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THE IMPORTANCE OF CONSECUTIVE SPELLS OF POVERTY: A PATH-DEPENDENT INDEX OF LONGITUDINAL POVERTY

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In this paper we propose a new index of individual poverty in the longitudinal perspective, taking into account the way poverty and non-poverty spells follow one another along individual life courses. The Poverty Persistence Index (PPI) is based on all the pairwise distances between the waves of poverty. The PPI is normalized and it assigns a higher degree of (longitudinal) poverty to people who experience poverty in consecutive, rather than separated, periods, for whom the distances from the poverty line are larger along time and moreover, when the worst years are consecutive and/or recent. We also propose an aggregate index of persistence in poverty (APPI) in order to measure the distribution of the persistence of poverty in a society, and evaluate at once the diffusion of poverty, its depth, duration, and recentness. The indices are tested in comparison with other measures from the literature both at the individual as well as at the societal level.

JEL Codes: I32, C23

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1. Introduction

Poverty scenarios provided by longitudinal surveys can be usefully placed side by side with the information coming from cross-sectional surveys. The former provide complementary information which enriches the study of the experience of poverty, allowing an appreciation of different aspects of the complexity of this phenomenon. A careful evaluation of the "real" status of being poor is based upon concurrent information and, together with the information provided by the cross-sectional surveys (e.g. if you are poor or not in a specific year, or how far below the threshold your income is) one could be interested in knowing something about the persistence of this phenomenon (e.g. how long you live with such a relatively low income).

Eurostat (2003) uses the term "at-risk-of-poverty" for individuals living in households whose income, after social transfers, is below a given threshold (60 percent of national equivalized median income) during the observation year. This definition marks the fact that being under the poverty line makes you "at risk of" becoming poor and it does not necessarily mean that you "are" poor. Indeed being

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poor at a given time is a different matter from being *persistently* poor, both in terms of determinants (Iacovou and Aassve, 2007; Mendola *et al*., 2009a; Arranz and Cantó, 2010) and in terms of effects (Jalan and Ravallion, 2000; Dercon and Shapiro, 2007; Fahmy, 2007).

Particularly during the last 25 years, the availability of longitudinal databases has been causing an increase in the number of studies adopting the longitudinal perspective when analyzing poverty and social exclusion. We agree with Jenkins (2000, pp. 531–2) when he argues that "the extent of mobility and poverty persistence are important social indicators to be placed alongside information about income distribution at a point of time."

Many questions arise when one needs to evaluate the longitudinal poverty experience of individuals. Some of the main questions are: Is the prolonged and uninterrupted experience of poverty worst than an interspersed pattern of poverty and non-poverty years? Can the length of the period of being out of poverty before a year of being in poverty give people the opportunity to accumulate material and immaterial resources to better face poverty in future years? Should more recent years of poverty be given more relevance than older ones? Does poverty hit harder if experienced at an early stage of life rather than that experienced in later stages of life? Is it necessary to assign different weights to different poverty patterns?

In recent years many scholars have proposed measures of longitudinal poverty which aim to give an *ex-post* evaluation of the individual's poverty experience. Most of these measures are characterized by axioms. Their proposals distinguish each other mainly by: (1) the weight they give to years of poverty according to their position inside the time-window or the life stage; and (2) the role of the experiences of poverty, preceding or following each year of poverty.

With reference to the different weights given to different spells of poverty on the basis of their positions in the lifespan, two of the strands of the literature are remarkable: one following the neurosciences and the other the behavioral sciences. The former claims that the higher impact of poverty in younger age is due to influences on neural development, memory, and language skills;[1] the latter (now incorporated in behavioral economics) stresses the role of adaptation among individuals so that, other things being equal, gradually slipping out of poverty (outflow poverty patterns) is preferred to gradually slipping into poverty (inflow poverty pattern) even if the total amount of poverty is the same. This phenomenon is conceptualized in the theory of "loss aversion" (Kahneman and Tversky, 1979).[2]

As per the impact of the neighborhood for each poverty year, a rich vein of literature has been developing in recent years. Some scholars give relevance to the number of periods of poverty experienced consecutively (following the idea of cumulative effects of poverty), whereas others choose to consider the length of the recovery period before a year of poverty (allowing for a compensation between "good" and "bad" periods), and a few work on the distance among poverty years (our contribution in this paper follows this last approach).

[1]See the wide discussion in Hoy and Zheng (2011).

[2]For a discussion, see Hojman and Kast (2009) and Günther and Maier (2008). Starting from a different perspective, the same kind of reasoning is found in Rodgers and Rodgers (1993) and Calvo and Dercon (2009).

In this paper we introduce two indices of longitudinal poverty, both at individual and at aggregate levels, which could be useful instruments to address some of the above mentioned issues. These indices are based upon the ideas that (1) the closer two years of poverty are, the more they contribute to the overall longitudinal poverty measure; and (2) the more recent the experienced years of poverty are, the worst the evaluation of the lifespan poverty is. In order to show the potentialities in the use of our indices, we compared them with other measures of longitudinal poverty.

This paper has the following structure. Section 2 presents a literature review of longitudinal poverty indices, with particular emphasis on those based on the spell approach. In Section 3 our proposal of an individual level index of longitudinal poverty and its properties are presented. Section 4 brings in the aggregate index and its characteristics. In Section 5 we compare both the individual and the societal level index with some similar indices from the literature, highlighting weaknesses and strengths in terms of satisfied properties and ability in tuning different situations of poverty over time. Section 6 concludes.

2. Literature Review

The index we propose in the next section represents a contribution to the very recent literature looking for new measures of poverty persistence, and aiming at catching the complexity of poverty experience across time. In this section we want to review some of the main contributions to this topic.

One of the first papers about the proposal of indices of longitudinal poverty was by Hoy and Zheng (2006, developed in 2007 and 2011). Their individual poverty measure is an average between the measures of poverty in each year/period (function of the distance from the poverty line) and the poverty due to permanent lifetime consumption ("retrospective poverty"). The index also pays attention to how poverty spells are distributed over a lifetime, adopting a weighting function decreasing in time. In the characterization provided by the authors, two axioms are particularly interesting: the "early poverty axiom" and the "chronic poverty axiom." The former is based on the idea that "poverty in earlier stages of life not only affects consumption in later periods but also leaves an inherently deeper mark on lifetime deprivation" (Hoy and Zheng, 2007, p. 3). The latter is based on the idea that repeated poverty spells are more harmful to an individual's well-being than would be the case if the same set of snapshot poverty experiences were more spread out over time.

A very simple index of longitudinal poverty was proposed by Mendola and Milito (2008) and then by Mendola *et al*. (2009b). Even in this case there is an emphasis on the repeated spells of poverty, but these indices differ from the others in that they are based on all the pairwise *distances* among the episodes of poverty in the observed period, and account indirectly for the length of the recovery spells. The index we propose in the next section of this paper is an improved version of that original idea.

Both Foster (2007, 2009) and Calvo and Dercon (2007, 2009) propose chronic poverty measures which allow, to some extent, the substitution between incomes (or consumptions) in different waves only if they are all below the poverty line. In

particular, Foster (2009) identifies the chronically poor by two distinct cut-offs: income cut-off and duration cut-off. The former defines the poor as those whose income is below the poverty line; the latter defines the chronically poor as those who have an incidence of poverty over time which is higher than a chosen fixed level. His class of measures is based upon the average of the generalized poverty gaps in each period. No attention at all is paid to either the position of the poverty episodes inside the observation period, or to their pattern. Calvo and Dercon (2009) focus on consecutive spells of poverty and assume that heavier years of poverty can be counterbalanced by lighter ones. Among the indices they propose, only one assumes that the shortfall at time t includes the memory of the shortfall at time $t-1$, if any. That is, they take into account the path-dependence property—which we explain in Section 3.2—admitting that poverty depends not only on the total number of years spent in poverty but also on their timing.

Bossert *et al.* (2008, 2011) propose a characterization for a new index of longitudinal poverty. It is based on the increasing effect of repeated spells of poverty (similar to our "cumulative hardship" property), and it allows for the balancing among years of poverty inside the same block. The index has memory of the years of poverty preceding a period below the poverty line (given that they are consecutive), whereas it ignores the recovery years preceding a block of poverty periods.[3]

Günther and Maier (2008) study poverty and vulnerability in a dynamic context. Grounding on behavioral sciences, they propose an individual parametric family of measures of chronic poverty based on the theory of loss aversion. They adopt the "path-dependence" notion, assuming that poverty in each period depends on what happened in the previous one. Moreover, they assume that other things being equal, increasing income streams are preferable to decreasing ones, therefore driving to lower lifetime poverty index values.

Hojman and Kast (2009) base their index of intertemporal poverty on the "loss aversion axiom." Their index combines a "stock" poverty, which is the average of per-period poverty measures, and a "flow" poverty accounting for the trend in the poverty experience (i.e. improving or worsening).

Mendola *et al.* (2011) propose a class of measures of longitudinal poverty which are based on the cumulative hardship hypothesis and are path-dependent (giving different weight to each pair of years of poverty—consecutive or not—on the basis of their mutual distance). Unlike the index we will introduce in the next sections, their indices consider explicitly the number of recovery periods between two years of poverty (consecutive or not), and embed the probability of persistence in poverty (via a parameter which indirectly accounts for poverty mobility). Moreover they do not state a duration cut-off to identify the longitudinally poor people (i.e. a degree of poverty is assigned to each individual, even if he spent only one year in poverty).

The class of poverty indices by Dutta *et al.* (2011) is, in a certain way, a mirrored version of the index by Bossert *et al.* (2011), as they focus on the consecutive years of non-poverty. It is based on the idea that the longer the period

[3]A generalization including the indices by Bossert *et al.* (2011) and Foster (2009) is provided in Gradin *et al.* (2011).

spent out of poverty, the lower the impact of the following years of poverty, due to the possibility of accumulating resources, material and immaterial (by the individual) to face the forthcoming year of poverty.

Among the above mentioned indices, a few have an upper bound, in particular Foster (2009), Mendola and Milito (2008), Mendola *et al*. (2009b, 2011), and Hojman and Kast (2009).

3. An Individual Poverty Persistence Index

The aim of this section is to introduce our index and explain its properties. The rationale of the index is based on the idea of the existence of cumulative effects of repeated poverty experiences. This implies that we assume that being poor for a number of consecutive periods has a worse effect than moving in and out of poverty over time, and it is associated with a wide range of detrimental outcomes. This idea relies on a wide literature reporting the effect of chronic poverty (see, among others, Guo, 1998; Baulch and Hoddinott, 2000; Jalan and Ravallion, 2000; Whelan *et al*., 2003; Gassman-Pines and Yoshikawa, 2006).

Moreover, particular attention is also paid to the sequencing of poverty gaps, because if one's income has been quite far from the poverty line for a prolonged period, this could have depleted assets, or seriously reduced savings (if any) and the possibility of obtaining credit from a bank or of resorting to resources from a personal "safety-net" (such as relatives, friends, etc.). So, *ceteris paribus*, given the total amount of poverty for an individual across time span (namely, the sum of normalized poverty gaps for an individual across his life trajectory), a key role is assigned to the sequencing of these poverty gaps: the longer the sequence of consecutive high poverty gaps, the worse the situation experienced (which we will refer to as the cumulative effect of the *severity* of poverty).

The longitudinal poverty measure here proposed, simultaneously pays attention to the length of poverty spells, and to their severity, taking into account in both cases their sequence in the observed individual's lifespan.

Moreover, since measuring poverty longitudinally implies the *ex post* evaluation of a period of life, an important issue becomes the situation of the individual in the more recent years. Is poverty still a current problem or have they managed to get through the situation? The way we account for the status (of poverty or non-poverty) of the individual during the last observed years is different from the rationale behind both the "early-poverty axiom" by Hoy and Zheng (2011) and the "loss aversion axiom" by Günther and Maier (2008). We maintain that what matters most is the recent situation, in that it is the only one for which social policy actions can still be effective, avoiding the worst effects. This is mainly why our index (if our hypothesis is accepted), allows us to take into account the recentness of the poverty experience as a measuring element, via a multiplicative factor that smoothes the intensity of poverty as much as this is a trouble that can be overcome.

3.1. *Poverty Persistence Index (PPI)*

Given a panel of $T = 7$ waves, suppose we observe the following time-ordered poverty sequence: (1100110). The latter is the poverty profile of an individual who

is poor at waves 1 and 2 (poverty status 1), who then experiences two years out of poverty (poverty status 0), then again a two-period spell of poverty (corresponding to waves 5 and 6), followed by one year out of poverty. Our attention here is mainly on the elements in the set S^*, defined as the set of the numerical-id of waves which an individual has spent in poverty. So, in our example, $S^* = (1, 2, 5, 6)$.

Given a duration cut-off of two years, which means that at least two years are required for an individual to be considered longitudinally poor at some degree different from zero (i.e. $\dim(S^*) \geq 2$), the analytical formulation of the Poverty Persistence Index at the individual level is:

$$PPI = \frac{\sum_{i,j \in S^*} (i-j)^{-1} w_{ij}}{\sum_{t=1}^{T-1} \frac{t}{(T-t)}} \cdot de \quad \text{with } i > j \tag{1}$$

in which i and j are the generic elements of the set S^* (given that i is greater than j), w_{ij} is a measure of the intensity of the poverty experiences recorded during the two years of poverty occupying positions i and j in the poverty sequence, and de is a "decay factor" which lowers the value at its left as much as the last episode of poverty experienced is not recent. Indeed the decay factor acts on the synthetic evaluation of the poverty sequence of each individual. It is a multiplicative factor for the whole ratio in equation (1) because it is invariant by t even if it depends on the characteristics of the poverty status profile. We chose to adopt a multiplicative relationship because we want de to be a smoothing factor which diminishes (proportionately) the value of the index according to the not recentness of poverty experiences. If both w_{ij} and de are normalized, that is, if they range in (0,1], then the PPI is normalized in the same interval, since the denominator of the ratio in equation (1) is the maximum of the numerator. The latter is proved considering a poverty sequence wholly made by 1s with maximum intensity of poverty measures (which all equal to 1). Suppose we have $T = 7$ and an individual with the following poverty measures sequence: (1111111). Then the numerator of equation (1) becomes indeed equal to the denominator as:

$$\begin{aligned} Num(PPI) = \Bigg[& (2-1)^{-1} \cdot \left(\frac{1+1}{2}\right) + (3-2)^{-1} \cdot \left(\frac{1+1}{2}\right) + (3-1)^{-1} \cdot \left(\frac{1+1}{2}\right) + \\ & (4-3)^{-1} \cdot \left(\frac{1+1}{2}\right) + (4-2)^{-1} \cdot \left(\frac{1+1}{2}\right) + (4-1)^{-1} \cdot \left(\frac{1+1}{2}\right) + \ldots + \\ & (7-6)^{-1} \cdot \left(\frac{1+1}{2}\right) + (7-5)^{-1} \cdot \left(\frac{1+1}{2}\right) + \ldots + (7-1)^{-1} \cdot \left(\frac{1+1}{2}\right) \Bigg] \\ = & 1+1+\frac{1}{2}+1+\frac{1}{2}+\frac{1}{3}+\ldots+1+\frac{1}{2}+\ldots+\frac{1}{6} = \sum_{t=1}^{6} \frac{t}{(7-t)} \end{aligned}$$

From an operative point of view we chose to use:[4]

[4]The following assumptions are made without loss of generality. Indeed, from a methodological point of view, any choice leading to a dichotomous status of poverty, whatever the well-being indicator is, and to a normalized measure of intensity of poverty, does not change the formulation and the properties of the index.

(i) a relative poverty line approach, with a different poverty line for each year; and

(ii) the mean of the normalized poverty gaps as intensity weights, that is:

$$w_{ij} = \frac{pg_i + pg_j}{2} = \frac{\left(\frac{z_i - y_i}{z_i}\right) + \left(\frac{z_j - y_j}{z_j}\right)}{2} \tag{2}$$

with i and j belonging to S^* and where pg_i is the relative poverty gap measured in wave i (z_i and y_i are, respectively, the poverty line and the equivalized income/expenditure of a longitudinally poor person at wave i), and similarly for pg_j; and

(iii) the following formulation, as *decay factor*:

$$de = 1 - \frac{r^2}{(r+1)^2} \tag{3}$$

where r is the number of consecutive recovery spells (zeros) at the end of the poverty profile, that is the number of years out of poverty after the last 1 in the sequence (r is an integer from 0 to $T - 2$). Whatever the length of the panel, $0 < de \leq 1$.

The *decay factor* displays the behavior in Figure 1 (where we suppose to have a panel of $T = 25$ waves, so that $r = 0, 1, 2, \ldots, 23$). It achieves its maximum value (which is 1) when the last element of the poverty sequence is a year spent in poverty. Moreover, if the last two years in the poverty profile are years of non-poverty, the index is nearly halved (reduction of 44 percent); after four years it is reduced by nearly two thirds (a reduction of 64 percent), meaning that previous

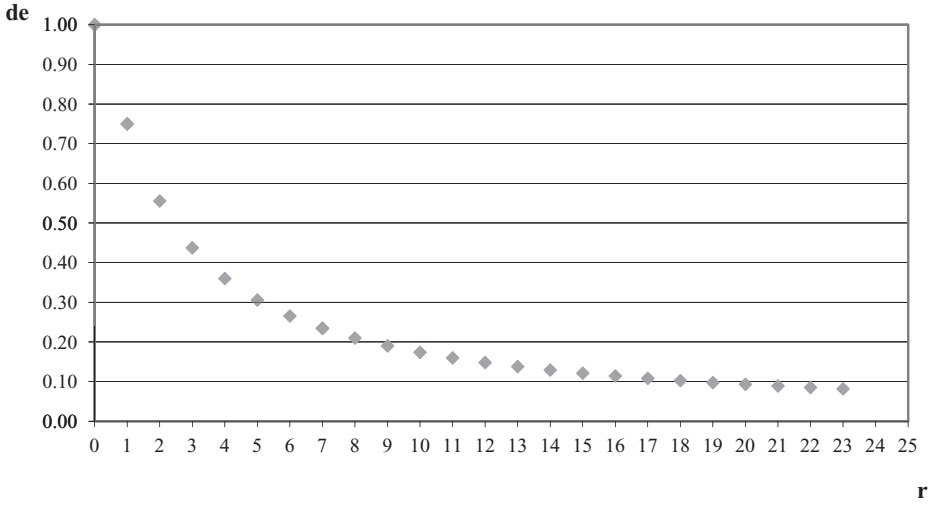

Figure 1. Behavior of the Decay Factor

episodes of poverty have little importance in evaluating the current situation of hardship of the individual, and the more they are set in the past, the less is their relevance in the computation of the index. This adopts the rationale behind the Laeken indicators of persistent poverty (Eurostat, 2003), giving a real importance only to the most recent years in the story of the individual (merely the last four years).[5]

Obviously, other specifications are possible for *de* and for w_{ij}. In particular for *de*, a different equation is possible which allows for a more smoothing decay, or a steeper one; the only attention that needs to be paid is to its ranging in (0,1] with 1 when the last year in the poverty profile is a year spent in poverty. As far as the measurement of the intensity of poverty (w_{ij}) is concerned, if one wishes to diminish the relative importance of very small slips below the poverty line and to increase the effect of larger gaps, it is possible to use the squared poverty gaps inside (2), or any other index in the class of the Foster, Greer, and Thorbecke indices with a parameter value higher than two (Foster *et al.*, 1984).

As an example, considering the poverty profile (1100110) mentioned above, and a hypothetical corresponding poverty gap profile (0.2, 0.7, 0, 0, 0.8, 0.5, 0), the PPI index is:

$$PPI = \left[\left\{(2-1)^{-1}\cdot\left(\frac{0.7+0.2}{2}\right)+(5-2)^{-1}\cdot\left(\frac{0.8+0.7}{2}\right)+(5-1)^{-1}\cdot\left(\frac{0.8+0.2}{2}\right)+\right.\right.$$
$$(6-5)^{-1}\cdot\left(\frac{0.5+0.8}{2}\right)+(6-2)^{-1}\cdot\left(\frac{0.5+0.7}{2}\right)+$$
$$\left.\left.(6-1)^{-1}\cdot\left(\frac{0.5+0.2}{2}\right)\right\}\Big/11.15\right]\cdot\left(1-\frac{1^2}{(1+1)^2}\right)=0.114$$

3.2. *Properties of the Poverty Persistence Index*

Let us now introduce some of the main features of the Poverty Persistence Index.

(1) *Boundedness*. The index is normalized, which means that it ranges in [0,1]. The lower bound is reached when an individual has never been poor or has been poor just once along the whole observed period. The upper bound can only be attained virtually. In fact, the situation in which an individual has always been poor during the observed lifespan and his normalized poverty gaps has always been equal to 1 (namely, yearly incomes equal zero), is unrealistic. Therefore, the denominator of equation (1) is a never achieved maximum, and could produce too much compression in the actual index range.

(2) *Path-dependence*. Given the length of the panel:

(2a) The PPI does not depend merely on the total number of years spent in poverty, but is also influenced by their timing, through the

[5]In the framework of Laeken indicators, people are defined as "at persistent risk of poverty" if they have "an equivalized disposable income below the at-risk-of-poverty threshold in the current year and in at least two of the preceding three years" (Eurostat, 2003).

relative distance between each ordered pair of 1s in the poverty sequence.[6]

(2b) In the same way the severity of longitudinal poverty does not merely depend on the intensity of year by year poverty (e.g. the value of poverty gaps) but also on the position of the most severe years inside the poverty profile.

(2c) The path is also relevant for the PPI, as recent years are evaluated differently from less recent ones. In particular, via the decay factor, the more recent the spells of poverty are, indicating an unsolved problem or a problem recent enough to be worrisome, the higher the longitudinal poverty index value is. This acceptation of the path-dependence property could be referred to as a "late-poverty axiom."

(3) *Weak distributional sensitiveness*. The index is able to distinguish among any permutation of the poverty measures inside the poverty profile, and also among any combination of values of the poverty measures, which gives the same amount of poverty.[7] This can be seen as a consequence of *path-dependence* of type 2b.[8] The only case in which this property fails (and this is why we refer to it as a "weak condition") is when there are only two years of poverty in the whole sequence, in positions i and j (consecutive or not), so that the weight w_{ij} in (2) is not able to distinguish between any combination of the poverty gaps which gives the same total (that is, for example, when the two poverty gaps are 0.9 and 0.1, or 0.8 and 0.2, or even 0.1 and 0.9).[9]

(4) *Cumulative hardship*. The cumulative effect of poverty, which is a normative issue at the basis of the PPI, acts on two levels: (a) the status sequencing level; and (b) the intensity sequencing level. Particularly:

(4a) Two or more consecutive years of poverty give a contribution to the index which is higher than two years of poverty interspersed with one or more years of non-poverty. This is why, for two consecutive years, the inverse of the distance $(i - j)$, that is the addendum $(i - j)^{-1}$, equals 1, while any other distance—greater than 1—produces a smaller contribution to the sum at the numerator of the ratio in

[6]We are aware that even the best or the longest panel dataset does not contain all the information on the whole income stream; hence, some information is necessarily censored. This is why, as highlighted by Foster and Santos (2009, p. 10), "any penalization of consecutiveness is at risk of being misleading."

[7]Note that the index does not satisfy the Pigou–Dalton condition, as adapted to the longitudinal context, because it is insensitive to the *direction* of income transfers among poverty spells experienced by the same individual (even regressive or progressive). Indeed this axiom is born to evaluate the inequality in a population, and it relates to the distribution of the income among poor people. As, at this stage, we focus on the evaluation of poverty condition in a single individual, we do not find this property to be relevant, although Foster (2009) refers to it in a longitudinal framework.

[8]For example, the sequences (0.3, 0, 0, 0.1, 0.9, 0.7, 0) and (0.3, 0, 0, 0.9, 0.1, 0.7, 0) or (0.3, 0,0, 0.5, 0.5, 0.7,0) produce different values of the PPI even if w_{45} is equal in all the three cases. This is due to the fact that w_{14} and w_{15} are always different in the three sequences above, so that the PPI has different values.

[9]In this case an easy, but partial, solution is to consider the mean of the squared poverty gaps as weights, instead of the mean in equation (2); since $(0.9^2 + 0.1^2)$ is different from $(0.8^2 + 0.2^2)$ or from $(0.5^2 + 0.5^2)$ even though $(0.9^2 + 0.1^2) = (0.1^2 + 0.9^2)$.

equation (1). This also allows us to take into account, implicitly, the length of the spells of recovery inside the poverty profile.

(4b) Two years of severe poverty condition (e.g. with high poverty gaps) hit harder if they are consecutive rather than otherwise. This is easily proved given that the intensity of poverty is multiplied by a non-negative quantity, which is the inverse of the distance between pairs of poverty spells.

As a corollary of both the path-dependence property and the cumulative hardship property, the following can be derived:

(5) *Poverty dynamics*. Given the total number of years spent in poverty, the index decreases as the number of transitions out of the poverty status (*volatility*) decreases over time, and, vice versa, it increases if the number of transitions in and out of the poverty status decreases (*stability*).

Moreover, the index also satisfies the following axioms:

(6) *Monotonicity*. Other things being equal, the index increases when the shortfall below the poverty line in one year of poverty increases (*intensity of poverty*) and, as a consequence of cumulative hardship (property 4b), when the most severe years of poverty are consecutive (*sequencing of poverty gaps*).

(7) *Scale invariance*. The PPI is invariant to any change in the unit of measurement of the well-being indicator (income or consumption) and of the poverty line, which could derive from any scaling up or down by the same factor. The fulfillment of this property is due to the PPI being calibrated to the poverty line.[10]

4. An Aggregate Longitudinal Poverty Index

Synthetic information about the intensity and diffusion of longitudinal poverty in a given country or group is essential to address effective policies and it helps understand the characteristics of the individuals' longitudinal poverty experience. An appropriate societal level index should take into account its depth (how far below a poverty line—however measured—people fall), its duration (length of time in which poor people experience a particular poverty condition), its incidence (share of people who fall into poverty), and its recentness (whether the situation of chronic poverty is overcome or is still present).

The seminal paper by Sen (1976) widely discusses the aggregation step as a crucial phase in the building of a poverty index. Also in the longitudinal context, this step is fundamental; they emerge two ways: (1) by starting from the measures of each individual poverty persistence and then aggregating across all individuals in a society; or (2) by aggregating cross-sectional poverty measures in each year and then aggregating across time (for a deeper discussion on this step in the building of a longitudinal societal poverty measure, see Calvo and Dercon, 2009 and Bossert *et al.*, 2011).

We chose to aggregate first across time, in order to obtain an index of poverty for each individual in the population, and then to aggregate across individuals.

[10]Moreover PPI satisfies axioms of Time focus and Time monotonicity, as stated by Foster (2007).

The reverse order of aggregation is not feasible for our index since this would contradict the "path dependence property" which does not allow for any compensation among individuals for the same year, but only for compensations among poverty profiles (sequences).

Note that for similar reasons, the same choice is made in order to obtain the aggregate level index in the papers by Bossert *et al*. (2011) and Gradin *et al*. (2011).

The choice of the proper aggregating function is driven by the need to guarantee some basic properties to the societal level index. Indeed, asymmetry in the distribution of poverty is an empirical evidence in developed countries, where a high percentage of people are rarely poor during their life or experience very few years of poverty. Therefore, the average of the individual poverty persistence indices is expected to be "structurally" low, and non-representative of the true intensity of longitudinal poverty within a society. In this case, a better choice for an aggregate measure could be the median value of the distribution of individual poverty indices.[11] However, the properties of subgroup consistency and of decomposability, which are usually required for aggregate level indices, would no more be satisfied if the median was used as an aggregation function. These are the reasons why we proceed through the simple arithmetic mean of the individual longitudinal poverty indices (PPI_H, with $H = 1, 2, \ldots, N$) in the strand of most of the literature contributions.

Therefore, to obtain an index of poverty persistence at a population level, we proceed to the aggregation of the N individual indices PPI. Hence, the Aggregate Poverty Persistence Index is:

$$APPI = \frac{\sum_{H=1}^{N} PPI_H}{N}. \tag{4}$$

APPI spans continuously in [0,1] where 0 corresponds to an ideal situation of a population with no longitudinally poor individuals,[12] whereas 1 corresponds to a hypothetical population in which all the individuals are always poor with constant and maximum intensity throughout the entire period. For all the intermediate values, the higher the value of the index, the higher is the long-lasting poverty in a society, according to our acceptation.

Let us now focus on the properties of the aggregate longitudinal poverty index.

(a) *Monotonicity axiom*. All things being equal, if one individual experiences a worsening of his longitudinal poverty condition (e.g. in the status sequencing, and/or in the intensity of poverty during at least one year, and/or in the intensity sequencing, and/or in the recentness), the societal APPI increases.

[11]The use of a symmetric mean of order r is sometimes suggested in order to have distribution-sensitive measures (see among others, Bossert *et al*., 2009).

[12]Note that, within our framework, this implies that people are never poor along T waves or are poor at a maximum of once in the observation period.

(b) *Anonymity property*. Any exchange among the ordered poverty profiles, by which the same poverty sequence moves from one person to another, does not affect the aggregate index of longitudinal poverty.

(c) *Decomposability property*. The APPI can be expressed as a weighted mean of subgroup poverty indices ($APPI_m$, with $m = 1, 2, \ldots, M$), in which the weights correspond to the size of the M groups (N_m), and, for each year, all the groups share the same poverty line. Therefore, the APPI is:

$$APPI = \sum_{m=1}^{M} APPI_m N_m \Big/ \sum_{m=1}^{M} N_m . \tag{5}$$

(d) *Subgroup consistency axiom*. If longitudinal poverty falls within a given subgroup and other subgroups remain unchanged, then the aggregate index must fall. Indeed this property is true for the APPI in a restricted form, that applies only when changes occur in terms of intensity and not of duration, or sequencing. This is due to the path-dependence property and, most of all, to the fact that the PPI is based on the mutual distances between the episodes of poverty, which does not make the decomposability property a direct consequence of the subgroup consistency (such as it was proved to happen for the single period measures; see Foster and Shorrocks, 1991).

(e) *Replication invariance*. If two or more identical populations are gathered, the aggregate index does not change, that is the index is independent from the population size.

(f) *Scale invariance*. As a consequence of the scale invariance described for the individual index, the APPI also satisfies this property.

5. Comparisons with Other Longitudinal Poverty Measures

5.1. *The PPI and Some Other Individual Level Longitudinal Poverty Indices*

Among the different measures mentioned in Section 2, we selected for this section three indices which pay the same kind of attention, as the PPI, toward the sequencing of spells of poverty, and which focus on the blocks of *consecutive* spells of poverty or of non-poverty.

In particular, we compare: (1) the PPI index (without the decay factor) with the index created by Bossert *et al*. (2011) and the one by Dutta *et al*. (2011); (2) due to reasons explained in the following paragraphs, the PPI index (including the decay factor) with an index in the class by Hoy and Zheng (2011); and (3) the PPI (including the decay factor) with one of the Foster (2009) indices, to put in evidence the differences resulting from accounting for, or not, consecutive years of poverty.

The index of Bossert *et al*. (2011), referred to as BCD in the following paragraphs, uses the length of the block of consecutive years of poverty as a weight for the poverty measures in each single year. The analytical formulation is:

$$BCD = \frac{1}{T} \sum_{t=1}^{T} D^t(p) \cdot p^t(y_t; z)$$

in which T is the length of the poverty profile, $D^t(p)$ is the length of the spell to which year t belongs, $p^t(y_t; z)$ is whatever measure of poverty at wave t in the class of the indices of poverty by Foster, Greer, and Thorbecke (Foster *et al.*, 1984), where y is the well-being variable and z is the poverty line.

The index by Dutta *et al.* (2011), referred to as DRZ in the following paragraphs, focuses on the length of the recovery period which immediately precedes each year of poverty. The index is given by:

$$DRZ = \frac{1}{T}\sum_{t=1}^{T}\left(\frac{1}{1+n_t}\right)^{\lambda} \cdot p^t(y_t; z)$$

in which n_t are the years of non-poverty preceding a year of poverty, T and $p^t(y_t; z)$ have the same meaning as given above, and λ is a parameter accounting for how much importance one chooses to give to the relief given by n_t.

The index by Hoy and Zheng (2011) is a weighted average between the weighted average of all per-period poverty levels and poverty level according to the average lifetime consumption. That is:

$$HZ = \beta(T)\left\{\sum_{t=1}^{T}\alpha(t,T)\,p^t(y_t; z)\right\} + (1-\beta(T)) \cdot p(\bar{y}; z)$$

where $\alpha(t, T)$ is a weighting function in (0,1) which is strictly decreasing in time, for example as suggested by the authors $\left(1-\frac{t}{T+1}\right)^{\gamma}$ with $\gamma > 0$; $p^t(y_t; z)$ is usual the measure of poverty at time t; whereas $p(\bar{y}; z)$ is the lifetime poverty measure (based on the average consumption across the observation period). As far as the parameters are concerned, the effect of the weighting function can be made non-linear if γ is greater than one, the influences of the snapshot poverty level and of the lifetime poverty level can be balanced by tuning the β parameter which ranges in (0,1). The lower the value of β, the higher the compensation.

The index by Foster (2009) is the most simple one, and it assumes no path-dependence among poverty spells. Its analytical formulation is:

$$F = \frac{\sum_{t=1}^{T}\left(p^t(y_t; z)\right)}{T}$$

with the same notation given above. Hence, the Foster index is the average of the per-period poverty measures experienced by chronically poor individuals. Here we chose the poverty line z as an income cut-off, and a two-year period as a duration cut-off.

In the following, we assume that $p^t(y_t; z)$ is the poverty gap (both for the PPI and for the other four indices considered for comparisons).

Let us suppose there are six individuals observed for $T = 8$ consecutive years and suppose we know for each year their poverty gaps. Table 1 reports the values of the compared indices of longitudinal poverty at an individual level. Now it is worthwhile to say that the values are not cardinally comparable, since only the PPI

TABLE 1

Comparisons among Measures of Individual Longitudinal Poverty

Individual	Wave								PPI without de	BCD	DRZ ($\lambda = 1$)	PPI with de	HZ ($\beta = 1$; $\gamma = 1$)	F
	1	2	3	4	5	6	7	8						
A	(0.50	0	0	0	0.33	0.48	0.25	0.90)	0.171	1.043	0.277	0.171	0.907	0.3075
B (permutation)	(0.50	0	0	0	0.33	0.90	0.25	0.48)	0.186	1.043	0.277	0.186	1.000	0.3075
C (decrease of recovery spell)	(0.50	0	0	0.33	0.48	0.25	0.90	0)	0.181	1.043	0.280	0.136	1.124	0.3075
D (shifted patterns)	(0	0.50	0	0	0.33	0.48	0.25	0.90)	0.181	1.043	0.280	0.181	0.851	0.3075
E (inflow)	(0.25	0.33	0.48	0.50	0.90	0	0	0)	0.225	1.538	0.308	0.098	1.477	0.3075
F (outflow)	(0.90	0.50	0.48	0.33	0.25	0	0	0)	0.225	1.538	0.308	0.098	1.803	0.3075

and Foster index have a delimited range, that is [0,1], whereas all the other ones are upper-unbounded. In Table 1 we can see that both BCD and DRZ are insensitive to any permutation of the poverty gaps. This is because they do not take into account changes inside the block of consecutive poverty gaps. Therefore, if we consider the profile of the two individuals A and B, who experienced the same poverty gaps but with a swap between waves 6 and 8, we notice that the indices BCD and DRZ do not distinguish the different distributions of income/consumption inside the two individuals' lifespan. On the contrary, the PPI index (in order to make a comparison, here assumed without the decay factor) evaluates the condition of individual B as worse than that of individual A because, swapping waves 6 and 8, the distance between the worst poverty gap—that is 0.90—and, respectively, 0.33 and 0.50 is reduced, whereas the distance between 0.90 and all the other poverty gaps is unchanged.

As far as the differences between individuals A and C are concerned, both the $PPI_{(without\ de)}$ and DRZ are sensitive (in the same direction) to the shortening of the recovery spell but for completely different reasons. The DRZ index evaluates the situation of C as more difficult than the situation of A because of the shorter recovery spell between the two blocks of poverty, which implies that there is less time to mitigate the successive poverty experience. On the other hand, the $PPI_{(without\ de)}$ is higher for C than for A because poverty experiences got closer, with a consequent increase of the hardship (according to the idea of cumulative hardship).

The effect of the decay factor can be seen comparing individuals C and D, who experimented the same "main pattern"[13] but with a different position inside their poverty sequence. From the PPI perspective (see column 13), individual D lived a worse poverty experience than individual C in that recent periods of poverty contribute more than earlier ones. This characteristic of the PPI refers to the fact that the later an experience of poverty is, the worse the evaluation of the longitudinal poverty of individuals should be (see "late-poverty axiom").

The last two profiles in Table 1 show that all the four indices ($PPI_{(with\ and\ without\ de)}$, BCD, and DRZ) are insensitive to "loss aversion," insofar as they give the same value if the individual is better off with a decreasing sequence of poverty gaps (outflow streams) as if he is worse off due to an increasing sequence of poverty gaps (inflow streams).

Columns 13 and 14 in Table 1 show, respectively, the values of the PPI index (full version) and of an index in the class by Hoy and Zheng (2011).[14] We chose this comparison because it is interesting to match two different ways of considering the pattern of poverty inside the individual profile. The first difference is that the decay factor acts *ex-post* as a weighting factor for the whole evaluation of poverty, whereas the function $\alpha(t,T)$ by Hoy and Zheng (2011) modifies differently the contribution of each year of poverty; it acts by simply grounding on the position of the years of poverty inside the profile. We could summarize by saying that, in some sense, the PPI focuses more on the present (or recent past), whereas the HZ

[13]"Main pattern" is the sub-sequence included between the first and the last observed 1 in the poverty sequence. It is the most relevant information for the numerator of the ratio in equation (1).

[14]Here, for the sake of comparability, we use the version of the Hoy and Zheng's index which accounts only for snapshots of poverty, excluding the term incorporating average lifetime poverty.

is deeply grounded in the past. Obviously, this is a normative issue, and one is free to choose the perspective that is more suitable to each specific measurement context. From comparing the two indices it is apparent that both the HZ and the PPI_{de} are sensitive to: (1) permutations; (2) decreases of poverty spells; and (3) shifting of the main pattern. Moreover, the HZ is the only index which is sensitive to "loss aversion," simply because one of its main characteristics is to discriminate between years of poverty according to their position in the observed lifespan.

Finally, as expected, the Foster index does not distinguish at all among the six poverty profiles, highlighting the importance of accounting for poverty sequences.

5.2. *The APPI and Some Other Aggregate Longitudinal Poverty Indices*

Let us now shift the focus to the societal level. For this purpose we have recourse to data from the seven waves of the European Community Household Panel (ECHP), 1994–2000.[15] The following are not substantive analyses on the characteristics of longitudinal poverty in Europe, but simply an illustration of some performances of our indices. We selected the dataset of the 11 countries participating in the survey for all the waves, and, within these, we selected only individuals with no missing information on the household income variable.[16]

For the sake of exemplification, let us first have a look at Figure 2 to see what kind of information could be drawn from the PPI distribution. Figure 2 provides a synthetic comparison of the longitudinal poverty distributions across European countries using the index in equation (1), temporarily omitting the decay factor. A distribution such as that in the Denmark panel, represents a situation where a higher proportion of individuals who experience low levels of PPI accommodates with a very low proportion of people with high index values. On the opposite side, we have a panel, such as the Greece (or Italy or Portugal) one, where there is a relatively small proportion of individuals with low levels of longitudinal poverty, in terms of duration and of intensity, together with a sizable proportion of people who have high levels of PPI.

Now let us have a look at the aggregate level index, in particular in comparison with other measures. As seen in Section 2, longitudinal poverty can be measured in many ways. In this section, the comparison among our aggregate measures of APPI (derived from PPI with and without the decay factor) and, respectively, (i) the aggregate measure by Foster (which does not account for the cumulative effect of repeated spells of poverty), (ii) the aggregate level index by Bossert *et al*. (2011), and (iii) the one by Hoy and Zheng (2011),[17] is shown in Table 2. Even in this case the indices are not comparable due to different ranges,

[15]Since, as known, at wave t the interviewed person declares the income that he perceived at time $t-1$, we made a time realignment of this variable.

[16]This is because we do not encourage the comparison of sequences of different lengths. In fact, as is well-known, poverty dynamics is strictly related to the length of the time window, and it usually goes down with the widening of the observation period. So the comparisons among individuals/countries with different lengths of observation periods are somehow tricky, even if both APPI and PPI allow for them (due to the nature of the denominator of the ratio in equation (1)). So the sample from ECHP is a balanced panel of 66,861 individuals, with the smallest sample of Dutch people (2449) and the largest sample of Italian people (10,228).

[17]Here the index by Dutta *et al*. (2011) has not been taken into consideration since they do not propose an aggregate level index.

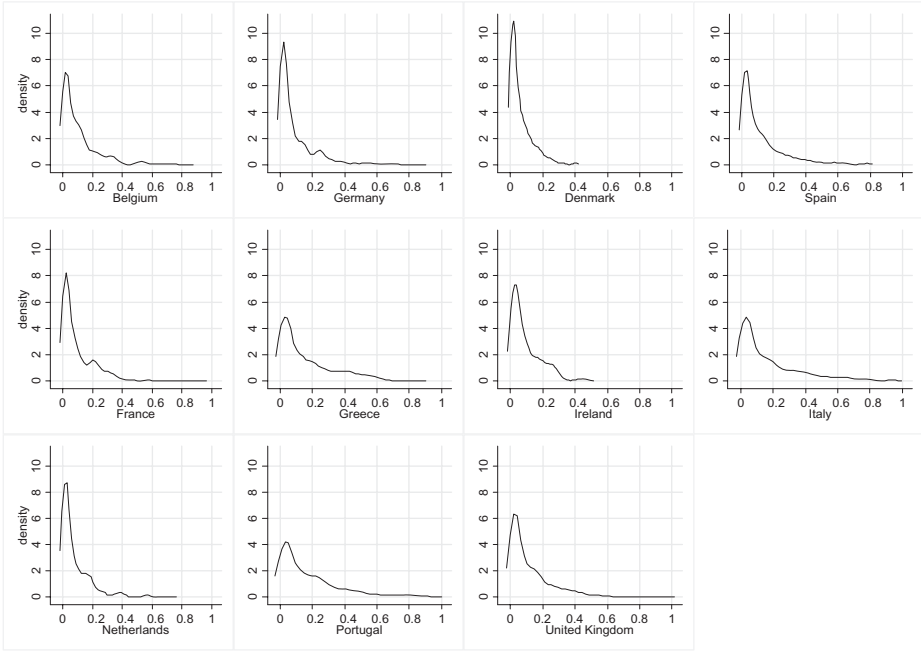

Figure 2. Kernel Smoothing of PPI (Omitting the Decay Factor) among People Who Are Poor More Than Once in 1994–2000 (Trimmed Distribution)

TABLE 2

Values of APPI, BCD, HZ, and F Indices (Sample of People Who Were Poor More Than Once between 1994 and 2000)

Country	APPI (without de)	APPI (with de)	Aggregate BCD	Aggregate HZ ($\beta = 1$; $\gamma = 1$)	Aggregate F
Denmark	0.061	0.053	0.355	0.334	0.102
Netherlands	0.081	0.066	0.474	0.489	0.135
Belgium	0.105	0.097	0.639	0.510	0.141
France	0.095	0.087	0.586	0.453	0.131
Ireland	0.093	0.085	0.558	0.405	0.126
Italy	0.171	0.157	1.040	0.834	0.229
Greece	0.156	0.145	0.956	0.771	0.211
Spain	0.116	0.102	0.672	0.631	0.173
Portugal	0.177	0.163	1.107	0.802	0.222
Germany	0.091	0.082	0.562	0.477	0.132
U.K.	0.119	0.108	0.743	0.548	0.157

indeed: (1) the lower bound (which is zero for all the indices) is achieved according to a different duration cut-off[18] for identifying poor people; and (2) the upper bound is only available for the APPI and Foster index, which range in [0,1]. This is why we chose to aggregate only the indices referring to individuals which spent

[18]The duration cut-off is two years for the APPI and one year for all the others.

TABLE 3

RANKINGS BY APPI, BCD, HZ, AND F INDICES (SAMPLE OF PEOPLE WHO WERE POOR MORE THAN ONCE BETWEEN 1994 AND 2000)

Country	APPI (without de)	APPI (with de)	Aggregate BCD	Aggregate HZ ($\beta = 1$; $\gamma = 1$)	Aggregate F
Denmark	11	11	11	11	11
Netherlands	10	10	10	7	7
Belgium	6	6	6	6	6
France	7	7	7	9	9
Ireland	8	8	9	10	10
Italy	2	2	2	1	1
Greece	3	3	3	3	3
Spain	5	5	5	4	4
Portugal	1	1	1	2	2
Germany	9	9	8	8	8
U.K.	4	4	4	5	5

at least a two-year period of poverty, and to compare the indices only in terms of rankings.

The aggregation step is obtained for all the indices by arithmetic mean, as suggested by the authors themselves (see Table 2).

Table 3 shows the rankings of the 11 European countries, according to the different indices of aggregate longitudinal poverty considered here. At an aggregate level, most of the differences among the indices, as highlighted in Section 5.1, seem to disappear or at least they seem more smoothed. This is a typical problem that can occur when one chooses a "compensative" function, such as the arithmetical mean, as an aggregation function. Since this function is widely preferred in the literature due to the properties of decomposability which it often guarantees, one solution could be found by applying the squared poverty gaps (instead of the poverty gaps), due to their ability in emphasizing the larger slips below the poverty line.

The aggregation step produces an equivalence between the ranks of the indices in the classes by Hoy and Zheng, and Foster. Indeed, we know that they are very different mostly because the former weights differently each poverty spell whereas the latter uses a uniform weighting function. The same "compensation" effect could explain the absence of differences between the rankings produced by the APPI with or without the decay factor.

However, the difference between the rankings by the aggregate Foster index and both the APPI and the aggregate BCD is striking. This sheds light on the nature of *persistence* of poverty, considered as an experience of repeated and close years of poverty, that reveals an effect in terms of results of the measurement and highlights interesting aspects of this complex phenomenon.

6. CONCLUSIONS

This paper proposes a measure of poverty (named PPI) in the longitudinal perspective based on the sequencing of individual poverty experiences throughout

the observed lifespan. The main innovations of PPI are: (1) the insertion of a smoothing factor lowering the relevance of the overall poverty experience as much as the poverty is settled in the past (late-poverty axiom); and (2) the way the cumulative effect of poverty is measured (i.e. considering all the pairwise distances: path-dependence axiom). This manner of dealing with the effect of repeated spells of poverty is a very general approach which allows one to take into account either consecutive or not consecutive episodes. At an individual level, the PPI simultaneously considers the duration, the sequencing, the severity and, if desirable, the recentness of poverty spells along an observed period. The Poverty Persistence Index assigns a higher degree of (longitudinal) poverty to people who experience poverty in consecutive, rather than separated, periods, for whom the distances from the poverty line are higher along time, and, moreover, when the worst years are consecutive and/or recent.

We also propose an aggregate index of persistence in poverty (APPI), which is the average of individual indices and is able to measure the distribution of the persistence of poverty within a given society. The APPI satisfies axioms of monotonicity, anonymity, decomposability, consistency for subgroups, replication, and scale invariance. Both the individual and societal level indices are normalized indices, which means they both range in the real interval [0,1], allowing an easy interpretation of findings.

The paper also highlighted weaknesses and strengths of our indices compared with some other ones, highlighting the importance of taking into account the effect of repeated and close spells of poverty.

We do not claim that our indices perform better in every considered aspect. However, we do argue that they satisfy a set of core axioms and that, most of all, they introduce a different approach to the measurement of longitudinal poverty that could enrich the framework of available measurement instruments and help study the complexity of the poverty phenomenon over time. The use of both the PPI and the APPI could also be useful to accurately target specific anti-poverty policies.

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