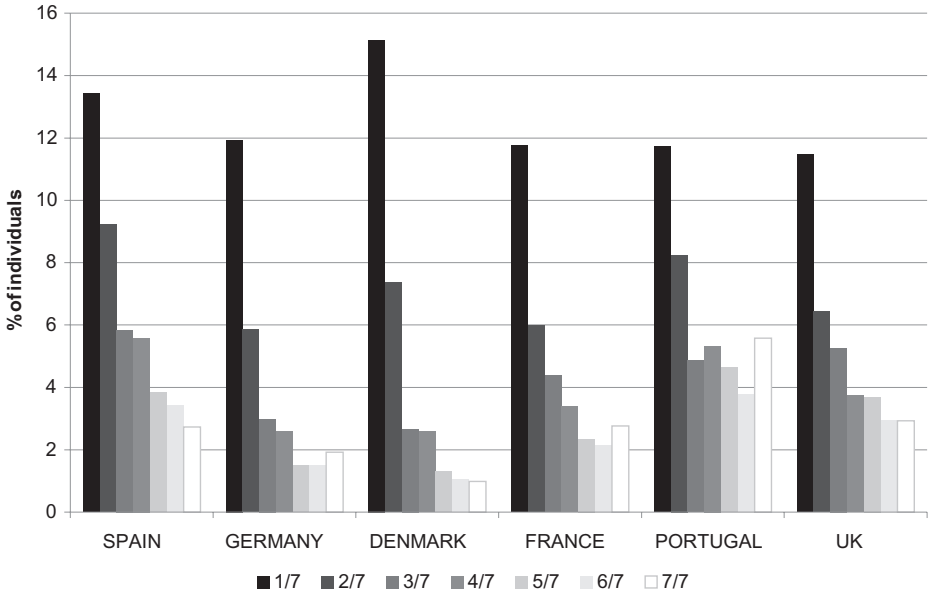

Figure 1. Distribution of Individual Intertemporal Poverty Indices (p_i) in Selected EU Countries: when $\gamma = \beta = 0$

Values of p_i are the fraction of time that each individual spends below the poverty threshold.

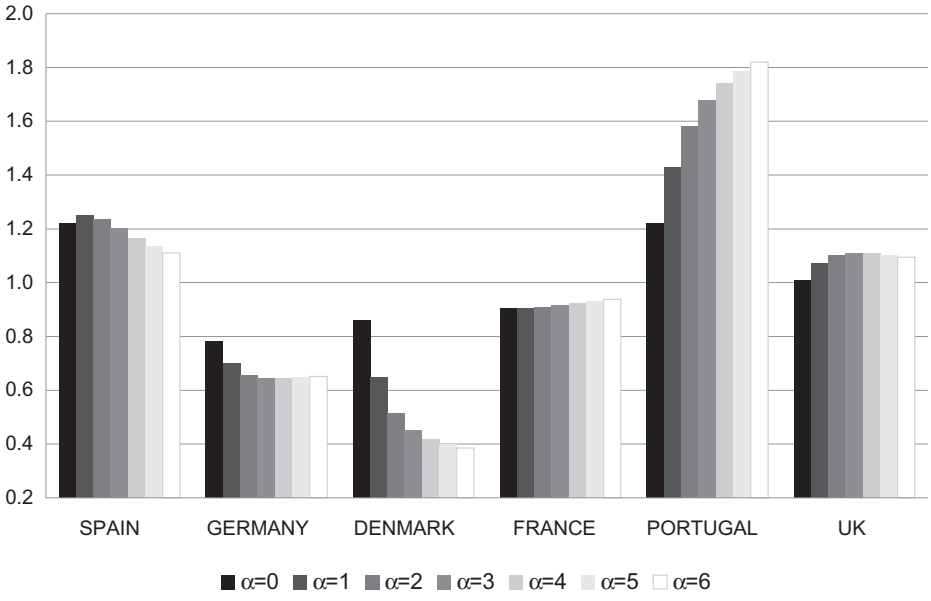

Figure 2. Aggregate Intertemporal Poverty Index Sensitivity to Accounting for Inequality Among the Ever Poor in Selected EU Countries: $P(\boldsymbol{Y}; z)$ when $\gamma = \beta = 0$ and Different Values of α*

Values are relative to the unweighted average of the index across countries.

* Note that when $\alpha = 0$ the value of the index is the same regardless of the value of γ and β following equation (4).

TABLE 1
Summary Statistics of Intertemporal Poverty in Selected EU Countries

Country	Proportion of Population Ever Poor $H = q/N$	Average Intensity of Poverty (duration) $\gamma = \beta = 0$ $I = \bar{p} = \frac{1}{q}\sum_{i=1}^{q} p_i$	Coefficient of Variation when $\gamma = \beta = 0$ C^2_{1-p}	Variance when $\gamma = \beta = 0$ V_p	Mean Duration of Poverty Spell	Average Intensity of Poverty $\gamma = 2, \beta = 1$ $I = \bar{p} = \frac{1}{q}\sum_{i=1}^{q} p_i$	Coefficient of Variation when $\gamma = 2, \beta = 1$ C^2_{1-p}	Variance when $\gamma = 2, \beta = 1$ V_p
Spain	0.441	0.423	0.469	0.073	0.312	0.034	0.075	0.005
Germany	0.283	0.368	0.428	0.073	0.294	0.024	0.064	0.004
Denmark	0.310	0.312	0.333	0.053	0.257	0.013	0.023	0.001
France	0.328	0.412	0.482	0.080	0.327	0.021	0.051	0.002
Portugal	0.441	0.482	0.581	0.091	0.396	0.050	0.098	0.009
U.K.	0.365	0.438	0.505	0.081	0.355	0.028	0.058	0.003
Unweighted average	0.361	0.406	0.466	0.075	0.324	0.028	0.061	0.004

share of individuals ever poor, where intertemporal poverty becomes smaller relative to the overall mean as α increases, given that this country registers a low proportion of population ever poor, a low average, and inequality of duration. In fact, while Denmark has a level of intertemporal poverty which is higher than that of Germany when $\alpha = 0$, it becomes substantially lower for higher values of this parameter. Similarly, Spain, with value of intertemporal poverty as high as that of Portugal when $\alpha = 0$, has a substantially lower relative level of poverty for higher values of sensitivity to inequality. In contrast, France and the U.K. keep their relative distance to the overall mean regardless the value of α. Note that these differences across countries could not be identified with any of the other indices that have been proposed in the literature so far (see discussion in Section 2.3) given that they all ignore the distribution of intertemporal poverty across the intertemporally poor population.

Aiming to analyze the sensitivity of our aggregate intertemporal index to introducing larger weights on poverty spells of a long duration, we isolate the impact of choosing different values of β (sensitivity to poverty spell duration) in the easiest case, i.e. when $\gamma = 0$ and $\alpha = 1$. Figure 3 depicts the results of the aggregate intertemporal poverty for all six countries relative to the overall mean. From the results in Table 1 (column 5) we can conclude that Portugal has the largest while Denmark has the smallest mean poverty spell duration. As a consequence, Portugal experiences a significant increase in its level of aggregate intertemporal poverty relative to the overall mean when we increase the

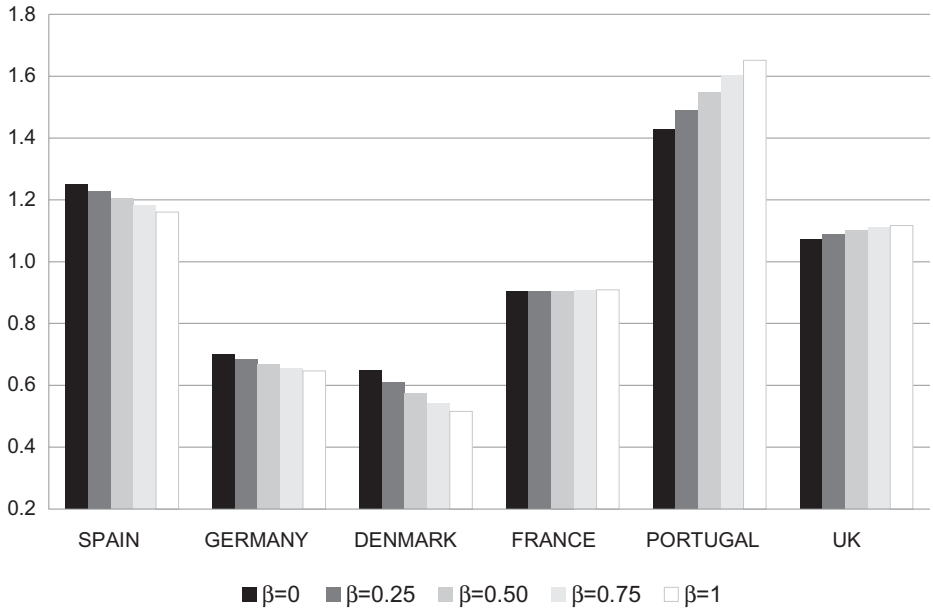

Figure 3. Aggregate Intertemporal Poverty Index Sensitivity to Accounting for Poverty Spell Duration in selected EU Countries: $P(Y; z)$ when $\gamma = 0$, $\alpha = 1$, and Different Values of β

Values are relative to the unweighted average of the index across countries.

penalization to larger spells, while Denmark experiences a sharp decrease. Spain and Germany also reduce their relative levels of intertemporal poverty when spell duration is accounted for, while the U.K. and France remain barely constant.

Finally, we discuss the impact of incorporating in the intertemporal poverty measure the sensitivity to inequality in a more complex case ($\gamma = 2$ and $\beta = 1$) in which we also take into account poverty gaps and their intertemporal distribution for each individual together with poverty duration. Results are shown in Figure 4 and are also relative to the overall mean. The results for Portugal in this figure show that the difference between this country and the rest is very large and increases rapidly with α. This follows from the accumulation in this country of all features that negatively impact on intertemporal poverty discussed above which are additionally aggravated by the magnitude and distribution of individual poverty gaps (see columns 6 to 8 in Table 1). Denmark is the opposite case to Portugal because it accumulates all poverty-reducing features. Note, however, that it is not necessarily true that countries with high (low) levels of intertemporal poverty when $\alpha = 1$ will always increase (decrease) their index as α increases. For example, Spain, being a country with a high level of intertemporal poverty when $\alpha = 1$, its differential to the mean decreases with $\alpha > 2$, while Germany, being a country with a low level of intertemporal poverty when $\alpha = 1$, its differential to the mean remains roughly constant as α increases. Further, while France and Germany have nearly the same intertemporal poverty levels when the aggregated intertemporal measure is distributionally insensitive ($\alpha = 1$),

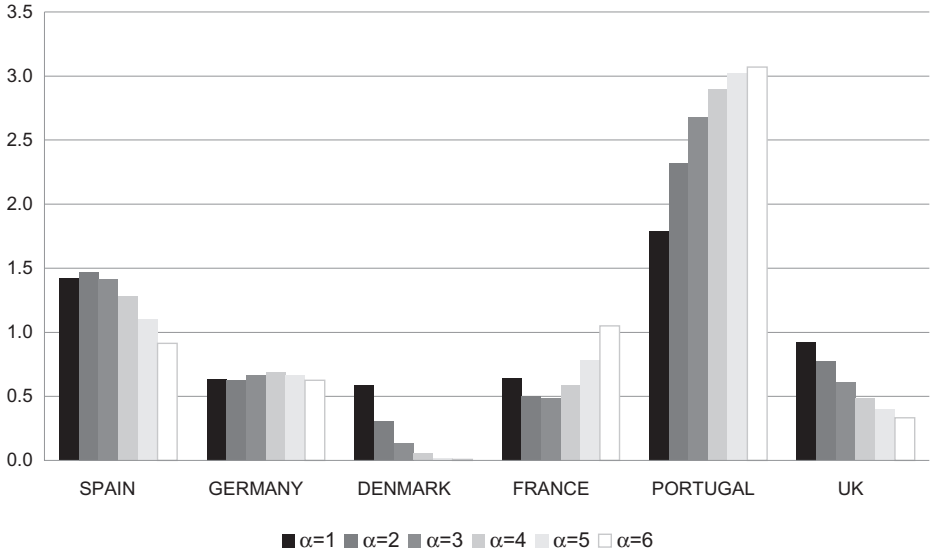

Figure 4. Aggregate Intertemporal Poverty Index Sensitivity to Accounting for Inequality Among the Ever Poor in Selected EU Countries: $P(\boldsymbol{Y}; z)$ when $\gamma = 2$, $\beta = 1$ and Different Values of α

Values are relative to the unweighted average of the index across countries.

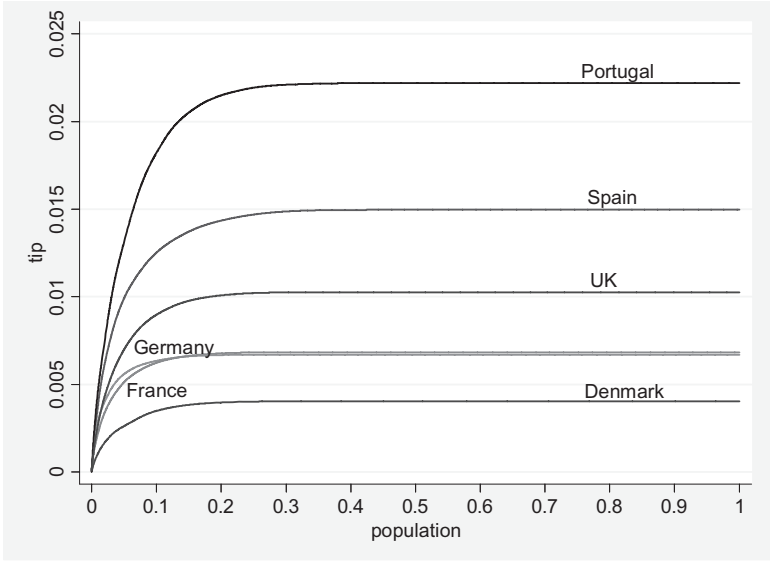

Figure 5. Intertemporal TIP Curves in Selected EU Countries: when $\gamma = 2$ and $\beta = 1$

when some sensitivity to the distribution is incorporated, i.e. when fixing $\alpha = 2$, the intertemporal poverty level becomes 32 percent higher in Germany than in France.[20]

Finally, intertemporal TIP curves, shown in Figure 5, allow us to unanimously rank some (even if not all) countries according to their level of intertemporal poverty regardless of the way individual intertemporal poverty is aggregated across individuals (thus, whatever the choice of α, provided $\alpha > 1$). Portugal has unambiguously a higher aggregate intertemporal poverty than Spain, while Denmark has a lower level of aggregate intertemporal poverty than any other country (their corresponding curves do not overlap). However, the ranking between Germany, the U.K., and France is unclear and will depend upon the specific value of the α parameter chosen.

Our results are largely consistent with those previously obtained in the literature. For example, the OECD (2008) report on a comparison of income poverty over time for 17 OECD countries measures poverty for three consecutive years; results indicate that chronic poverty is high in Portugal (more than 7 percent) and particularly low in Denmark (less than 2 percent). Also, Spain stands out as one of the countries with a large percentage of temporary poverty, in line with our observation of the reduction of its relative level of intertemporal poverty when spell duration is accounted for. Finally, the report also identifies Germany and Denmark within the group of countries with the lowest prevalence of both temporary and chronic poverty. Other relevant comparative papers on persistent

[20]Note that high values of α might cause problems because the index becomes extremely sensitive to outliers with levels of individual intertemporal poverty indices close to one. This is in fact the case in France for values of $\alpha \geq 4$.

poverty in various European Union countries, such as Otto and Goebel (2002) or Fouarge and Layte (2003), are along the same lines. They find that Denmark and Portugal represent extreme positions in the EU regarding poverty dynamics given that permanent poverty is a minor phenomenon in Denmark and the reverse is true for Portugal. Finally, Antolín *et al.* (1999), who include Germany and the U.K. in an analysis of poverty dynamics in four OECD countries in the early 1990s, also conclude that Germany has a significantly lower prevalence of the share of individuals in the total population who were poor in every year through a six-year period.

Conclusions

This paper proposes a new family of aggregate intertemporal poverty indexes that satisfies a set of relevant properties. These properties are based on those of the standard static poverty analysis adapted to a dynamic framework. Thus, our index measures poverty in a dynamic setting in a way that is consistent with the core dimensions of poverty measurement proposed by Sen (1976). Our index is strongly rooted in the previous literature embracing other intertemporal poverty indices that have been recently proposed as special cases.

The main contribution of our index is that it incorporates social preference for equality between individual complete poverty experiences over time, while maintaining other desirable features of previous indices such as spell duration sensitivity. An empirical exercise illustrates the relevance of incorporating this in an analysis of poverty for a group of European countries.

In this proposal we consider the implications of the complete poverty pattern in time on our index in a particular and practical way even if one could think of alternative ways of including other relevant aspects of individual time trajectories discussed by other authors due to their different implications in terms of welfare. These could be, for instance, the distance between poverty spells, the preference for upward trajectories versus downward ones, the implications of an excess of variability in well-being, or the point within the life-cycle when the spells take place, among others.

References

Antolín, P., T. Dang, and H. Oxley, "Poverty Dynamics in Four OECD Countries," OECD Working Papers, ECO/WKP(99)4, Paris, 1999.

Arranz, J. M. and O. Cantó, "Measuring the Effect of Spell Recurrence on Poverty Dynamics," UNU-WIDER, Working Paper No. 2010/72, 2010.

Azpitarte, F., "Measurement and Identification of Asset-Poor Households: A Cross-National Comparison of Spain and the United Kingdom," *Journal of Economic Inequality*, 9, 87–110, 2011.

Bane, M. J. and D. T. Ellwood, "Slipping Into and Out of Poverty: The Dynamics of Spells," *Journal of Human Resources*, 21, 1–23, 1986.

Borooah, V. K., "A Duration-Sensitive Measure of the Unemployment Rate: Theory and Application," *Labour*, 16, 453–68, 2002.

Bossert, W., S. Chakravarty, and C. D'Ambrosio, "Poverty and Time," UNU-WIDER, Working Paper No. 2010/74, 2010.

Calvo, C. and S. Dercon, "Chronic Poverty and All That: The Measurement of Poverty over Time," in T. Addison, D. Hulme, and R. Kanbur (eds), *Poverty Dynamics: Interdisciplinary Perspectives*, Oxford University Press, Oxford, 2009.

Clark, C. R., R. Hemming, and D. Ulph, "On Indices for the Measurement of Poverty," *Economic Journal*, 91, 515–26, 1981.
Duncan, G. J. and W. Rodgers, "Has Children's Poverty Become More Persistent?" *American Sociological Review*, 56, 538–50, 1991.
Duncan, G. J., R. D. Coe, and M. S. Hill, "The Dynamics of Poverty," in G. J. Duncan, R. D. Coe, M. E. Corcoran, M. S. Hill, S. D. Hoffman, and J. N. Morgan (eds), *Years of Poverty, Years of Plenty: The Changing Economic Fortunes of American Workers and Families*, Institute for Social Research, University of Michigan, Ann Arbor, 1984.
Duncan, G., B. Gustafsson, R. Hauser, G. Schmaus, R. Messinger, H. Muffels, B. Nolan, and J. C. Ray, "Poverty Dynamics in Eight Countries," *Journal of Population Economics*, 6, 215–34, 1993.
Foster, J. E., "A Class of Chronic Poverty Measures," Working Paper No. 07-W01, Department of Economics, Vanderbilt University, 2007.
———, "A Class of Chronic Poverty Measures," in T. Addison, D. Hulme, and R. Kanbur (eds), *Poverty Dynamics: Interdisciplinary Perspectives*, Oxford University Press, Oxford, 2009.
Foster, J. E. and M. E. Santos, "Measuring Chronic Poverty," Paper presented at the Third Meeting of ECINEQ held at Buenos Aires, 2009.
Foster, J. E., J. Greer, and E. Thorbecke, "A Class of Decomposable Poverty Measures," *Econometrica*, 52, 761–6, 1984.
Fouarge, D. and R. Layte, "Duration of Poverty Spells in Europe," EPAG Working Papers 2003-47, Colchester, University of Essex, 2003.
Gaiha, R. and A. B. Deolalikar, "Persistence, Expected and Innate Poverty: Estimates for Semi Arid Rural South India," *Cambridge Journal of Economics*, 17, 409–21, 1993.
Hojman, D. and F. Kast, "On the Measurement of Poverty Dynamics," Faculty Research Working Papers Series, RWP09-035, Harvard Kennedy School, 2009.
Hoy, M. and B. Zheng, "Measuring Lifetime Poverty," Department of Economics, University of Guelph, Working Paper No. 2008/14, 2008.
Jalan, J. and M. Ravallion, "Transient Poverty in Post-Reform Rural China," *Journal of Comparative Economics*, 26, 338–57, 1998.
Jappelli, T., "Who is Credit Constrained in the U.S. Economy?" *Quarterly Journal of Economics*, 105, 219–34, 1990.
Jenkins, S. P. and P. J. Lambert, "Three I's of Poverty Curves, with an Analysis of UK Poverty Trends," *Oxford Economic Papers*, 49, 317–27, 1997.
Kempson, E., *Life on a Low Income*, Joseph Rowntree Foundation, York, 1996.
Mendola, D., A. Busetta, and A. M. Milito, "The Importance of Consecutive Spells of Poverty: A Longitudinal Poverty Index," IRISS Working Paper Series 2009-21, CEPS, 2009.
OECD, "Does Income Poverty Last Over Time? Evidence from Longitudinal Data," in *Growing Unequal? Income Distribution and Poverty in OECD Countries*, OECD, Paris, 2008.
Otto, B. and J. Goebel, "Incidence and Intensity of Permanent Income Poverty in European Countries," EPAG Working Paper 28, University of Essex, Colchester, 2002.
Paul, S., "An Illfare Approach to the Measurement of Unemployment," *Applied Economics*, 24, 739–43, 1992.
Porter, C. and A. N. Quinn, "Intertemporal Poverty Measurement: Tradeoffs and Policy Options," CSAE WPS/2008-21, 2008.
Riese, M. and J. K. Brunner, "Measuring the Severity of Unemployment," *Journal of Economics*, 67, 167–80, 1998
Rodgers, J. R. and J. L. Rodgers, "Chronic Poverty in the United States," *Journal of Human Resources*, 28, 25–54, 1993.
Sen, A., "Poverty: An Ordinal Approach to Measurement," *Econometrica*, 44, 219–31, 1976.
Sengupta, M., "Unemployment Duration and the Measurement of Unemployment," *Journal of Economic Inequality*, 7, 273–94, 2009.
Shorrocks, A., "Spell Incidence, Spell Duration and the Measurement of Unemployment," *Journal of Economic Inequality*, 7, 295–310, 2009a.
———, "On the Measurement of Unemployment," *Journal of Economic Inequality*, 7, 311–27, 2009b
Slesnick, D., *Consumption and Social Welfare*, Cambridge University Press, Cambridge, 2001.
Yaqub, S., "Poverty Dynamics in Developing Countries," IDS Development Bibliography No. 16, University of Sussex, 2000.
Zheng, B., "Aggregate Poverty Measures," *Journal of Economic Surveys*, 11, 123–62, 1997.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

APPENDIX: Information on the actual values of $P(\boldsymbol{Y}; \boldsymbol{z})$ in order to construct Figures 2 to 4 and two examples to highlight the relevance of incorporating the distribution of intertemporal poverty across the population.

Table A1. Aggregate Intertemporal Poverty Index Sensitivity to Accounting for Inequality among the Ever Poor in Selected EU Countries: $P(y; z)$ when $\gamma = \beta = 0$ and Different Values of α (Figure 2).

Table A2. Aggregate Intertemporal Poverty Index Sensitivity to Accounting for Poverty Spell Duration in Selected EU Countries: $P(y; z)$ when $\gamma = 0$, $\alpha = 1$ and Different Values of β (Figure 3).

Table A3. Aggregate Intertemporal Poverty Index Sensitivity to Accounting for Inequality among the Ever Poor in Selected EU Countries: $P(y; z) \times 100$ when $\gamma = 2$, $\beta = 1$ and Different Values of α (Figure 4).

Figure A1. Distribution of Individual Intertemporal Poverty Indices (p_i) among the Poor in Spain and Portugal: when $\gamma = 2$ and $\beta = 1$.

Figure A2. Distribution of Individual Intertemporal Poverty Indices (p_i) among the Poor in Germany and Denmark: when $\gamma = 2$ and $\beta = 1$.

Please note: Wiley-Blackwell are not responsible for the content or functionality of any supporting materials supplied by the authors. Any queries (other than missing material) should be directed to the corresponding author for the article.