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Abstract

We examine the measurement of individual poverty in an intertemporal context. In contrast to earlier contributions, we assign importance to the persistence in a state of poverty and we characterize a class of individual intertemporal poverty measures reflecting this feature. In addition, we axiomatize an aggregation procedure to obtain intertemporal poverty measures for entire societies and we illustrate our new indices with an application to EU countries.

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1 Introduction

In a seminal contribution, Sen (1976) distinguished two fundamental issues in poverty measurement, namely, (i) identifying the poor among the total population; and (ii) constructing an index of poverty using the available information on the poor. The first problem has been solved in the literature by setting a poverty line (which may or may not depend on the income distribution under consideration) and identifying as poor the individuals whose incomes fall below this threshold. Regarding the second, the aggregation problem, many indices have been proposed capturing not only the fraction of the population which is poor (the *head-count ratio*), that is, the incidence of poverty, but also the extent of individual poverty and the inequality among those who are poor. The literature on poverty measurement has advanced to a high degree of sophistication since Sen (1976). However, there remain substantial issues to be addressed. One of these issues is concerned with the measurement of *intertemporal* poverty as opposed to limiting attention to single-period considerations. For instance, consider an observer comparing two individuals both of whom are poor today to the same degree. Suppose that, while the first was not poor in any of the previous two periods, the second individual experienced poverty in both previous periods in addition to the present. Is the degree of intertemporal poverty of those two individuals the same? This does not seem to be the case—the second individual is poorer as soon as the entire intertemporal income distribution is taken into consideration. Now consider again two individuals both of whom are poor today to the same degree but the first was poor also last year, while the second was out of poverty last year but in poverty the year before that. Is the intertemporal poverty of those two individuals the same? Again, we believe not. Both individuals were poor twice (and we are assuming that they were poor to the same degree) but the first individual experienced poverty in two *consecutive* periods while the second did not. The relative degree of overall poverty when comparing the two individuals over time depends on the role and evaluation of *persistence* in a state of poverty. To us, the negative effects of being in poverty are cumulative, hence a two-period poverty spell is much harder to handle than two one-period spells that are interrupted by one (or more) periods out of poverty. We believe that intertemporal information should not be neglected in assessing individual poverty. Nowadays, the availability of panel data for most of the countries in the world makes it possible for researchers to expand the information set when evaluating poverty. In addition to poverty lines, per-period poverty values and inequality among the poor, the lengths of individual poverty spells can be incorporated. We propose a way to add this time dimension to the information used in poverty measurement.

This paper is similar in spirit to Hoy and Zheng (2006) but the individual intertemporal poverty measures we characterize differ from theirs due to the properties that are deemed relevant to capture the role of time and persistence. Hoy and Zheng (2006) demand that aggregating first across individuals and then across time periods should be equivalent to aggregating in the reverse order—first across time periods for each single individual and then across members of the society. This leads to a notion of *path independence.* In contrast to Hoy and Zheng (2006), we consider the phenomenon of persistence to be crucial in assessing individual intertemporal poverty. Aggregating across individuals first means that this information is lost when we reach the second stage of aggregation. Hence we characterize an index of intertemporal poverty for each member of the society under analysis and then aggregate across members of society.

Foster (2007) expresses a similar view in proposing *chronic poverty* indices by aggregating first across time. In contrast to our contribution, persistence in the state of poverty is not assigned any relevance. The measures Foster (2007) proposes—generalizations of the Foster-Greer-Thorbecke (1984) class that allow for time to matter—do satisfy a property of *time anonymity* under which the sequencing of incomes in individual intertemporal profiles does not affect poverty. Foster (2007) defines an individual as chronically poor if its income is below the poverty line for at least a given number of periods. Thus, in addition to a poverty line, there is a second cut-off point in defining the chronically poor—a point defined in terms of the incidence of poverty over time. As is the case for our contribution, the order of aggregation matters in Foster's approach—in order to identify the chronically poor, the first aggregation step has to be performed across periods for each individual. The individual Foster (2007) indices are means over time of per-period Foster-Greer-Thorbecke (1984) indices. The aggregate indices are obtained by calculating average poverty among the chronically poor. Recall that, in Foster (2007), only individuals who are poor for at least a given number of periods are considered. Thus, if an individual is poor, but rarely so, it is treated in the analysis as one of the individuals who are never poor. This is not the case in the present contribution. We do not restrict our sample to chronically poor individuals, hence we take into account spells of poverty of any length. Foster (2007) formulates a set of axioms and discusses them in the context of his class of measures but he does not provide a characterization. The class of measures that we propose in this paper contains Foster's (2007) as a special case *if* applied to the chronically poor only. This corresponds to the limiting case where no importance is given to persistence and where the per-period individual poverty indicators are the gaps according to the indices belonging to the Foster-Greer-Thorbecke (1984) class.

Calvo and Dercon (2007) consider intertemporal measures of individual poverty as well. As is the case for Foster (2007), they formulate desirable properties of such measures but do not characterize specific classes. They suggest measures some of which allow for different treatment of different time periods by means of discounting. They also address the persistence issue but the proposed measure is very different from ours and deals only with poverty in the immediately preceding period without allowing the entire history of individuals to matter.

It seems to us that the negative effects of being in poverty are cumulative and depend on experienced histories. Empirical evidence is in favor of this view. Individuals who have been persistently poor are often discriminated against and "have little access to productive assets and low capabilities in term of health, education and social capital" (Chronic Poverty Research Centre, 2004, p.3). In addition, there is true state dependence in poverty status since the chances of being poor in the future are higher for individuals who are already poor, even after controlling for individual heterogeneity, observed and unobserved. "For example, the experience of poverty itself might induce a loss of motivation, lowering the chances that individuals with given attributes escape poverty in the future" (Cappellari and Jenkins, 2004, p.598). Regarding children, Bradbury, Jenkins and Micklewrite (2001) report that those who have been poor for a long time are worse off than those who are poor in a single period only. Walker (1995, p.103) writes that "When poverty predominantly occurs in long spells (...) the poor have virtually no chance of escaping from poverty and, therefore, little allegiance to the wider community."

The path-independence property mentioned above can be called into question in other models of social evaluation as well. For example, in a framework where well-being is to be aggregated across time and across individuals, aggregating across individuals first means that, in the second step of the procedure, we do not have information on the period of life of an *individual*—only *aggregate* per-period information is available. Hence, a given per-period level of individual well-being has to be treated in the same way, no matter in which period of life this level is achieved. This seems to be rather counter-intuitive and restrictive, and the same reasoning applies to the issue of intertemporal poverty measurement considered here. See, for instance, Blackorby, Bossert and Donaldson (1996, 2005) for discussions.

Hoy and Zheng (2006) is, to the best of our knowledge, the only other contribution that addresses the issue of intertemporal poverty measurement axiomatically and provides characterization results. While axiomatic discussions are provided in Calvo and Dercon

(2007) and in Foster (2007) as well, characterizations are absent and, therefore, the axioms do not provide a justification for narrowing down the class of measures to those suggested in these papers because it is not established that they are the only ones with the requisite properties.

Our approach is not restricted to formulations involving a fixed poverty line—we allow for *any* method to obtain individual per-period poverty indicators. In particular, use of a relative poverty line, that is, using a percentage of average or median income as the poverty line is compatible with our framework, and this is the procedure that is used in the applied part of our paper. This is in contrast with Hoy and Zheng's (2006) setting where a fixed poverty line is essential in order to ensure that their path-independence axiom is well-defined. Moreover, we do not assume the number of periods under consideration to be fixed, thus allowing for a richer set of possible comparisons as compared to those available in models where the time horizon is given.

The empirical and econometric literature on poverty measurement has recognized for some time the importance of being able to distinguish between chronic and transitory poverty and proposes alternative methods for capturing the relevant phenomenon; for surveys of this literature, see, among others, Rodgers and Rodgers (1993) and Jenkins (2000). Numerous applied contributions provide a detailed description of poverty persistence in various countries and help in shaping social policies but the measures used are established in an *ad hoc* fashion without much of a theoretical foundation. This paper contributes to this literature by filling this gap. Specifically, some of the empirical literature involving persistence in poverty proceed by counting the proportion of people being poor in each period. Alternatively, the percentage of 'long' poverty spells or the sequence of multiple spells is used as a crude measure of intertemporal poverty. In order to try to include information on the intensity of poverty, some authors capture the temporal aspect of individual poverty by using a measure of permanent income and then applying standard (static) indices of poverty such as members of the Foster-Greer-Thorbecke class (Foster, Greer and Thorbecke, 1984) to the resulting distribution of permanent incomes. See, for instance, Rodgers and Rodgers (1993, p.31) who use as permanent income "the maximum sustainable annual consumption level that the agent could achieve with his or her actual income stream over the same T years, if the agent could save and borrow at prevailing interest rates."

The main purpose of this paper is to provide an axiomatic foundation for the measurement of intertemporal poverty that differs from earlier approaches such as those of Hoy and Zheng (2006), Calvo and Dercon (2007) and Foster (2007) in the way persistence is taken into consideration. Our measure pays attention to the length of individual poverty spells by assigning a higher level of poverty to situations where, *ceteris paribus,* poverty is experienced in consecutive rather than separated periods. In the theoretical part of the paper, we provide a characterization of our new class of measures. In addition, we characterize aggregate intertemporal poverty as the arithmetic mean of the individual intertemporal poverty indices. In the applied part of the paper, we use our new aggregate indices as well as measures suggested in the earlier literature to illustrate the commonalities and the differences with alternative approaches. The application pertains to poverty patterns among EU countries in the years from 1994 to 2001.

2 Individual Intertemporal Poverty Measures

This paper is concerned with the intertemporal aggregation of per-period individual poverty indicators (such as relative poverty gaps or their square values) over time and the across-society aggregation of these individual measures into a social measure of intertemporal poverty. We begin with a discussion of individual intertemporal poverty and its link to what we refer to as persistence. Suppose that individual poverty indicators are observed in each of a non-empty and finite set of periods. A standard way of generating these per-period indicators consists of defining them, in each period, as the difference between a (constant or income-distribution-dependent) poverty line and the individual's income divided by the poverty line if its income is below this poverty line and as equal to zero otherwise. We do not need to commit to a specific way of obtaining these indicators and treat them, for simplicity, as the primary inputs for our analysis.

The novel feature we suggest in intertemporal poverty measurement is to take into consideration the length of the poverty spells an individual is subjected to. For example, suppose two per-period individual poverty profiles are compared, where the first profile is given by $(1/3, 1/2, 1/4, 1/2, 0)$ and the second by $(1/3, 0, 1/2, 1/4, 1/2)$. We claim that individual intertemporal poverty should be higher in the first than in the second: in the second profile, the individual experiences a break from being in poverty rather than being poor in four *consecutive* periods.

Moreover, the length of spells out of poverty matters in the sense that, *ceteris paribus,* a longer break between poverty spells is better than a shorter break. For instance, suppose we have two per-period individual poverty profiles $(1/2, 0, 1/3, 1/4, 0, 1/2)$ and $(1/2, 0, 0, 1/3, 1/4, 0, 1/2)$. According to our hypothesis, the first of these profiles is associated with a higher value of individual intertemporal poverty. The two profiles involve an identical triple of spells—namely, a one-period spell with a per-period poverty of 1/2, a two-period spell with poverty values of 1/3 and 1/4, and another one-period spell with poverty 1/2. However, there is one zero-poverty period separating the spells in the first profile but a break of two periods in the second and, thus, intertemporal poverty is lower in the second option.

As the second example illustrates, we include comparisons of poverty profiles of different length (and profiles coming from societies of possibly different populations and population sizes); this is essential in order to perform international comparisons involving data sets with different sampling periods. Let $\Omega = \cup_{T \in \mathbb{N}} \mathbb{R}^T_+$. For $T \in \mathbb{N}$, an individual per-period individual poverty *profile* of dimension T is a vector $p_i \in \mathbb{R}^T_+$, where p_i^t is individual i's poverty experienced in period $t \in \{1, \ldots, T\}$. An individual intertemporal poverty measure is a function $\mathbf{P}_i \colon \Omega \to \mathbb{R}_+$ where, for all $p_i \in \Omega$, $\mathbf{P}_i(p_i)$ is the intertemporal poverty experienced by person i.

The purpose of this paper is to formalize the idea that the lengths of poverty spells and the lengths of spells out of poverty affect individual intertemporal poverty. In this respect, our approach differs from that of Hoy and Zheng (2006). Furthermore, we do not restrict attention to environments with a fixed poverty line—we allow for any method to obtain individual per-period poverty indicators; in particular, the commonly-used procedure of using a percentage of average or median income as the poverty line is compatible with our setup, and this is the procedure that is used in the applied part of this paper.

The result of this section consists of a characterization of an individual intertemporal poverty measure that reflects the length-of-spell hypothesis mentioned above. This basic idea also motivates a characterization in the context of deriving measures of social exclusion from measures of individual deprivation (Bossert, D'Ambrosio and Peragine, 2007), where similar considerations apply. However, the axioms we employ are different and we obtain a different class of measures as a consequence.

The first property we impose on an individual intertemporal poverty measure requires that, in degenerate cases where there is only one period, individual intertemporal poverty and individual per-period poverty coincide.

One-period equivalence. For all $p_i \in \mathbb{R}_+$,

$$\mathbf{P}_i(p_i) = p_i.$$

As is standard in many issues involving social index numbers (see, for instance, Ebert and Moyes, 2000, in the context of individual deprivation measurement), we impose *de-*

composability properties both across spells and within spells. Across spells, that is, in situations where two groups of periods in poverty are separated by at least one period with zero poverty, we require individual intertemporal poverty to be equal to a weighted average of poverty experienced in each spell, where the weights are given by the proportional lengths of the two spells. The scope of the axiom is restricted to separate spells due to one of the features we want to highlight—the importance of the lengths of poverty spells and spells out of poverty.

Across-spells average decomposability. For all $T \in \mathbb{N} \setminus \{1\}$, for all $p_i \in \mathbb{R}^T_+$ and for all $t \in \{1, \ldots, T-1\}$, if $p_i^t = 0$ or $p_i^{t+1} = 0$, then

$$\mathbf{P}_i(p_i) = \frac{t}{T}\,\mathbf{P}_i(p_i^1, \ldots, p_i^t) + \frac{T-t}{T}\,\mathbf{P}_i(p_i^{t+1}, \ldots, p_i^T).$$

The second decomposability property applies to situations where there is but a single poverty spell—that is, the individual is in poverty in all T periods. Individual intertemporal poverty is a weighted average of individual poverty when the single spell is separated into two sets of periods. The weights involve an exponential expression in addition to the proportional lengths employed in the previous axiom. This is one possibility of requiring a superadditive structure in consecutive periods of poverty but it is clearly not the only one; alternative axioms, such as one that is based on linear rather than exponential weights (see Bossert, D'Ambrosio and Peragine, 2007), could be employed.

Single-spell exponential decomposability. There exists $c \geq 1$ such that, for all $T \in \mathbb{N} \setminus \{1\}$, for all $p_i \in \mathbb{R}^T_{++}$ and for all $t \in \{1, \ldots, T-1\}$,

$$\mathbf{P}_i(p_i) = \frac{t}{T}\,c^{T-t}\,\mathbf{P}_i(p_i^1, \ldots, p_i^t) + \frac{T-t}{T}\,c^t\,\mathbf{P}_i(p_i^{t+1}, \ldots, p_i^T).$$

The restriction $c \geq 1$ is imposed to ensure that the resulting measures are superadditive in the lengths of poverty spells. For $c = 1$, the axiom extends the average-decomposability property of the previous axiom to within-spell situations.

According to the class of measures we propose in this paper, individual intertemporal poverty is calculated as the weighted average of the individual per-period poverty values where, for each period, the weight is given by a generalized exponential function with base $\gamma \geq 1$. The argument of this exponential function is the length of the spell to which this period belongs minus one. To formalize this notion, consider any $T \in \mathbb{N}$ and $p_i \in \mathbb{R}^T_+$. For $t \in \{1, \ldots, T\}$ such that $p_i^t > 0$, let $\mathbf{D}^t(p_i)$ be the maximal number of consecutive periods including t with positive per-period poverty values. For $t \in \{1, \ldots, T\}$ such that $p_i^t = 0$, let $\mathbf{D}^t(p_i)$ be the maximal number of consecutive periods including t with zero per-period poverty. To illustrate this definition, consider the profile $p_i = (0, 1/2, 1/4, 1/3, 0, 0, 1/4) \in \mathbb{R}_+^7$. The length of the first non-poverty spell is one and, thus, $\mathbf{D}^1(p_i) = 1$. This is followed by a poverty spell of length three, which implies $\mathbf{D}^2(p_i) = \mathbf{D}^3(p_i) = \mathbf{D}^4(p_i) = 3$. The next two periods are periods out of poverty and we obtain $\mathbf{D}^5(p_i) = \mathbf{D}^6(p_i) = 2$. Finally, there is a one-period poverty spell and we thus have $\mathbf{D}^7(p_i) = 1$.

Foster's (2007) measure is obtained when (i) attention is restricted to the chronically poor; (ii) no importance is given to persistence (that is, the parameter γ is equal to one); and (iii) the per-period individual poverty indicators are the gaps according to the indices belonging to the Foster-Greer-Thorbecke (1984) class.

Our class of individual intertemporal poverty measures, parameterized by $\gamma \geq 1$, is now defined as

$$\mathbf{P}_i^\gamma(p_i) = \frac{1}{T} \sum_{\tau=1}^{T} \gamma^{\mathbf{D}^\tau(p_i)-1} p_i^\tau$$

for all $T \in \mathbb{N}$ and for all $p_i \in \mathbb{R}_+^T$. For example, if $\gamma = 2$, the individual intertemporal poverty associated with the profile $p_i = (0, 1/2, 1/4, 1/3, 0, 0, 1/4)$ is

$$\begin{aligned}
\mathbf{P}_i^2(p_i) &= \frac{1}{7} \sum_{\tau=1}^{7} 2^{\mathbf{D}^\tau(p_i)-1} p_i^\tau \\
&= \frac{1}{7} \left(2^0 \cdot 0 + 2^2 \cdot 1/2 + 2^2 \cdot 1/4 + 2^2 \cdot 1/3 + 2^1 \cdot 0 + 2^1 \cdot 0 + 2^0 \cdot 1/4\right) \\
&= \frac{1}{7} \left(4 \cdot 1/2 + 4 \cdot 1/4 + 4 \cdot 1/3 + 1 \cdot 1/4\right) = \frac{55}{84}.
\end{aligned}$$

The axioms introduced above characterize the class $\mathbf{P}_i^\gamma$. We obtain

Theorem 1 *An individual intertemporal poverty measure $\mathbf{P}_i \colon \Omega \to \mathbb{R}_+$ satisfies one-period equivalence, across-spells average decomposability and single-spell exponential decomposability if and only if there exists $\gamma \geq 1$ such that $\mathbf{P}_i = \mathbf{P}_i^\gamma$.*

Proof. 'If.' Let $\gamma \geq 1$. That $\mathbf{P}_i^\gamma$ satisfies one-period equivalence is straightforward to verify.

To prove across-spells average decomposability, let $T \in \mathbb{N} \setminus \{1\}$, $p_i \in \mathbb{R}_+^T$ and $t \in \{1, \ldots, T-1\}$ be such that $p_i^t = 0$ or $p_i^{t+1} = 0$. By definition of $\mathbf{P}_i^\gamma$, we have

$$\begin{aligned}
\frac{t}{T}\, \mathbf{P}_i^\gamma(p_i^1, \ldots, p_i^t) + \frac{T-t}{T}\, \mathbf{P}_i^\gamma(p_i^{t+1}, \ldots, p_i^T) &= \frac{1}{T} \sum_{\tau=1}^{t} \gamma^{\mathbf{D}^\tau(p_i^1, \ldots, p_i^t)-1} p_i^\tau \\
&+ \frac{1}{T} \sum_{\tau=t+1}^{T} \gamma^{\mathbf{D}^\tau(p_i^{t+1}, \ldots, p_i^T)-1} p_i^\tau. \qquad (1)
\end{aligned}$$

Because $p_i^t = 0$ or $p_i^{t+1} = 0$, it follows that $\mathbf{D}^\tau(p_i^1, \ldots, p_i^t) = \mathbf{D}^\tau(p_i)$ for all $\tau \in \{1, \ldots, t\}$ such that $p_i^\tau > 0$ and $\mathbf{D}^\tau(p_i^{t+1}, \ldots, p_i^T) = \mathbf{D}^\tau(p_i)$ for all $\tau \in \{t+1, \ldots, T\}$ such that $p_i^\tau > 0$. Therefore, (1) implies

$$\frac{t}{T}\,\mathbf{P}_i^\gamma(p_i^1, \ldots, p_i^t) + \frac{T-t}{T}\,\mathbf{P}_i^\gamma(p_i^{t+1}, \ldots, p_i^T) = \frac{1}{T}\sum_{\tau=1}^{T} \gamma^{\mathbf{D}^\tau(p_i)-1} p_i^\tau = \mathbf{P}_i^\gamma(p_i),$$

as was to be established.

Let $c = \gamma \geq 1$, $T \in \mathbb{N} \setminus \{1\}$, $p_i \in \mathbb{R}^T_{++}$ and $t \in \{1, \ldots, T-1\}$. By definition of $\mathbf{P}_i^\gamma = \mathbf{P}_i^c$ and because $\mathbf{D}^\tau(p_i) = T$ for all $\tau \in \{1, \ldots, T\}$, it follows that

$$\begin{aligned}
\mathbf{P}_i^c(p_i) &= \frac{1}{T}\sum_{\tau=1}^{T} c^{\mathbf{D}^\tau(p_i)-1} p_i^\tau = \frac{1}{T}\sum_{\tau=1}^{T} c^{T-1} p_i^\tau \\
&= \frac{c^{T-1}}{T}\sum_{\tau=1}^{T} p_i^\tau = \frac{c^{T-1}}{T}\sum_{\tau=1}^{t} p_i^\tau + \frac{c^{T-1}}{T}\sum_{\tau=t+1}^{T} p_i^\tau \\
&= \frac{1}{T}\,\frac{c^{T-1}}{c^{t-1}}\sum_{\tau=1}^{t} c^{t-1} p_i^\tau + \frac{1}{T}\,\frac{c^{T-t}}{c^{T-t-1}}\sum_{\tau=t+1}^{T} c^{T-t-1} p_i^\tau \\
&= \frac{t}{T}\,c^{T-t}\,\mathbf{P}_i^c(p_i^1, \ldots, p_i^t) + \frac{T-t}{T}\,c^t\,\mathbf{P}_i^c(p_i^{t+1}, \ldots, p_i^T)
\end{aligned}$$

and single-spell exponential decomposability is proven.

'Only if.' Now suppose $\mathbf{P}_i$ satisfies the axioms of the theorem statement. Let $T \in \mathbb{N}$ and $p_i \in \mathbb{R}^T_+$. If $T = 1$, $\mathbf{P}_i(p_i) = p_i = \mathbf{P}_i^\gamma(p_i)$ for all $\gamma \geq 1$ follows immediately from one-period equivalence.

Now consider the case $T \geq 2$. If $p_i^\tau = 0$ for all $\tau \in \{1, \ldots, T\}$, repeated application of one-period equivalence and across-spells average decomposability implies $\mathbf{P}_i(p_i) = 0 = \mathbf{P}_i^\gamma(p_i)$ for all $\gamma \geq 1$.

If there exists $\tau \in \{1, \ldots, T\}$ such that $p_i^\tau > 0$, we proceed by induction on the number of poverty spells.

Suppose first that there is only one poverty spell, which means that $p_i \in \mathbb{R}^T_{++}$ and, therefore, $\mathbf{D}^\tau(p_i) = T$ for all $\tau \in \{1, \ldots, T\}$. By repeated application of one-period equivalence and single-spell exponential decomposability, there exists $c \geq 1$ such that

$$
\begin{aligned}
\mathbf{P}_i(p_i) &= \frac{c(T-1)}{T}\,\mathbf{P}_i(p_i^1,\ldots,p_i^{T-1}) + \frac{c^{T-1}}{T}\,\mathbf{P}_i(p_i^T) \\
&= \frac{c(T-1)}{T}\left(\frac{c(T-2)}{T-1}\,\mathbf{P}_i(p_i^1,\ldots,p_i^{T-2}) + \frac{c^{T-2}}{T-1}\,p_i^{T-1}\right) + \frac{c^{T-1}}{T}\,p_i^T \\
&= \frac{c^2(T-2)}{T}\,\mathbf{P}_i(p_i^1,\ldots,p_i^{T-2}) + \frac{c^{T-1}}{T}\,p_i^{T-1} + \frac{c^{T-1}}{T}\,p_i^T \\
&\vdots \\
&= \frac{1}{T}\sum_{\tau=1}^{T} c^{T-1}p_i^\tau = \mathbf{P}_i^\gamma(p_i) \qquad (2)
\end{aligned}
$$

with $\gamma = c \geq 1$.

To complete the induction argument, suppose (2) is true for all profiles with at most $M \in \{1,\ldots,T-1\}$ poverty spells, and consider $p_i \in \mathbb{R}_+^T$ such that the number of poverty spells is $M+1$. Let $t \in \{1,\ldots,T-1\}$ be such that the last poverty spell starts in period $t+1$. By assumption, this implies that $p_i^t = 0$; otherwise $t+1$ would not represent the beginning of a separate poverty spell. Thus, we can employ across-spells average decomposability twice to obtain

$$
\begin{aligned}
\mathbf{P}_i(p_i) &= \frac{t}{T}\,\mathbf{P}_i(p_i^1,\ldots,p_i^t) + \frac{T-t}{T}\,\mathbf{P}_i(p_i^{t+1},\ldots,p_i^T) \\
&= \frac{t}{T}\left(\frac{t-1}{t}\,\mathbf{P}_i(p_i^1,\ldots,p_i^{t-1}) + \frac{1}{t}\,\mathbf{P}_i(0)\right) + \frac{T-t}{T}\,\mathbf{P}_i(p_i^{t+1},\ldots,p_i^T) \\
&= \frac{t-1}{T}\,\mathbf{P}_i(p_i^1,\ldots,p_i^{t-1}) + \frac{1}{T}\mathbf{P}_i(0) + \frac{T-t}{T}\,\mathbf{P}_i(p_i^{t+1},\ldots,p_i^T).
\end{aligned}
$$

By the induction hypothesis and one-period equivalence, it follows that

$$
\begin{aligned}
\mathbf{P}_i(p_i) &= \frac{t-1}{T}\,\mathbf{P}_i^\gamma(p_i^1,\ldots,p_i^{t-1}) + 0 + \frac{T-t}{T}\,\mathbf{P}_i^\gamma(p_i^{t+1},\ldots,p_i^T) \\
&= \frac{1}{T}\sum_{\tau=1}^{t-1}\gamma^{\mathbf{D}^\tau(p_i^1,\ldots,p_i^{t-1})-1}p_i^\tau + \frac{1}{T}p_i^t + \frac{1}{T}\sum_{\tau=t+1}^{T}\gamma^{\mathbf{D}^\tau(p_i^{t+1},\ldots,p_i^T)-1}p_i^\tau.
\end{aligned}
$$

Because $p_i^t = 0$, it follows that $\mathbf{D}^\tau(p_i^1,\ldots,p_i^{t-1}) = \mathbf{D}^\tau(p_i)$ for all $\tau \in \{1,\ldots,t-1\}$ such that $p_i^\tau > 0$ and $\mathbf{D}^\tau(p_i^{t+1},\ldots,p_i^T) = \mathbf{D}^\tau(p_i)$ for all $\tau \in \{t+1,\ldots,T\}$ such that $p_i^\tau > 0$, which implies $\mathbf{P}_i(p_i) = \mathbf{P}_i^\gamma(p_i)$. ■

3 Aggregate Intertemporal Poverty Measures

Given the individual intertemporal poverty measures $\mathbf{P}_i^\gamma$ for each individual in a society, we use an *aggregate intertemporal poverty index* to obtain an overall measure of poverty that allows us to compare intertemporal poverty across societies, possibly involving different sampling periods and different populations and population sizes. Although it is possible to define an aggregate intertemporal measure from first principles (that is, using individual per-period poverty indicators as the basic objects to be aggregated into societal poverty), we proceed by implicitly assuming that the intertemporal aggregation is performed first (see the discussion in the Introduction) and the second step consists of aggregating these indicators across individuals in a society to arrive at an overall measure of intertemporal poverty. This choice is motivated primarily by our desire to keep the exposition simple. To describe the second part of the aggregation process, let $\Pi = \cup_{n\in\mathbb{N}}\mathbb{R}^n_+$ and consider a function $\mathbf{P}\colon \Pi \to \mathbb{R}_+$, to be interpreted as a measure that assigns an aggregate value of intertemporal poverty to each vector of individual intertemporal poverty values. To justify the rich domain of this measure, assume that the procedure to aggregate individual intertemporal poverty is independent of the specific way the per-period individual poverty values are determined—in particular, they could be determined by poverty gaps divided by a fixed poverty line (or the squares of these values) for any given level of this fixed poverty line. It is clear that, for any population size $n \in \mathbb{N}$, any vector $\mathbf{p} = (\mathbf{p}_1, \ldots, \mathbf{p}_n) \in \mathbb{R}^n_+$ of individual intertemporal poverty values according to the measure characterized in the previous section can be obtained by choosing a suitable poverty line and a suitable income distribution so that the resulting vector of individual intertemporal poverty measures is given by $\mathbf{p}$.

The aggregate intertemporal poverty measure we propose is defined as average individual intertemporal poverty, that is, we employ the index $\mathbf{P}^\Gamma$ defined by

$$\mathbf{P}^\Gamma(\mathbf{p}) = \frac{1}{n}\sum_{i=1}^{n}\mathbf{p}_i \tag{3}$$

for all $n \in \mathbb{N}$ and for all $\mathbf{p} \in \mathbb{R}^n_+$. We view aggregate poverty as an *ordinal* variable and, thus, any increasing transformation of $\mathbf{P}^\Gamma$ can equivalently be employed. Of course, *individual* intertemporal poverty measures must contain more than ordinal and interpersonally non-comparable information—clearly, the definition of $\mathbf{P}^\Gamma$ is incompatible with the assumption that the $\mathbf{p}$ carry ordinally measurable and interpersonally non-comparable information only. We provide a characterization of $\mathbf{P}^\Gamma$ that is based on results in population ethics due to Blackorby, Bossert and Donaldson (2002, 2005). However, we provide a self-contained proof because the domain we consider here is different from the one in these contributions.

The first axiom is a weak monotonicity property. It requires that, in situations where the level of individual poverty is equal across individuals, aggregate intertemporal poverty is increasing in individual intertemporal poverty. The scope of the axiom is restricted to comparisons involving a given population size. For any $n \in \mathbb{N}$, let $\mathbf{1}_n$ denote the vector consisting of n ones.

Minimal increasingness. For all $n \in \mathbb{N}$ and for all $a, b \in \mathbb{R}_+$, if $a > b$, then

$$\mathbf{P}(a\mathbf{1}_n) > \mathbf{P}(b\mathbf{1}_n).$$

Minimal increasingness is a very mild monotonicity requirement because it applies to equal distributions of individual intertemporal poverty and to fixed-population-size comparisons only.

The second axiom we impose on $\mathbf{P}$ is an impartiality property with respect to increases or decreases in individual poverty. If a single individual's intertemporal poverty level changes by a given amount, it does not matter whose poverty changes. Let $n \geq 2$. We use the notation $\mathbf{1}_n^j$ for the vector $w \in \mathbb{R}_+^n$ such that $w_j = 1$ and $w_i = 0$ for all $i \in \{1, \ldots, n\} \setminus \{j\}$.

Incremental equity. For all $n \in \mathbb{N} \setminus \{1\}$, for all $\mathbf{p} \in \mathbb{R}_+^n$, for all $d \in \mathbb{R}$ and for all $j, k \in \{1, \ldots, n\}$ with $j \neq k$, if $(\mathbf{p} + d\mathbf{1}_n^j) \in \mathbb{R}_+^n$ and $(\mathbf{p} + d\mathbf{1}_n^k) \in \mathbb{R}_+^n$, then

$$\mathbf{P}\left(\mathbf{p} + d\mathbf{1}_n^j\right) = \mathbf{P}\left(\mathbf{p} + d\mathbf{1}_n^k\right).$$

Minimal increasingness and incremental equity together characterize ordinal aggregate poverty measures based on average (or total) individual poverty for any fixed population size; see Blackorby, Bossert and Donaldson (2002, 2005). However, further axioms are needed to extend this characterization to the entire domain Π, that is, to aggregate poverty comparisons that may involve different population sizes. One possibility is to require that average individual poverty is a *critical level* for any poverty vector $\mathbf{p} \in \Pi$; see, again, Blackorby, Bossert and Donaldson (2005) for a detailed discussion. That is, aggregate poverty is unaffected if an individual with average poverty is added to a given distribution $\mathbf{p} \in \Pi$.

Average critical levels. For all $n \in \mathbb{N}$ and for all $\mathbf{p} \in \mathbb{R}_+^n$,

$$\mathbf{P}\left(\mathbf{p}, \frac{1}{n}\sum_{i=1}^{n} \mathbf{p}_i\right) = \mathbf{P}(\mathbf{p}).$$

The three axioms defined above characterize the class of all aggregate poverty measures that are ordinally equivalent to $\mathbf{P}^\Gamma$. The axioms can be motivated further by noting that they are implied by other properties with intuitive interpretations. For instance, minimal increasingness is a consequence of standard increasingness, incremental equity is implied by a fixed-population information-invariance property and average critical levels is implied by increasingness, the existence of critical levels and a variable-population information-invariance condition; see Blackorby, Bossert and Donaldson (2005, Chs. 4–6) for a detailed discussion. In the statement of the following theorem, we use $\circ$ to denote function composition.

Theorem 2 *An aggregate intertemporal poverty measure* $\mathbf{P}$ *satisfies minimal increasingness, incremental equity and average critical levels if and only if there exists an increasing function* $\varphi\colon \mathbb{R}_+ \to \mathbb{R}_+$ *such that* $\mathbf{P} = \varphi \circ \mathbf{P}^\Gamma$*.*

Proof. That any increasing transformation of $\mathbf{P}^\Gamma$ satisfies minimal increasingness, incremental equity and average critical levels is straightforward to verify.

Conversely, suppose that $\mathbf{P}$ satisfies the three axioms. If $n = 1$, minimal increasingness alone implies the result.

Now let $n \geq 2$. Consider $\mathbf{p} \in \mathbb{R}^n_+$ and $j, k \in \{1, \ldots, n\}$ with $j \neq k$, and suppose $d \in \mathbb{R}_+$ is such that $\mathbf{p}_j \geq d$. By incremental equity,

$$\mathbf{P}(\mathbf{p} - d\mathbf{1}^j_n + d\mathbf{1}^k_n) = \mathbf{P}(\mathbf{p} - d\mathbf{1}^j_n + d\mathbf{1}^j_n) = \mathbf{P}(\mathbf{p}). \tag{4}$$

Let $\mathbf{p} \in \mathbb{R}^n_+$ and suppose, without loss of generality, that $\mathbf{p}_1 \geq \mathbf{p}_2 \geq \ldots \geq \mathbf{p}_n$. By (repeated if necessary) application of (4), it follows that

$$\begin{aligned}
\mathbf{P}(\mathbf{p}) &= \mathbf{P}\left(\mathbf{p}_1 - \left(\mathbf{p}_1 - \frac{1}{n}\sum_{i=1}^n \mathbf{p}_i\right), \mathbf{p}_2, \ldots, \mathbf{p}_n + \left(\mathbf{p}_1 - \frac{1}{n}\sum_{i=1}^n \mathbf{p}_i\right)\right)\\
&= \mathbf{P}\left(\frac{1}{n}\sum_{i=1}^n \mathbf{p}_i, \mathbf{p}_2, \ldots, \mathbf{p}_n + \mathbf{p}_1 - \frac{1}{n}\sum_{i=1}^n \mathbf{p}_i\right)\\
&\;\;\vdots\\
&= \mathbf{P}\left(\frac{1}{n}\sum_{i=1}^n \mathbf{p}_i, \frac{1}{n}\sum_{i=1}^n \mathbf{p}_i, \ldots, \sum_{i=1}^n \mathbf{p}_i - \frac{n-1}{n}\sum_{i=1}^n \mathbf{p}_i\right)\\
&= \mathbf{P}\left(\left(\frac{1}{n}\sum_{i=1}^n \mathbf{p}_i\right)\mathbf{1}_n\right).
\end{aligned}$$

Together with minimal increasingness, this implies

$$\begin{aligned}\mathbf{P}(\mathbf{p}) \geq \mathbf{P}(\mathbf{q}) \;&\Leftrightarrow\; \mathbf{P}\left(\left(\frac{1}{n}\sum_{i=1}^{n}\mathbf{p}_i\right)\mathbf{1}_n\right) \geq \mathbf{P}\left(\left(\frac{1}{n}\sum_{i=1}^{n}\mathbf{q}_i\right)\mathbf{1}_n\right)\\ &\Leftrightarrow\; \frac{1}{n}\sum_{i=1}^{n}\mathbf{p}_i \geq \frac{1}{n}\sum_{i=1}^{n}\mathbf{q}_i\\ &\Leftrightarrow\; \mathbf{P}^{\Gamma}(\mathbf{p}) \geq \mathbf{P}^{\Gamma}(\mathbf{q})\\ &\Leftrightarrow\; \varphi(\mathbf{P}^{\Gamma}(\mathbf{p})) \geq \varphi(\mathbf{P}^{\Gamma}(\mathbf{q})) \qquad (5)\end{aligned}$$

for all $n \in \mathbb{N}$, for all $\mathbf{p}, \mathbf{q} \in \mathbb{R}^n_+$ and for all increasing functions $\varphi\colon \mathbb{R}_+ \to \mathbb{R}_+$. Thus, all fixed-population-size comparisons must be performed according to $\mathbf{P}^{\Gamma}$.

Now consider $n, m \in \mathbb{N}$ such that $n \neq m$, $\mathbf{p} \in \mathbb{R}^n_+$ and $\mathbf{q} \in \mathbb{R}^m_+$. Without loss of generality, suppose $n > m$. By (repeated if necessary) application of average critical levels, we obtain

$$\mathbf{P}(\mathbf{q}) = \mathbf{P}\left(\mathbf{q}, \frac{1}{m}\sum_{i=1}^{m}\mathbf{q}_i\right) = \ldots = \mathbf{P}\left(\mathbf{q}, \left(\frac{1}{m}\sum_{i=1}^{m}\mathbf{q}_i\right)\mathbf{1}_{n-m}\right)$$

and, therefore,

$$\mathbf{P}(\mathbf{p}) \geq \mathbf{P}(\mathbf{q}) \;\Leftrightarrow\; \mathbf{P}(\mathbf{p}) \geq \mathbf{P}\left(\mathbf{q}, \left(\frac{1}{m}\sum_{i=1}^{m}\mathbf{q}_i\right)\mathbf{1}_{n-m}\right). \qquad (6)$$

Because $\mathbf{p}$ and $(\mathbf{q}, ((1/m)\sum_{i=1}^{m}\mathbf{q}_i)\mathbf{1}_{n-m})$ have the same population size n, (5) implies

$$\begin{aligned}\mathbf{P}(\mathbf{p}) \geq \mathbf{P}\left(\mathbf{q}, \left(\frac{1}{m}\sum_{i=1}^{m}\mathbf{q}_i\right)\mathbf{1}_{n-m}\right) \;&\Leftrightarrow\; \frac{1}{n}\sum_{i=1}^{n}\mathbf{p}_i \geq \frac{1}{n}\left(\sum_{i=1}^{m}\mathbf{q}_i + \frac{n-m}{m}\sum_{i=1}^{m}\mathbf{q}_i\right)\\ &\Leftrightarrow\; \sum_{i=1}^{n}\mathbf{p}_i \geq \sum_{i=1}^{m}\mathbf{q}_i + \frac{n-m}{m}\sum_{i=1}^{m}\mathbf{q}_i\end{aligned}$$

which implies

$$\mathbf{P}(\mathbf{p}) \geq \mathbf{P}\left(\mathbf{q}, \left(\frac{1}{m}\sum_{i=1}^{m}\mathbf{q}_i\right)\mathbf{1}_{n-m}\right) \;\Leftrightarrow\; \frac{1}{n}\sum_{i=1}^{n}\mathbf{p}_i \geq \frac{1}{m}\sum_{i=1}^{m}\mathbf{q}_i.$$

By (6), we obtain

$$\mathbf{P}(\mathbf{p}) \geq \mathbf{P}(\mathbf{q}) \;\Leftrightarrow\; \frac{1}{n}\sum_{i=1}^{n}\mathbf{p}_i \geq \frac{1}{m}\sum_{i=1}^{m}\mathbf{q}_i \;\Leftrightarrow\; \mathbf{P}^{\Gamma}(\mathbf{p}) \geq \mathbf{P}^{\Gamma}(\mathbf{q}) \;\Leftrightarrow\; \varphi(\mathbf{P}^{\Gamma}(\mathbf{p})) \geq \varphi(\mathbf{P}^{\Gamma}(\mathbf{q}))$$

for any increasing function $\varphi\colon \mathbb{R}_+ \to \mathbb{R}_+$, which completes the proof. ■

4 An Application to European Countries

The purpose of this section is to illustrate the aggregate measure of poverty, $\mathbf{P}^{\Gamma}$ as defined in (3) with individual intertemporal poverty measures $\mathbf{p}_i$ given by $\mathbf{P}_i^{\gamma}(p_i)$ for different parameter values γ, using the European Community Household Panel (ECHP). We base our analysis on all the waves available in ECHP, which cover the period from 1994 to 2001. The surveys are conducted at a European national level. We do not aim at providing an accurate analysis of poverty persistence in EU countries, hence we take the available years as such without considering the possibility that poverty spells are censored at the beginning or at the end of the sample we observe. (For a discussion of these estimation techniques see, among others, Bane and Ellwood, 1986, and Jenkins, 2000.) The ECHP is an ambitious effort at collecting information on the living standards of the households of the EU member states using common definitions, information collection methods and editing procedures. It contains detailed information on incomes, socio-economic characteristics, housing amenities, consumer durables, social relations, employment conditions, health status, subjective evaluation of well-being, etc.. Of the 15 EU member states, we could not consider Sweden since the data for this country is cross-sectional only. For Finland and Austria, data were not available for all the waves. While the former joined from wave three onwards, the Austrian data are available beginning with the second wave. The full ECHP data format for the UK, Germany and Luxembourg is available only for the years 1994–1996. We therefore use the ECHP data format derived from national surveys instead. These data are available for the UK and Germany for 1994–2001; for Luxembourg, on the other hand, they are available from 1995 onwards only. For this reason, Luxembourg, like Austria, was included from the second wave onwards. The unit of our analysis is the individual. The calculation uses required sample weights. Since we are interested in analyzing poverty spells and the effect of persistence in the state of poverty, we consider only individuals that were interviewed in all the waves for each country. The variable studied is net yearly household income equivalized using the OECD-modified equivalence scale in order to account for different household size and composition. For each country and for each period in the sample, the poverty line is set to 60% of the national median. Thus, for any given per-period income distribution y^t, the poverty line in this period, $z^t(y^t)$, is given by 0.6 times the median of y^t. An individual is classified as poor if its income is strictly below the poverty line.

It has been assumed that the parameter γ takes on its values in the set $\{1, \ldots, 10\}$. An increase in the value of γ indicates that higher weight is assigned to the persistence of individual poverty.

For the per-period individual poverty indicators, we choose three among the most commonly used ones in empirical studies, namely, the normalized relative gaps raised to the power $\alpha \in \{0, 1, 2\}$ so that, for any period $t \in \mathbb{N}$,

$$p_i^t = \begin{cases} \left(\frac{z^t(y^t) - y_i^t}{z^t(y^t)}\right)^\alpha & \text{if } y_i^t < z^t(y^t), \\ 0 & \text{if } y_i^t \geq z^t(y^t). \end{cases}$$

The individual index is then the product of two components: the weight and the individual poverty indicator. When $\alpha = 0$, the individual poverty indicator captures only the number of periods spent in poverty. In this case, p_i^t assumes the value one for those in poverty and zero for everybody else. This individual index is similar in spirit to the head-count ratio. When $\alpha = 1$, we consider not only the incidence of poverty but also its intensity since we take into account how poor each poor individual is expressed as a proportion of the poverty line. In this case, the index resembles the normalized poverty gap. When $\alpha = 2$, the normalized gaps are squared. As a result, we give more importance to poorer individuals as opposed to those poor whose income is less distant from the poverty line.

When the parameter γ is equal to one, persistence does not play a role. This is the only case where aggregating first across time and then across individuals produces exactly the same results as the reverse order of aggregation does, that is, aggregating first across individuals and then across time. The aggregate index coincides with the average of per-period standard poverty indices. If, in addition, $\alpha = 0$, the aggregate index is the average of the per-period head-count ratios; if $\alpha = 1$, it is the average of the aggregate normalized poverty gap indices; and, lastly, if $\alpha = 2$, it is the average of the aggregate squared normalized poverty gaps.

Results are contained in Table 1, while in Table 2 we report the rankings of the countries under alternative indices. In the first column the names of the countries are reported while the following ten columns present poverty indicators for different values of γ. In Panel a, the individual poverty indicators capture only the incidence of poverty and when $\gamma = 1$, the index is the mean of per-period head-count ratios. In Panel b, the intensity of poverty plays a role and when $\gamma = 1$ the index is the mean of per-period normalized poverty gaps. In Panel c, the shortfalls from the poverty line (as a proportion of the line itself) are squared and when $\gamma = 1$ the index is the mean of per-period normalized squared poverty gaps. The results show that persistence in a state of poverty does play a major role in poverty measurement. It constitutes relevant information and its omission would not give a correct picture of the phenomenon. As the weight of persistence in the index increases, the rankings of the countries change, particularly among the least poor. Portugal, followed by Greece, is indeed always the poorest country among those under analysis. At the opposite end of the ranking the situation is very different. Finland occupies the second position according to standard poverty measurement, that is when $\gamma = 1$; as soon as we increase the value of the persistence parameter to 2 Finland jumps to the first position implying that there is less persistence in poverty in this country than in the Netherlands when $\alpha = 0$, and in Denmark for the other two cases. Of high interest is the case of Denmark and Austria. Poverty is a very different phenomenon in these countries. Denmark's position worsens heavily as the weight of persistence considerations increases for all individual poverty indicators: it is relegated from the first to the fourth (see Panel b) or fifth (see Panel c) position and from the third to the fifth when the intensity of poverty is not considered (see Panel a). Austria, on the other hand, experiences the reverse phenomenon moving from the sixth to the third (see Panel b and c) or to the second (see Panel a) position. Similar observations apply to Luxembourg (with one exception in Panel b, third column). From a social policy point of view the discovery of this temporal characteristic of poverty should lead to different recommendations: in a country like Denmark, for example, policy should aim at helping individuals and households to escape from poverty; in Austria, on the other hand, a more effective policy would be one preventing individuals from becoming poor.

5 Concluding Remarks

Individuals live and time is an important aspect of their lives. Experiences matter and persistence of experiences could matter more, as in the case of poverty. The indices we propose aim at adding past experiences to the incidence of poverty and inequality among those who are poor when measuring poverty. Information on the time spent in poverty should not be neglected. The results of our simple application to EU countries show that a very different picture can emerge when we value individuals' experiences.

Various extensions of the approach proposed in this paper are possible.

We restrict attention to the intertemporal aggregation of per-period overall poverty in this paper. However, our approach can be modified easily in order to obtain a measure of *chronic* poverty (Foster, 2007) based on the idea underlying our new index. To do so, chronic poverty can be defined by setting an additional *duration* line and declaring an individual to be chronically poor if there is at least one poverty spell of at least a given length and then perform the aggregation over individuals by calculating the arithmetic mean of the poverty values only of all those satisfying this criterion.

Further works could in addition perform statistical inference with the indices we proposed and consider the possibility when estimating intertemporal poverty that poverty spells are censored.

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Table 1: Aggregate Intertemporal Poverty in EU Member States (Index Values).

Country	$\gamma=1$	$\gamma=2$	$\gamma=3$	$\gamma=4$	$\gamma=5$	$\gamma=6$	$\gamma=7$	$\gamma=8$	$\gamma=9$	$\gamma=10$
Netherlands	0.0868	1.7107	20.8059	136.8829	609.36	2092.32	5979.077	14907.88	33460.15	69082.5
Finland	0.0937	1.3148	8.6823	34.7584	103.33	253.0727	541.2151	1047.203	1876.362	3163.57
Denmark	0.0963	2.0270	27.6766	195.2880	908.22	3211.848	9374.401	23747.51	53962.2	112516
Germany	0.1069	3.8645	58.5503	422.9942	1982.14	7029.736	20540.72	52054.87	118293.3	246629
Luxembourg	0.1136	2.5472	24.9206	133.1780	495.945	1460.231	3648.493	8077.062	16295.93	30549.9
Austria	0.1156	2.2580	22.1169	118.3555	440.919	1298.293	3243.738	7180.503	14486.02	27155.1
Belgium	0.1339	4.5511	66.9738	477.0555	2217.06	7820.253	22762.73	57520.27	130421.9	271432
France	0.1438	4.9846	74.0871	530.8611	2476.24	8756.273	25532.97	64607.68	146646.3	305455
UK	0.1761	6.2017	89.4302	631.7939	2924.72	10294.24	29924.76	75553.84	171210.5	356169
Italy	0.1806	5.6926	81.0528	570.4175	2635.75	9267.133	26919.85	67932.74	153882.4	320028
Ireland	0.1868	6.3118	90.7736	639.6769	2954.82	10381.99	30137.26	76002.93	172064.8	357663
Spain	0.1904	5.2128	74.0989	524.3173	2433.59	8585.312	25003.85	63225.83	143453.7	298738
Greece	0.2008	7.1498	106.2620	761.0029	3548.64	12545.99	36578.84	92548.94	210051.9	437500
Portugal	0.2201	8.9531	131.5753	934.8185	4338.69	15292.78	44494.04	112403.1	254815.7	530248

Panel a: Per-Period Individual Poverty Indicator with $\alpha=0$

Country	$\gamma=1$	$\gamma=2$	$\gamma=3$	$\gamma=4$	$\gamma=5$	$\gamma=6$	$\gamma=7$	$\gamma=8$	$\gamma=9$	$\gamma=10$
Denmark	0.0175	0.3780	5.1994	36.7818	171.2735	606.134	1769.95	4485.15	10194.18	21259.69
Finland	0.0175	0.2573	1.7070	6.8448	20.3677	49.91639	106.8015	206.728	370.5226	624.8557
Luxembourg	0.0206	0.5316	5.2963	28.4377	106.1073	312.741	781.9052	1731.73	3494.949	6553.489
Netherlands	0.0235	0.4516	5.5139	36.2835	161.3318	553.1483	1578.484	3930.76	8812.724	18177.42
Germany	0.0279	1.1359	17.3123	125.0316	585.4653	2075.033	6060.015	15351	34872.57	72684.86
Austria	0.0283	0.6516	6.6158	35.8669	134.5147	397.7055	996.4105	2210.13	4465.517	8380.908
Belgium	0.0315	1.1247	16.9126	121.8367	570.2505	2021.311	5904.618	14961.6	33997.28	70878.3
France	0.0328	1.3367	20.4430	147.8494	692.8390	2456.778	7177.283	18185.6	41319.83	86135.65
Ireland	0.0351	1.2929	19.0648	135.7653	630.8301	2224.916	6475.882	16364	37104.05	77221.22
UK	0.0480	1.8914	27.6901	196.6636	912.8886	3218.433	9366.074	23665.9	53659.66	111678.2
Italy	0.0578	2.2606	33.1681	235.7147	1094.5230	3859.727	11234.5	28391.4	64382.98	134011.1
Spain	0.0581	1.8840	27.4036	195.1768	908.7242	3211.807	9365.813	23704.4	53820.46	112140.8
Greece	0.0671	2.9364	44.6910	322.0719	1505.9580	5332.223	15561.26	39397.5	89460.2	186396.7
Portugal	0.0715	3.3758	50.0419	355.4550	1647.7750	5801.189	16861.48	42560.5	96415.88	200513.3

Panel b: Per-Period Individual Poverty Indicator with $\alpha=1$

Country	$\gamma=1$	$\gamma=2$	$\gamma=3$	$\gamma=4$	$\gamma=5$	$\gamma=6$	$\gamma=7$	$\gamma=8$	$\gamma=9$	$\gamma=10$
Denmark	0.0056	0.0992	1.3033	9.1169	42.2823	149.3645	435.740	1103.585	2507.471	5228.14
Finland	0.0059	0.0793	0.5147	2.0485	6.0753	14.8631	31.768	61.451	110.090	185.599
Luxembourg	0.0059	0.1519	1.5143	8.1353	30.3695	89.5458	223.948	496.111	1001.440	1878.14
Ireland	0.0114	0.3899	5.7941	41.5052	193.5661	684.3954	1995.546	5049.284	11460.650	23871.7
Netherlands	0.0122	0.2036	2.4307	15.7959	69.5609	236.6840	671.277	1663.274	3713.604	7633.16
Austria	0.0123	0.3003	3.1078	16.9823	63.9600	189.6012	475.878	1056.913	2137.572	4014.91
Germany	0.0131	0.5138	7.7770	56.0281	262.0120	927.8723	2708.255	6857.545	15573.150	32450.7
Belgium	0.0133	0.4570	6.9459	50.3817	236.8219	841.8787	2464.427	6254.398	14229.440	29695.2
France	0.0135	0.5059	7.7562	56.2118	263.7342	935.9132	2735.656	6934.250	15760.110	32861.4
UK	0.0217	0.8793	12.9039	91.6582	425.3578	1499.1520	4361.445	11017.440	24975.090	51968.6
Spain	0.0290	0.9857	14.4119	102.7987	479.0183	1694.0250	4942.021	12512.280	28416.810	59223.1
Italy	0.0306	1.2719	18.8898	134.8874	627.9591	2218.0350	6463.242	16347.010	37093.050	77245.9
Greece	0.0329	1.5105	23.1207	166.8333	780.4162	2763.7310	8066.126	20422.240	46373.550	96622.9
Portugal	0.0371	1.7591	25.8889	183.0247	845.7083	2970.5050	8618.869	21725.570	49163.440	102153

Panel c: Per-Period Individual Poverty Indicator with $\alpha=2$

Table 2: Aggregate Intertemporal Poverty in EU Member States (Rankings).

Country	$\gamma=1$	$\gamma=2$	$\gamma=3$	$\gamma=4$	$\gamma=5$	$\gamma=6$	$\gamma=7$	$\gamma=8$	$\gamma=9$	$\gamma=10$
Netherlands	1	2	2	4	4	4	4	4	4	4
Finland	2	1	1	1	1	1	1	1	1	1
Denmark	3	3	5	5	5	5	5	5	5	5
Germany	4	6	6	6	6	6	6	6	6	6
Luxembourg	5	5	4	3	3	3	3	3	3	3
Austria	6	4	3	2	2	2	2	2	2	2
Belgium	7	7	7	7	7	7	7	7	7	7
France	8	8	8	9	9	9	9	9	9	9
UK	9	11	11	11	11	11	11	11	11	11
Italy	10	10	10	10	10	10	10	10	10	10
Ireland	11	12	12	12	12	12	12	12	12	12
Spain	12	9	9	8	8	8	8	8	8	8
Greece	13	13	13	13	13	13	13	13	13	13
Portugal	14	14	14	14	14	14	14	14	14	14

Panel a: Per-Period Individual Poverty Indicator with $\alpha=0$

Country	$\gamma=1$	$\gamma=2$	$\gamma=3$	$\gamma=4$	$\gamma=5$	$\gamma=6$	$\gamma=7$	$\gamma=8$	$\gamma=9$	$\gamma=10$
Denmark	1	2	2	5	5	5	5	5	5	5
Finland	2	1	1	1	1	1	1	1	1	1
Luxembourg	3	4	3	2	2	2	2	2	2	2
Netherlands	4	3	4	4	4	4	4	4	4	4
Germany	5	7	7	7	7	7	7	7	7	7
Austria	6	5	5	3	3	3	3	3	3	3
Belgium	7	6	6	6	6	6	6	6	6	6
France	8	9	9	9	9	9	9	9	9	9
Ireland	9	8	8	8	8	8	8	8	8	8
UK	10	11	11	11	11	11	11	10	10	10
Italy	11	12	12	12	12	12	12	12	12	12
Spain	12	10	10	10	10	10	10	11	11	11
Greece	13	13	13	13	13	13	13	13	13	13
Portugal	14	14	14	14	14	14	14	14	14	14

Panel b: Per-Period Individual Poverty Indicator with $\alpha=1$

Country	$\gamma=1$	$\gamma=2$	$\gamma=3$	$\gamma=4$	$\gamma=5$	$\gamma=6$	$\gamma=7$	$\gamma=8$	$\gamma=9$	$\gamma=10$
Denmark	1	2	2	3	3	3	3	4	4	4
Finland	2	1	1	1	1	1	1	1	1	1
Luxembourg	3	3	3	2	2	2	2	2	2	2
Ireland	4	6	6	6	6	6	6	6	6	6
Netherlands	5	4	4	4	5	5	5	5	5	5
Austria	6	5	5	5	4	4	4	3	3	3
Germany	7	9	9	8	8	8	8	8	8	8
Belgium	8	7	7	7	7	7	7	7	7	7
France	9	8	8	9	9	9	9	9	9	9
UK	10	10	10	10	10	10	10	10	10	10
Spain	11	11	11	11	11	11	11	11	11	11
Italy	12	12	12	12	12	12	12	12	12	12
Greece	13	13	13	13	13	13	13	13	13	13
Portugal	14	14	14	14	14	14	14	14	14	14

Panel c: Per-Period Individual Poverty Indicator with $\alpha=2$