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Missing poor and income mobility☆

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ABSTRACT

Higher mortality among the poor prevents standard poverty measures from quantifying the actual extent of old-age poverty. Whereas existing attempts to deal with the "missing poor" problem assume the absence of income mobility and assign to the prematurely dead a fictitious income equal to the last income enjoyed, this paper relaxes that assumption in order to study the impact of income mobility on the size of the missing poor bias. We use data on poverty above age 60 in 12 countries from the EU-SILC database, and we compare standard poverty rates with the hypothetical poverty rates that would have prevailed if (i) all individuals, whatever their income, had enjoyed the same survival conditions, and if (ii) all individuals within the same income class had been subject to the same income mobility process. Taking income mobility into account has unequal effects on corrected poverty measures across countries, and, hence, affects international comparisons in terms of old-age poverty.

1. Introduction

Despite the rise of the modern Welfare State, our economies can be regarded, at the beginning of the 21st century, as Malthusian economies, in the sense that poor individuals still face nowadays higher mortality rates than non-poor persons, in line with the "positive population check" phenomenon underlined by Malthus (1798). Although the extent of overmortality of the poor has been reduced since Malthus's epoch, empirical studies show that there exists nowadays an increasing non linear relationship between income and life expectancy.[1]

As this was stressed by Kanbur and Mukherjee (2007), the positive correlation between income and life expectancy prevents standard measures of poverty from quantifying the actual extent of old-age poverty. The intuition behind this measurement problem is simple: poor persons face higher mortality rates than non-poor persons, which implies that, when measuring old-age poverty by means of standard indicators (focusing only on the surviving population), the poor are under-represented with respect to the non-poor. This phenomenon can be coined the "missing poor" problem, in line with Sen's (1998) "missing women" problem.

In order to correct for the missing poor problem, Kanbur and Mukherjee (2007) proposed to assign, to the prematurely dead poor persons, a fictitious income, and to compute hypothetical poverty rates under the hypothetical income distribution. Alternatively,

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[1] On this relation, see Duleep (1986); Deaton and Paxson (1998); Backlund et al. (1999); Deaton (2003); Jusot (2004); Duggan et al. (2007) and Salm (2011).

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Lefebvre et al. (2013) proposed to assign to all prematurely dead persons (poor and non-poor) a fictitious income, and to compute poverty rates on that new hypothetical income distribution.

Under those two approaches, the fictitious income assigned to the prematurely dead consists of the last income that the individual enjoyed before dying. This assignment procedure constitutes a good proxy in an economy where there is little or no income mobility. However, in economies with sizeable income mobility, taking the last income as a proxy of the income level that would have been enjoyed in case of survival constitutes a stronger assumption.

The goal of this paper is precisely to reexamine the missing poor problem for poverty measurement while taking income mobility into account. For that purpose, we propose to compare standard old-age poverty measures with corrected old-age poverty measures that assign to prematurely dead individuals not the last income enjoyed before dying, but the income that *would have been enjoyed* in case of survival given the prevailing income mobility process.

Our motivation for studying the effect of income mobility on the missing poor problem goes as follows. Actually, if there is a strong upward income mobility, assigning to the prematurely dead a fictitious income equal to the last income enjoyed would lead to overestimate the number of missing poor, since we would then count as poor individuals who died prematurely and would not have been poor in case of survival. As a consequence, corrected poverty measures would then overestimate the actual extent of old-age poverty.[2] One can thus expect that income mobility matters when incorporating the prematurely dead in poverty measures. An important issue is to know the precise extent to which income mobility matters empirically for the correction of poverty measures.

In order to examine the impact of income mobility on the missing poor problem, this paper uses data on poverty above age 60 in 12 countries from the EU-SILC database.[3] We first compare standard old-age poverty rates with the hypothetical old-age poverty rates that would have prevailed if (i) all individuals, whatever their income, had enjoyed the same survival conditions, and if (ii) all individuals within the same income class had been subject to the same income mobility process. Assumption (ii) amounts to assign to prematurely dead persons a fictitious income equal to the one that would have been enjoyed in case of survival, given the income mobility process (conditional on survival). This procedure requires us to estimate actual income mobility processes in the economies under study. Then, in order to assess the impact of income mobility, we compare the corrected poverty rates under income mobility with the ones obtained under no income mobility for missing (i.e. prematurely dead) persons.

Anticipating on our results, we show that poverty rates corrected under assumptions (i) and (ii) differ from standard poverty rates, and that the correction for the missing poor problem affects the comparison of old-age poverty across countries and gender. When comparing the gaps between adjusted and standard poverty measures with the ones obtained while assuming no income mobility (and thus relaxing assumption (ii)), we show that upward income mobility reduces those gaps, but to an extent that varies across countries. Thus taking income mobility into account matters for the correction of poverty measures. In addition, our analysis shows that the size of the gap between standard and corrected poverty rates depends also on whether the poverty line is based either on the pre-adjustment income distribution, or on the post-adjustment income distribution, and on whether the poverty line is relative or absolute.

Our paper is related to the literature on the missing poor, such as Kanbur and Mukherjee (2007) and Lefebvre et al. (2013,2018). Our paper, which examines poverty measurement in presence of income-differentiated mortality, is also related to the growing literature on lifetime poverty, such as Foster (2009), Bossert et al. (2011) and Hoy and Zheng (2011), since the assignment of fictitious incomes to the prematurely dead constitutes a solution to allow for the comparison of poverty along lives of unequal lengths. Finally, we also complement the literature on income mobility (Fields and Ok, 1996, 1999; Van Kerm (2004, 2009); Van Kerm and Alperin (2013)), by examining the relation between income mobility and the missing poor problem.[4]

The paper is organized as follows. Section 2 develops a simple model of old-age poverty measurement under income-differentiated mortality. Section 3 compares standard and hypothetical old-age poverty rates for 12 European countries. Section 4 studies the robustness of the correction of poverty rates to the assumption on income mobility. Section 5 examines the robustness of our results to allowing the poverty line to vary with the addition of missing persons. Finally, Section 6 assesses the robustness of our results to adopting an absolute poverty line equal to 10 euros a day. Additional robustness issues are examined in Section 7. Section 8 concludes.

2. Missing poor: Theory

2.1. The framework

Let us consider a cohort of size $N \in \mathbb{N}$. Each member of that cohort lives the young age for sure, and reaches the old age with a probability s. There exists K income levels $y_1, ...,y_K \in \mathbb{R}_+$, including a particular poverty line y_P. Those income levels are ranked in increasing order:

$$y_1 < ...<y_P < ...<y_K \tag{1}$$

[2] Inversely, if there is a strong downward income mobility, abstracting from income mobility would lead to underestimate the number of missing poor, since we would then count as non-poor individuals who died prematurely while being non-poor, but who would have fallen into poverty in the absence of premature death.

[3] The countries are Bulgaria, Czech Republic, Denmark, Estonia, Finland, Hungary, Italy, Norway, Poland, Portugal, Romania and Sweden.

[4] See Janti and Jenkins (2015) for a comprehensive review of studies on income mobility.

The distribution of income at the young age is represented by a vector $\mathbf{n}$ of size K, whose entries $n_1, \ldots, n_K$ are the number of young individuals with incomes $y_1, \ldots, y_K$.

To each income level y_k enjoyed at the young age is associated a survival probability to the old age denoted by $s_k \in \mathbb{Q}_+$. We assume that there exists a perfect rank correlation between income and survival conditions:

$$s_1 < \ldots < s_P < \ldots < s_K \tag{2}$$

Conditionally on survival to the old age, each member of the cohort enjoys a particular income level at the old age. The income mobility process conditionally on survival to the old age is described by the right-stochastic matrix $\mathbf{\Lambda}$:

$$\mathbf{\Lambda} \equiv \begin{pmatrix} \lambda_{11} & \ldots & \lambda_{1K} \\ \ldots & \ldots & \ldots \\ \lambda_{K1} & \ldots & \lambda_{KK} \end{pmatrix} \tag{3}$$

where $\lambda_{ik} \in \mathbb{Q}_+$ is the probability that a young individual with income y_i enjoys, in case of survival to the old age, an income y_k.

The distribution of income at the old age is represented by a vector $\mathbf{m}$ of size K, whose entries $m_1, \ldots, m_K$ are the number of old individuals with incomes $y_1, \ldots, y_K$. The distribution of income at the old age can be obtained from the income distribution at the young age as follows:

$$\mathbf{m} = \mathbf{\Psi}'\mathbf{n} \tag{4}$$

where the matrix $\mathbf{\Psi}$ is the Hadamard product of matrices $\mathbf{\Lambda}$ and $\mathbf{\Sigma}$:

$$\begin{aligned} \mathbf{\Psi} &\equiv \underbrace{\begin{pmatrix} \lambda_{11} & \ldots & \lambda_{1K} \\ \ldots & \ldots & \ldots \\ \lambda_{K1} & \ldots & \lambda_{KK} \end{pmatrix}}_{\mathbf{\Lambda}} \circ \underbrace{\begin{pmatrix} s_1 & \ldots & s_1 \\ \ldots & \ldots & \ldots \\ s_K & \ldots & s_K \end{pmatrix}}_{\mathbf{\Sigma}} \\ &= \begin{pmatrix} \lambda_{11}s_1 & \ldots & \lambda_{1K}s_1 \\ \ldots & \ldots & \ldots \\ \lambda_{K1}s_K & \ldots & \lambda_{KK}s_K \end{pmatrix} \end{aligned} \tag{5}$$

2.2. The standard old-age poverty headcount ratio

For a given poverty line y_P, the standard poverty headcount ratio at the old age P is defined as:

$$P = \frac{\sum_{i=1}^{P-1} m_i}{\sum_{j=1}^{K} m_j} \tag{6}$$

Using the equation $\mathbf{m} = \mathbf{\Psi}'\mathbf{n}$, one can rewrite the poverty headcount ratio at the old age P as:

$$P = \frac{\sum_{i=1}^{P-1} \sum_{l=1}^{K} n_l s_l \lambda_{li}}{\sum_{j=1}^{K} \sum_{l=1}^{K} n_l s_l \lambda_{lj}} \tag{7}$$

This rewriting of the old-age poverty rate allows us to highlight that its level depends on three factors: first, the income distribution at the young age; second, the income mobility process; third, the survival conditions, which are differentiated according to the income level.

Whereas the influence of the income distribution at the young age and of the income mobility process are something worth being captured by old-age poverty measures, it is not clear to see to what extent one may want the old-age poverty rate to be dependent on income-differentiated survival conditions. Actually, old-age poverty measures depending on income-differentiated mortality lead, in some cases, to quite counterintuitive results.

A major problem faced by standard poverty measures in the context of income-differentiated mortality is the Mortality Paradox (see Lefebvre et al. (2013)). The Mortality Paradox arises when a deterioration of the survival conditions faced by the poor leads to a reduction in the measured extent of poverty. To illustrate this, consider the example of a cold winter, which increases mortality among the poor (and not among the non-poor). At the level of poverty measures, this rise of mortality among the poor will lead, everything else being unchanged, to a reduction of measured poverty. This result is quite counterintuitive, since for sure the cold winter did not reduce the actual extent of the poverty phenomenon.

Income-differentiated mortality generates some kind of noise in the measurement of old-age poverty. Measurement consists, in general, in assigning numbers to objects or events in an objective way, in order to describe those objects or events with more accuracy. In order to be able to measure old-age poverty, one needs thus to assign numbers to this social phenomenon, in such a way as to describe it. The problem with income-differentiated mortality is that those survival statistics interact, within standard poverty measures, with other statistics (income at the young age and income mobility probabilities) in a way that makes the resulting assigned numbers not good at describing the phenomenon under study. The Mortality Paradox exemplifies the noise introduced by income-differentiated mortality in standard measures of old-age poverty.

It should be stressed that, in the hypothetical case where the entire population faced the same survival conditions, mortality would not create noise in the measurement of old-age poverty. Indeed, if survival rates were equal for all income groups, then it would be possible to factorize by s at the numerator and at the denominator of P, so that the old-age poverty rate would be

independent from survival conditions. Thus the problem does not come from mortality itself, but from income-differentiated mortality, which prevents standard poverty measures from quantifying the actual extent of the poverty phenomenon.

In order to avoid counterintuitive results due to income-differentiated mortality, Lefebvre et al. (2013,2018) introduced a property called Robustness to Mortality Changes (RMC). The RMC property states that a measure of poverty should take values that do not depend on the survival rates prevailing in the population. Put it differently, the RMC property states that the level taken by the poverty measure should be invariant to any variation in survival rates.

As discussed in Lefebvre et al. (2013), a major virtue of the RMC property is that poverty measures satisfying the RMC property escape the Mortality Paradox. The intuition behind that result is simple: since poverty measures satisfying the RMC property do not depend on survival rates, a decrease in the survival rates of the poor does not affect the values taken by those poverty measures. Escaping from counterintuitive results such as the Mortality Paradox is thus an important achievement of poverty measures satisfying the RMC property. This is the reason why we will, throughout this paper, regard RMC as a desirable property to be satisfied by measures of poverty.

It should be stressed that, in general, the standard old-age poverty measure does not satisfy the RMC property. As shown in Lefebvre et al. (2018), there is only one case where the old-age poverty measure is independent from income-differentiated survival conditions, which is when all young individuals face the same expected extent of poverty, whatever their initial income is, that is, when:

$$\sum_{j=1}^{P-1} \lambda_{ij} = \sum_{j=1}^{P-1} \lambda_{kj} \quad \forall\, i \neq k \tag{8}$$

That condition is unlikely to be satisfied by actual income mobility processes. Hence, the fact that poor persons face worse survival conditions is likely to affect the level of poverty measures at the old age.

2.3. An adjusted old-age poverty measure

Let us now consider a measure of old-age poverty that satisfies the RMC property. In order to make the old-age poverty measure invariant to survival conditions, a simple way to proceed consists in replacing, within the standard old-age headcount ratio, income-specific survival probabilities by a common survival probability, hypothetically shared by all income classes.

The adjusted old-age poverty measure $\bar{P}$ is defined as the poverty measure based on a hypothetical population where all income classes would face *similar* survival conditions, for instance the ones of the highest income class:

$$\bar{P} = \frac{\sum_{i=1}^{P-1} \sum_{l=1}^{K} n_l s_K \lambda_{li}}{\sum_{j=1}^{K} \sum_{k=1}^{K} n_k s_K \lambda_{kj}} \tag{9}$$

where s_K is the survival probability associated to the top income class.

The adjusted poverty measure $\bar{P}$ is the headcount old-age poverty rate that would prevail in the hypothetical case where all income classes would face the same survival conditions (here the ones of the top income class).

It is easy to see that the poverty measure $\bar{P}$ satisfies the RMC property. Indeed, since the probability s_K applies to all income classes at the numerator and at the denominator, this can be factorized from all terms at the numerator and at the denominator, and, then, cancelled out, making $\bar{P}$ invariant to variations in survival conditions. Thus, a deterioration of the survival conditions faced by the poor will have no impact on the old-age poverty measure $\bar{P}$.

Note that the RMC property would also be satisfied if the common survival probability imposed on all income classes were not the one faced by the top income class s_K, but the one faced by any other income class s_i. Having stressed this, we will, throughout this paper, consider adjusted old-age poverty measures based on the survival conditions of the top income class, since this consists of an intuitive counterfactual, which amounts to measure old-age poverty while doing *as if* all income classes were facing the most favorable survival conditions. But that point is a pure matter of presentation since, whatever the survival conditions used as a reference, the value taken by the adjusted old-age poverty rate $\bar{P}$ does not depend on the particular reference chosen.

3. Missing poor: Empirics

3.1. Data and method

Given that the missing poor problem affects mainly poverty measurement at the old age, we focus here on old-age poverty, that is, on poverty at age 60 and more. The analysis is based on the EU-SILC (cross-sectional and longitudinal) databases for the years 2006 to 2012, and on life expectancy tables by level of education from EUROSTAT. Our sample focuses on people aged 60 and more, and involves 12 countries: Bulgaria ($N = 5064$), Czech Republic ($N = 6307$), Denmark ($N = 1449$), Estonia ($N = 3671$), Finland ($N = 6830$), Hungary ($N = 6797$), Italy ($N = 13934$), Norway ($N = 3077$), Poland ($N = 9044$), Portugal ($N = 5155$), Romania ($N = 5951$) and Sweden ($N = 4158$).[5]

We take as a benchmark the standard poverty headcount ratios computed from the cross-sectional EU-SILC database for each

[5] The selection of countries is based on the availability of life expectancy and income data.

country in 2012, the population aged 60+ being taken as a whole. Then, we compute, for each country, adjusted poverty rates presented in Section 2, for the population aged 60+.

The reason why our analysis focuses on the population aged 60+ taken as a whole lies in data limitations. Two main data limitations arise. First, considering smaller age-groups would limit the number of observations in each income class, which would be problematic for the computation of income mobility matrices. Second, data on survival conditions by education level are not sufficiently rich to allow us to consider a larger number of age-groups.[6]

The computation of adjusted old-age poverty rates involves five steps.

Step 1. For each country, EUROSTAT data on life expectancy at age 60 by education are used to extrapolate life expectancy at age 60 by income class.
Step 2. For each country, and using cross-sectional data on income distribution at age 60+ from the EU-SILC database, the size of each income class is adjusted by taking as adjustment factors the ratio between the life expectancy at age 60 of the top income class and the life expectancy at age 60 of the income class under study (both obtained in Step 1).
Step 3. For each country, the longitudinal subsample of the EU-SILC database is used to compute income mobility matrices.
Step 4. For each country, the income mobility matrix obtained from Step 3 is applied to the hypothetical population aged 60+ obtained in Step 2. We then obtain the hypothetical income distribution at age 60+ that would prevail if (i) all individuals faced the same survival conditions and if (ii) all individuals were subject to the same income mobility matrix.
Step 5. For each country, the adjusted poverty rate is computed on the basis of the hypothetical income distribution at age 60+ obtained in Step 4.

Among those steps, Steps 2, 4 and 5 are purely computational, whereas Steps 1 and 3 are more demanding. Therefore, for presentation purposes, Section 3.2 will present Step 1, that is, the computation of life expectancy by income class, while Section 3.3 will present Step 3, that is, the computation of income mobility matrices. The final results of our computations will be presented in Section 3.4.

3.2. Life expectancy by income class

To our knowledge, there exists no database with lifetables by income levels for European countries. However, EUROSTAT provides, for a number of European countries, lifetables by education levels (see Table 1).

From these numbers, it is possible to estimate lifetables by income class using a weighted ordinary least square regression, as in Bossuyt et al. (2004) and Van Oyen et al. (2005). For that purpose, we take advantage of the high correlation that exists between education and income and their similar impact on health to extrapolate mortality by income class on the basis of mortality by education. Our methodology is presented in details in the Appendix.

Figs. 1 and 2 present estimates of life expectancy at age 60 by income class in each country for the year 2012, for, respectively, men and women.

The slope of the income/life expectancy gradient is, in general, steeper for males than for females. There is also a strong heterogeneity across countries. Whereas the differential between life expectancies by income classes is relatively low for Nordic countries, it is larger among Eastern European countries.

Life expectancy statistics by income classes allow us to quantify, for each country and for each gender, the missing persons, that is, those who died prematurely in comparison to individuals enjoying the best survival conditions (i.e. the highest income class). Actually, in our simple framework, the ratio of the survival probability to the old age within a high income class to the survival probability to the old age within a low income class can be approximated by the ratio of the two associated life expectancies. Hence, it is possible to adjust the size of each income class for each country and each gender (Step 2 of our calculations) by multiplying its initial size by an adjustment factor equal to the ratio of the life expectancy in the top income class to the life expectancy within the income class under study. For the sake of illustration, Table 2 shows the associated adjustment factors for the particular case of the bottom income class. Adjustment factors are larger for males than for females. These tend to be quite small for Nordic countries, and larger for Eastern European countries.

3.3. Income mobility matrices

In order to obtain income mobility matrices, we use data from Longitudinal EU-SILC, which includes fewer observations than the cross-sectional EU-SILC, but allows us to follow the same individual during 4 years. The sample used to estimate income mobility is based on the EU-SILC Longitudinal databases between 2009 and 2012. In each longitudinal database the sample is based on four subgroups of equal size, each one being representative of the total population of each year. Each year, the subgroup that completes four years is dropped from the sample and replaced by another equivalent, meaning that each individual or family can only be followed by a period of four years. For example, the 2012 longitudinal database includes individuals who were followed between 2009 and 2012, between 2010 and 2012 and between 2011 and 2012. So there is an overlap between the various longitudinal

[6] In order to study the robustness of our results to taking the population aged 60+ as a whole, Section 7.2 examines the robustness of our results by considering an alternative population, being a subset of the population aged 60+.

Table 1
Life expectancy at age 60 by education level, 2012. Source: EUROSTAT.

	Life expectancy at age 60					
	Men			Women		
Countries	Primary	Secundary	Tertiary	Primary	Secundary	Tertiary
Bulgaria	14.9	18.4	19.9	20.6	22.6	23.4
Czech R.	14.5	19.5	20.3	23.0	23.7	23.8
Denmark	20.5	21.5	22.8	23.8	24.9	25.5
Estonia	14.3	19.0	20.6	22.1	24.3	25.7
Finland	21.1	21.8	23.1	25.6	26.2	26.9
Hungary	14.2	18.9	20.1	21.1	23.2	23.4
Italy	22.2	24.5	24.5	26.7	27.8	27.8
Norway	21.3	22.7	23.7	24.5	25.9	26.7
Poland	17.4	18.6	21.6	23.5	23.9	25.3
Portugal	21.3	23.2	23.9	25.9	26.3	27.4
Romania	16.2	19.2	19.1	21.8	23.0	23.2
Sweden	22.0	23.0	23.9	24.6	26.0	26.4

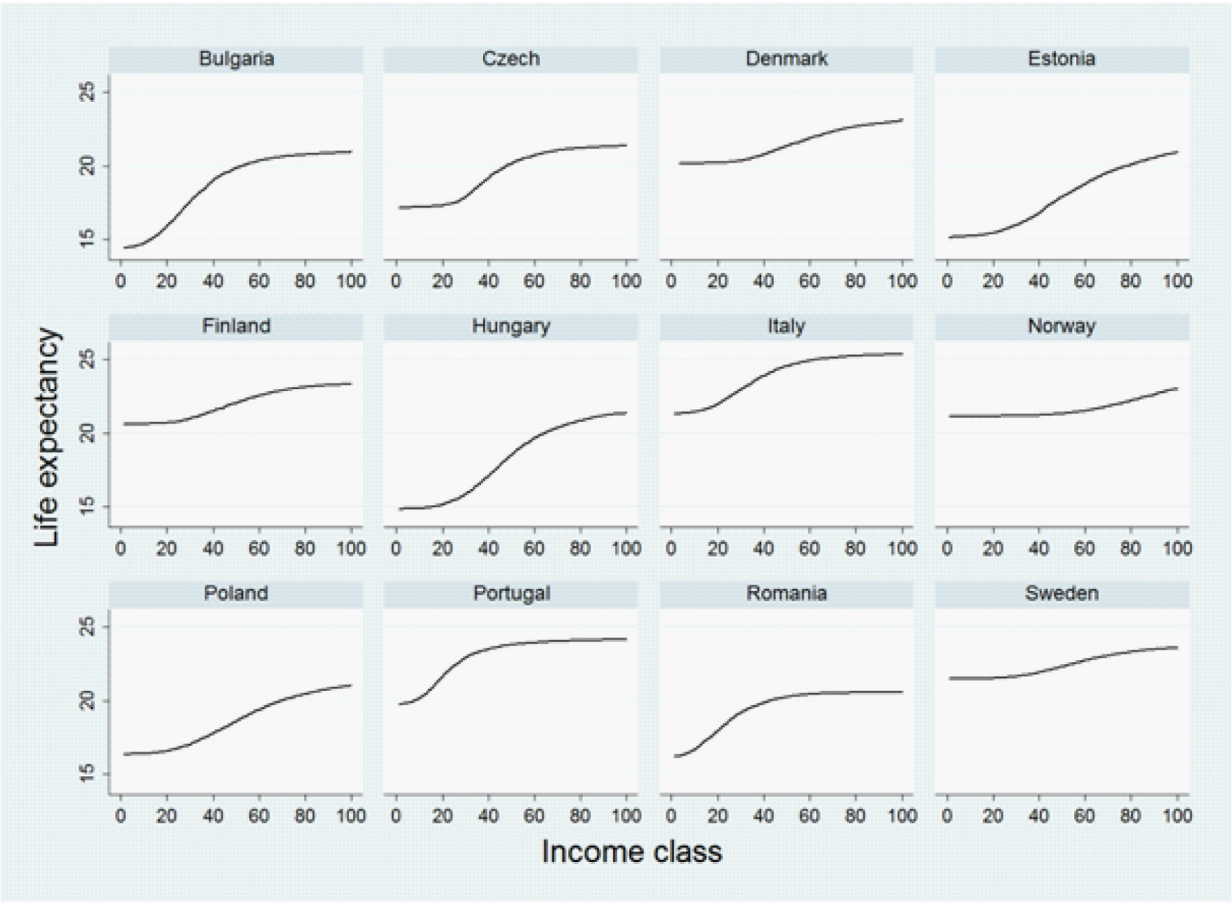

Fig. 1. Life expectancy by income class at age 60, men, 2012.

databases.[7]

We exploit four longitudinal data sets, covering the periods 2006-2007-2008-2009, 2007-2008-2009-2010, … , 2009-2010-2011-2012. Income mobility is obtained by comparing pairs of income for a given individual in periods t and $t-1$. As for poverty

[7] The coverage is not uniform across countries: some years are not available in some countries.

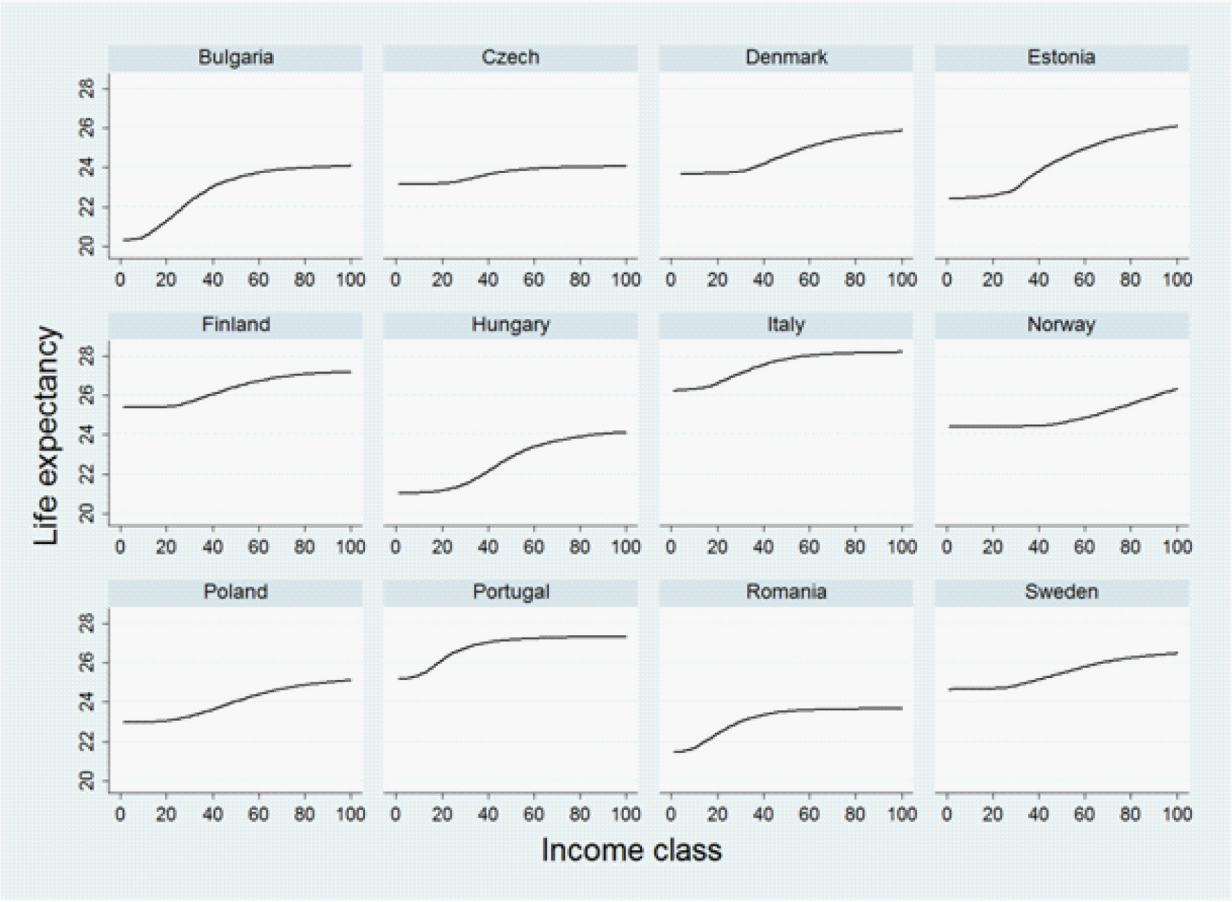

Fig. 2. Life expectancy by income class at age 60, women, 2012.

Table 2
Life expectancy at age 60 for the bottom and top income classes, with the associated adjustment factors.

	Life expectancy at age 60				Adjustment factor	
	Bottom income class		Top income class			
Countries	Males	Females	Males	Females	Males	Females
Bulgaria	13,5	19,0	22,3	24,5	1,65	1,29
Czech R.	15,0	22,0	24,0	25,1	1,60	1,14
Denmark	20,2	23,5	22,8	25,8	1,13	1,10
Estonia	14,5	22,9	20,3	25,6	1,41	1,12
Finland	20,2	25,3	23,3	26,8	1,15	1,06
Hungary	15,0	20,9	21,2	23,9	1,41	1,14
Italy	21,3	25,9	24,6	27,5	1,16	1,06
Norway	21,0	24,2	23,2	26,2	1,11	1,08
Poland	16,4	22,9	20,7	25,0	1,26	1,09
Portugal	20,0	25,2	23,2	26,6	1,16	1,06
Romania	16,2	21,2	20,0	23,0	1,24	1,09
Sweden	21,5	24,6	23,6	26,5	1,10	1,07

measurement, we rely on individual single-adult equivalized household disposable income (according to the modified-OECD equivalence scale). Following Van Kerm and Alperin (2013), we only keep individuals with income larger or equal to zero in two consecutive years, respectively.[8] The individual income in each year refers to equivalent income at 2012 constant prices (using the

[8] We follow standard practices in the literature on income mobility. Our unit of analysis is a pair of single-adult equivalent household disposable incomes for an individual measured between two periods. That means that all members of a household at time *t* are assumed to share equally total household income, adjusted by equivalence scales (see EUROSTAT, 2009). In order to avoid results that are influenced by extreme data, we have

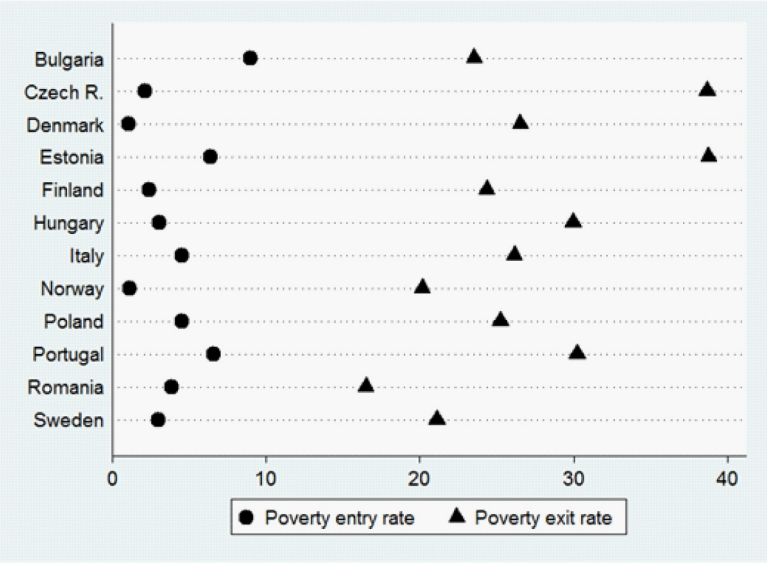

Fig. 3. Poverty entry and exit rate for the year 2012 people aged 60+.

harmonized index of consumer prices, available from EUROSTAT) such that all income changes are in real terms. All results were calculated using the longitudinal weights available.

We are interested in mobility as a positional change in the income distribution. More specifically, we want to evaluate the probability that an individual in an income category y_i goes one year later in a category y_j. Given our purpose, we are interested in absolute income mobility and not relative one such as mobility across deciles (in the sense of Fields and Ok, 1999). We can then look at mobility across income class as the ones we use in our poverty measure.

To maximize the sample size, income mobility is calculated based on annual income transitions following the aggregation of all annual transitions in the successive waves of EU-SILC. This allows to obtain a higher number of observations but also to get rid of some specific shock that could happen in one year. However, 100 income classes may be too many to obtain a complete mobility matrices. Therefore, we look at mobility across 10 income groups.[9]

The computed income mobility matrices are presented by country and gender in the Appendix. Those matrices show that there exists downward and upward income mobility, especially around the diagonal of the matrices, that is, towards income classes that are close to the initial income class to which the person belongs. In the light of this, the correction of poverty rates for mortality differentials could hardly ignore income mobility, since, given this mobility, it is not certain that a person who died prematurely would, in case of survival, have enjoyed the same income level as the one enjoyed when being still alive.

To summarize the information contained in income mobility matrices, Fig. 3 displays, for each country, the probability to exit poverty and the probability to enter poverty for the people aged 60+. A person is here considered as poor if her income is below a poverty line set at 60 percent of her country's median income.[10] Fig. 3 presents for each year of a longitudinal dataset the poverty exit rates (i.e. the fraction of individuals in poverty at time $t-1$ that are not poor at time t) and the poverty entry rates (i.e. the fraction of individuals not in poverty at time $t-1$ that are poor at time t). There are important differences among countries both in terms of entry and exit rates.

We can also calculate, for each income class, the probability to enter or exit poverty.[11] Fig. 4 shows that the probability to enter poverty tends generally to be smaller for people who belong initially to higher income classes. Hence, the property of equal probability to enter poverty (see Section 2) is not satisfied, implying that income-differentiated mortality will interfere with the measurement of poverty. The probability to exit poverty is generally lower for those who belong to lower income classes. Those probabilities to exit poverty differ from zero, which suggests that, among the poor who died prematurely, some could have, in case of survival, escaped poverty. Thus taking income mobility into account matters for the definition of appropriate counterfactuals.

Despite those general tendencies, there are important differences among countries in terms of entry and exit. In Estonia and

(*footnote continued*)
deleted income smaller than 75% of the lowest percentile or higher than 125% of the highest percentile of the income distribution for each year and each country. It does not affect the sample substantially, and concerns a small number of cases (about 1% of the initial sample).

[9] For instance, in the case of Sweden, we consider classes of 5000 euros. This implies, given that the poverty line is fixed at 14,988 euros, that only those in the three first groups are poor in $t-1$.

[10] The median income is computed on the basis of the initial, actual income distribution, that is, before the adjustment of missing persons is made. See the Appendix for the poverty thresholds.

[11] Obviously, the exit rate is only available for lower income classes; i.e those which are below the poverty line, and the poverty entry rate is not available for lower income classes.

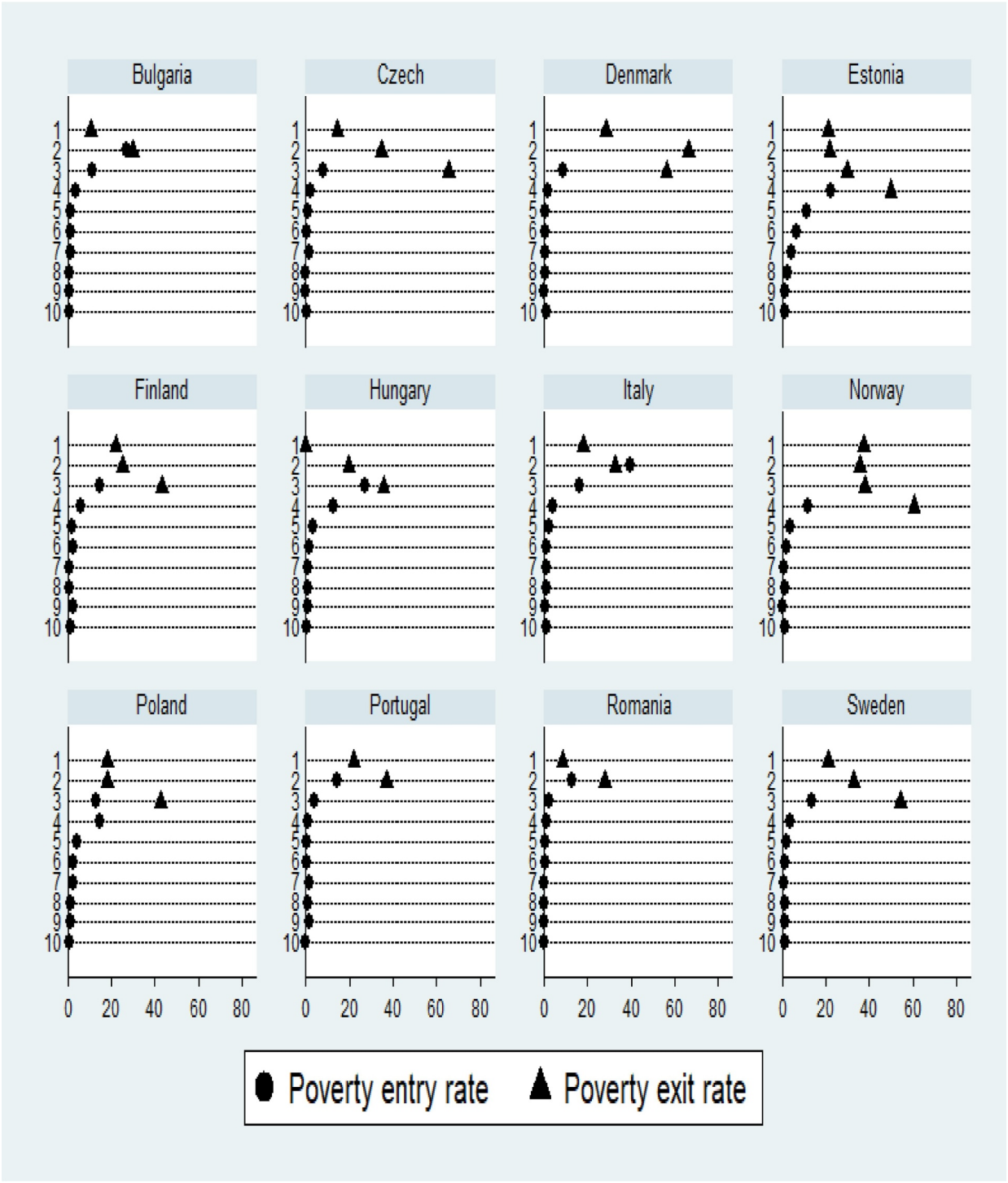

Fig. 4. Poverty entry rates and exit rates for year 2012, by income class (people aged 60 and more).

Poland, we observe entry into poverty for higher income classes, while in Sweden and Denmark, poverty dynamics is limited across the poverty line.

3.4. Results

On the basis of income-specific life expectancies computed in Section 3.2, we calculate, for the 12 countries under study, the

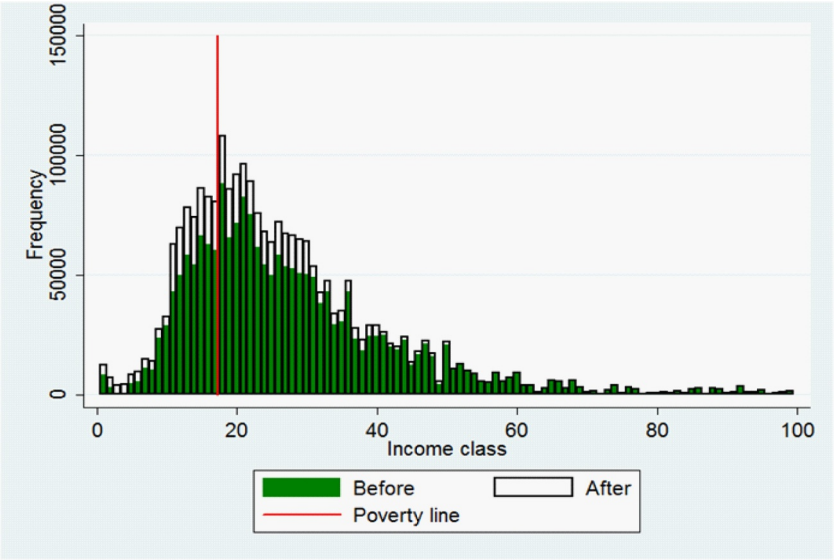

Fig. 5. Income distribution (frequency) in Bulgaria (men and women aged 60 +), 2012, before and after the addition of missing persons.

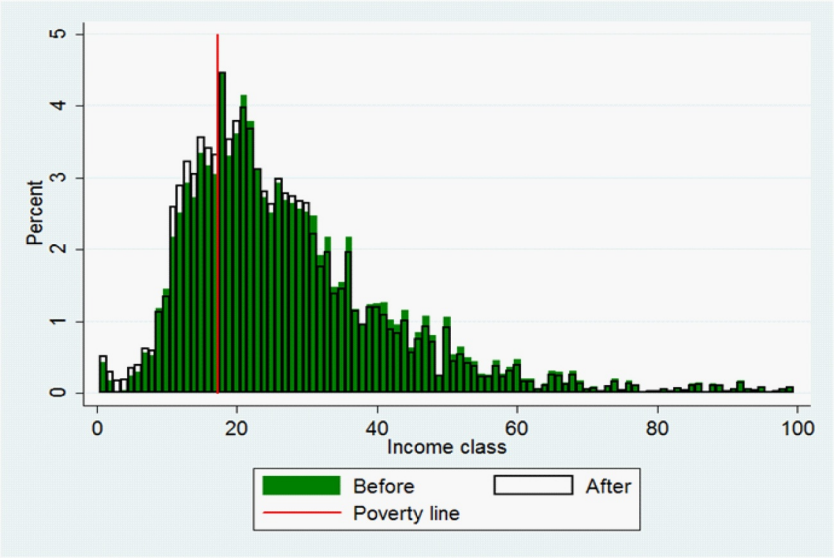

Fig. 6. Income distribution (density) in Bulgaria (men and women aged 60 +), 2012, before and after the addition of missing persons.

number of missing (i.e. prematurely dead) individuals in each initial income class (taken from the cross-sectional EU-SILC database for year 2012), to which we assign a fictitious income using transition matrices estimated in Section 3.3. As an illustration, Fig. 5 shows, for Bulgaria, the income distribution (in frequency), before and after the addition of missing persons, i.e. those who died but would have survived if they had benefited from the survival conditions of the highest income class.

On the basis of frequencies, it is possible to derive the distribution in density (Fig. 6), which allows us to visualize directly the impact of the addition of missing persons on the measurement of poverty. The difference between the two income distributions reflects not only the addition of prematurely dead persons, but, also, the postulated counterfactual (the fictitious income of each added missing person being determined by the prevailing income mobility process).

Assuming a constant poverty line, the variation in the poverty headcount measure can be computed directly from the density graph, by calculating the extra percent of individuals who lie on the left of the poverty line. In the case of Bulgaria, the number of added poor persons exceeds 2 percents of the population. This implies that if all Bulgarian individuals, whatever their income levels are, had faced the survival conditions of the highest income class, then the poverty rate above age 60 would have increased by about 2 percentage points.

Using the same method, we can compare standard old-age poverty rates with corrected ones by country and gender. Our results

Table 3
Standard and corrected poverty rates at age 60 + (%), 2012.

	Standard poverty rate 60+			Corrected poverty rate 60+		
Countries	Total	Males	Females	Total	Males	Females
Bulgaria	25.7	19.8	30.1	27.6	22.8	31.5
Czech R.	6.7	4.5	8.3	6.8	4.9	8.4
Denmark	10.4	8.6	12.0	10.7	8.9	12.2
Estonia	16.8	13.1	18.9	18.2	15.6	19.7
Finland	16.5	13.4	19.1	16.9	14.0	19.3
Hungary	7.5	6.8	7.9	8.5	8.3	8.6
Italy	17.0	14.1	19.3	17.5	14.8	19.6
Norway	7.7	4.0	11.0	7.9	4.2	11.2
Poland	14.8	12.5	16.4	15.4	13.6	16.7
Portugal	17.9	16.4	19.1	18.3	17.0	19.3
Romania	15.6	12.2	18.2	16.2	13.1	18.6
Sweden	15.4	10.2	19.7	15.7	10.6	20.0

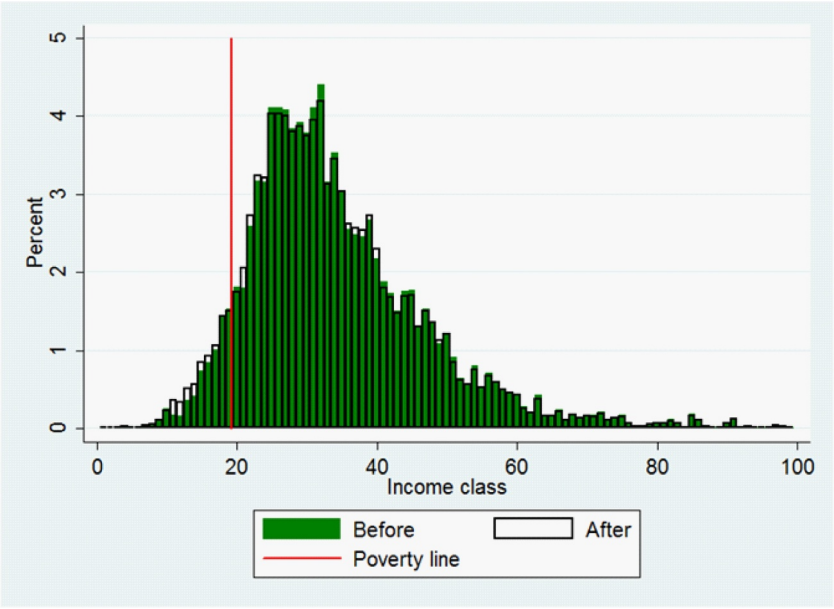

Fig. 7. Income distribution (density) in Hungary (men and women aged 60+), 2012, before and after the addition of missing persons.

are collected in Table 3.[12]

For all countries and genders, corrected poverty rates exceed standard poverty rates. In the hypothetical case where all individuals would have faced the same survival conditions, and would have been subject to the same income mobility matrix, old-age poverty measures would have taken levels that are superior to the standard ones. Thus income-differentiated mortality has tended to reduce the measured poverty at the old age.

Note, however, that the size of the correction varies across countries. Whereas the differential between the adjusted and the standard poverty rate is low in countries such as Norway, Sweden and Finland, it is larger in countries such as Bulgaria, Estonia and Hungary. As a consequence, taking the missing poor into account tends to affect the picture of international comparisons of old-age poverty across Europe. For instance, whereas Norway presents a higher poverty rate at age 60+ than Hungary (7.7% for Norway against 7.5% for Hungary), this is no longer the case once poverty rates are corrected. Actually, the corrected old-age poverty rate equals 8.5% in Hungary, against 7.9% in Norway. This inversion in the international ranking in terms of poverty is illustrated on Figs. 7 and 8, which show the changes in the income distributions in, respectively, Hungary and Norway.

The correction also affects the comparison of poverty measures across gender. To illustrate this, take the case of Portugal. The usual poverty rates at age 60 + show that poverty is higher among females than among males (19.1% for females against 16.4% for males). There is a 2.7 points difference between female and male's poverty rates. But in corrected terms, the gender gap falls to 19.3 -

[12] Distributions in density before and after the adjustment are presented for all countries in the Appendix. The poverty line is fixed at 60% of the median income in each country.

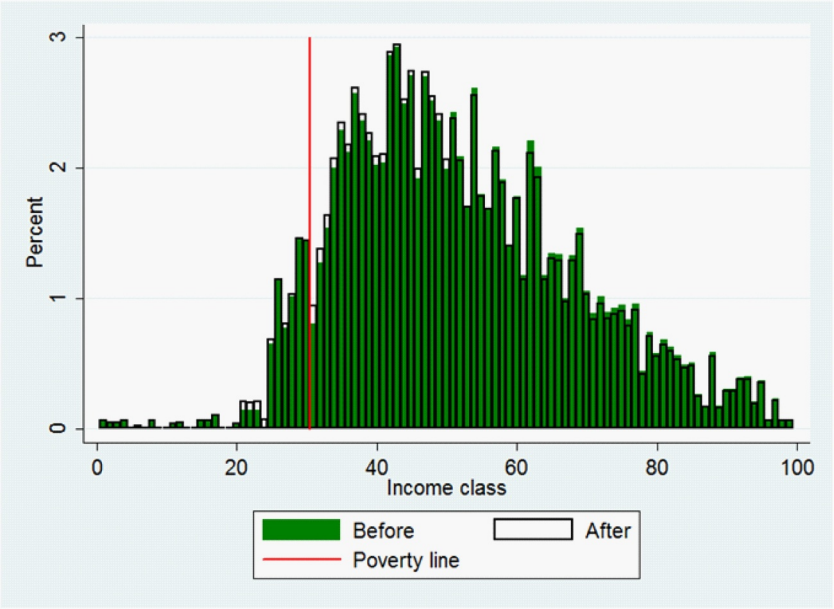

Fig. 8. Income distribution (density) in Norway (men and women aged 60 +), 2012, before and after the addition of missing persons.

Table 4
Corrected poverty rates at age 60 + under two counterfactuals: income mobility (left) and no income mobility (right) (%), 2012.

	Corrected poverty rate 60 + (income mobility)			Corrected poverty rate 60 + (no income mobility)		
Countries	Total	Males	Females	Total	Males	Females
Bulgaria	27.6	22.8	31.5	28.4	23.5	32.4
Czech R.	6.8	4.9	8.4	7.2	5.5	8.7
Denmark	10.7	8.9	12.2	10.8	9.0	12.4
Estonia	18.2	15.6	19.7	17.9	14.9	19.7
Finland	16.9	14.0	19.3	17.0	14.1	19.5
Hungary	8.5	8.3	8.6	7.9	7.5	8.2
Italy	17.5	14.8	19.6	17.6	15.0	19.7
Norway	7.9	4.2	11.2	8.0	4.2	11.4
Poland	15.4	13.6	16.7	15.7	13.9	17.0
Portugal	18.3	17.0	19.3	18.5	17.4	19.5
Romania	16.2	13.1	18.6	16.4	13.3	18.8
Sweden	15.7	10.6	20.0	15.9	10.7	20.2

17.0 = 1.7 points. Thus incorporating the missing (i.e. prematurely dead) individuals into the poverty headcount ratio can, in some countries, reduce the level of the gender poverty gap at the old age.

4. The effect of income mobility

To identify the influence of the income mobility process on the adjustment of poverty rates, let us now construct another counterfactual than the one considered so far. Instead of assigning to each missing person a fictitious income equal to the one that he would have enjoyed in case of survival given the prevailing income mobility process, let us now assign as a fictitious income the last income enjoyed when being alive. This alternative counterfactual amounts to assume the absence of income mobility: $\lambda_{ik} = 0\ \forall i \neq k$ and $\lambda_{ii} = 1$.

We can then compute corrected poverty rates under that alternative counterfactual, and compare these with the corrected poverty rates obtained from assuming income mobility as a counterfactual. Table 4 shows the two corrected poverty rates at age 60 and more, for the different countries and gender.

Table 4 shows that corrected poverty rates vary with the postulated counterfactual. Depending on whether the prematurely dead persons are assigned the income they would have enjoyed in case of survival under the prevailing income mobility process or, alternatively, the income they actually enjoyed just before dying, we obtain different values for the corrected poverty rates. Thus the assumed counterfactual in terms of income mobility matters for the incorporation of prematurely dead persons into old-age poverty

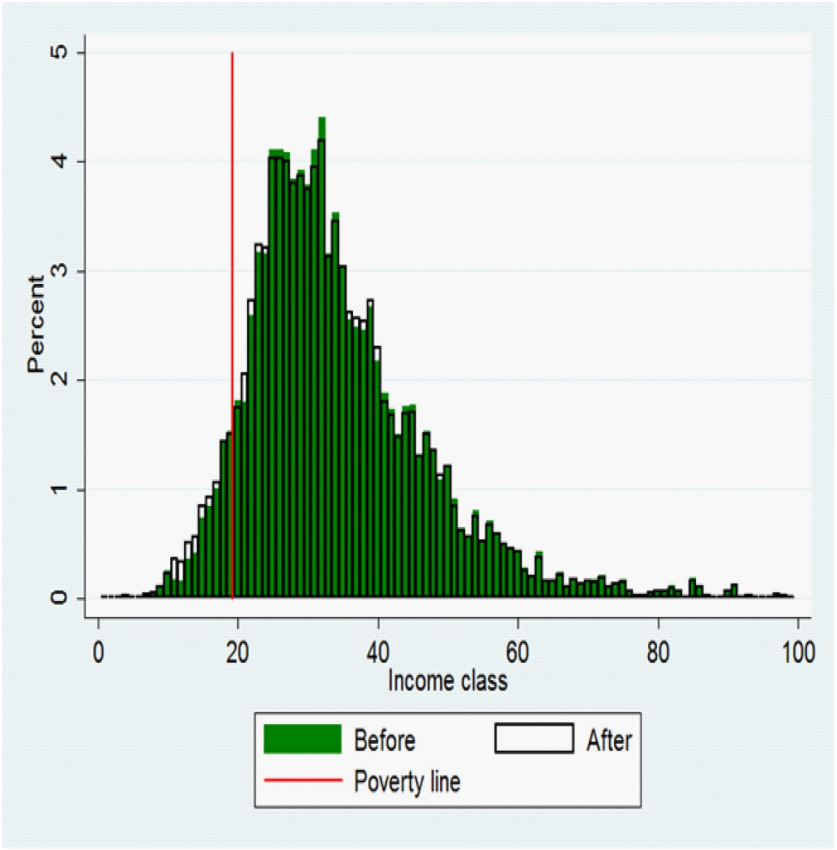

Fig. 9. Adjustment of income distribution (density) in Bulgaria (men and women aged 60+), 2012. Counterfactual: no income mobility.

measures.

Regarding the direction of changes, relying on past incomes as a counterfactual leads to higher corrected poverty rates for countries such as Bulgaria, Czech Republic, Poland, Portugal, Romania and Sweden, whereas corrected poverty rates remain almost unchanged in Denmark, Finland, Italy and Norway. Note also that relying on past incomes as a counterfactual leads to a reduction in corrected poverty rates in Estonia and Hungary. That result is quite surprising, since one would expect, given the presence of upward income mobility, that using the actual income mobility process as a counterfactual would lead to a reduction in the corrected poverty rates. This is not the case in those two countries.

To understand why imposing alternative counterfactuals can have quite opposite effects across countries, let us compare the adjustment of income distribution in Bulgaria with, as counterfactuals, income mobility (Fig. 6) and without income mobility (Fig. 9). We contrast this with the case of Hungary, for which we show Fig. 7 (adjustment with income mobility as a counterfactual) and Fig. 10 (no income mobility as a counterfactual).

The comparison of Figs. 6 and 9 shows that, in the case of Bulgaria, more density is added on the left of the poverty line under the no income mobility counterfactual in comparison to the case when income mobility is taken as a counterfactual. On the contrary, comparing Figs. 7 and 10 reveals that, in the case of Hungary, the opposite result prevails, since more density is added on the left of the poverty line when income mobility is taken as a counterfactual.

In sum, Table 4 illustrates the importance of the postulated counterfactual (income mobility or no income mobility) as far as the adjustment of old-age poverty headcount ratios is concerned. If one supposes that prematurely dead individuals would have, in case of survival, enjoyed the same income as the one they enjoyed at the time of dying, the adjustment of poverty measures is, in general, larger than when one assumes that prematurely dead individuals would have, in case of survival, faced the same income mobility process as the one faced by those who survived. The presence of income mobility tends to reduce the extent to which premature deaths lower measured old-age poverty. Note, however, that there are some exceptions, such as Estonia and Hungary, for which the correction is larger under the income mobility counterfactual than under the no mobility counterfactual.

5. Varying relative poverty lines

When measuring poverty, a crucial issue consists in the selection of a poverty line, below which individuals are counted as poor.

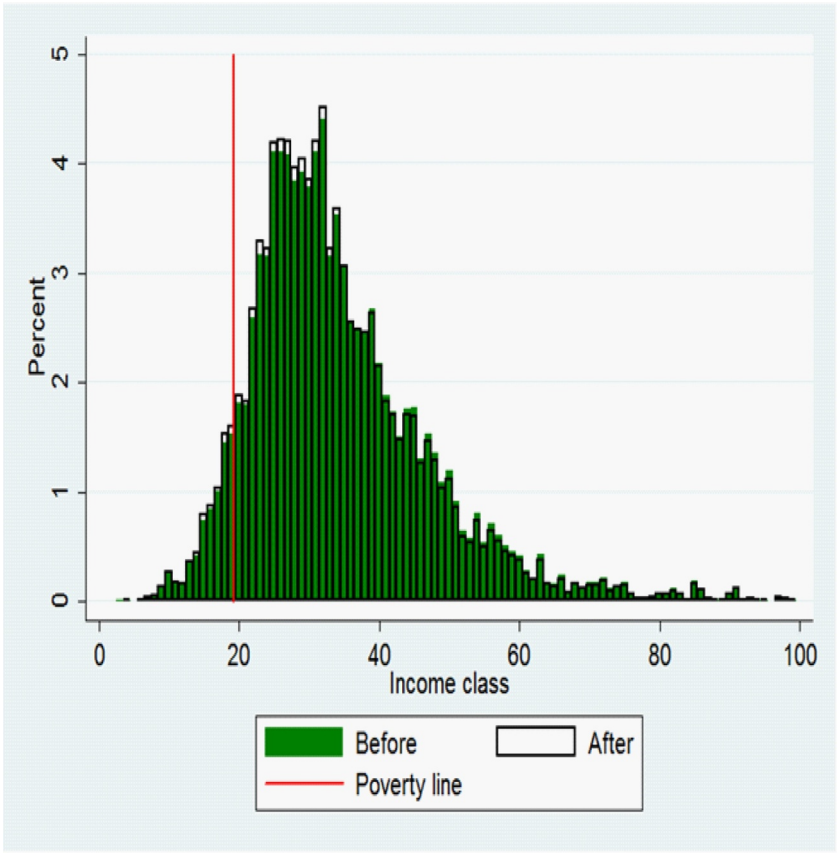

Fig. 10. Adjustment of income distribution (density) in Hungary (men and women aged 60 +), 2012. Counterfactual: no income mobility.

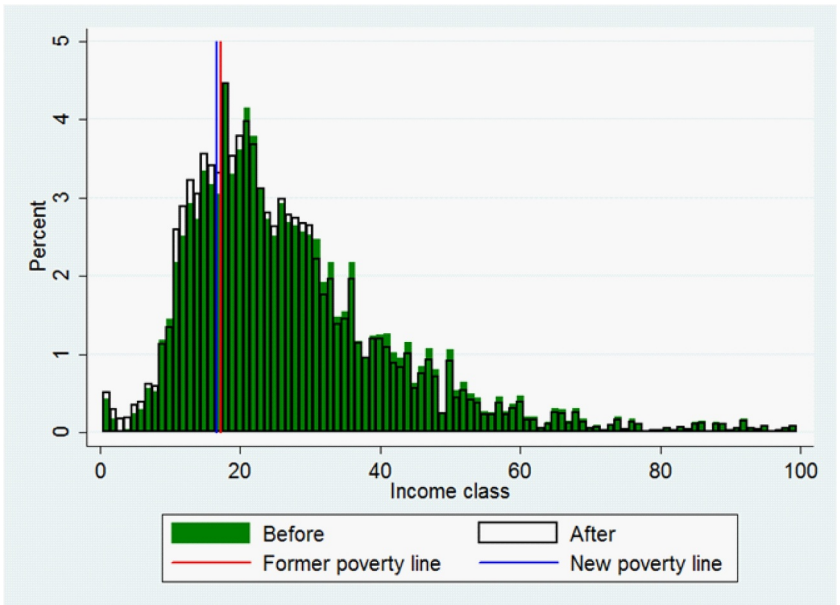

Fig. 11. Income distribution (density) in Bulgaria (men and women aged 60 +), 2012, before and after the addition of missing persons. Old and new poverty lines.

Up to now, we used, for our calculations, a poverty line equal to 60% of the median income in each country considered, the median income being computed on the basis of the income distribution prevailing before the adjustment is made. Note, however, that one may have used, as an alternative poverty line, a threshold equal to 60% of the median income in each country on the basis of the

Table 5
Corrected poverty rates at age 60 + (under income mobility), initial and new poverty threshold (%), 2012.

	Corrected poverty rate 60+ (income mobility, initial threshold)			Corrected poverty rate 60+ (income mobility, new threshold)		
Countries	Total	Males	Females	Total	Males	Females
Bulgaria	27.6	22.8	31.5	25.7	20.9	29.7
Czech R.	6.8	4.9	8.4	6.6	4.9	8.1
Denmark	10.7	8.9	12.2	10.2	8.4	11.7
Estonia	18.2	15.6	19.7	15.6	13.0	17.2
Finland	16.9	14.0	19.3	16.7	13.7	19.2
Hungary	8.5	8.3	8.6	8.4	8.2	8.6
Italy	17.5	14.8	19.6	17.3	14.8	19.4
Norway	7.9	4.2	11.2	7.6	4.2	10.7
Poland	15.4	13.6	16.7	15.2	13.5	16.5
Portugal	18.3	17.0	19.3	18.3	17.0	19.3
Romania	16.2	13.1	18.6	16.0	13.0	18.3
Sweden	15.7	10.6	20.0	15.4	10.2	19.8

Table 6
Standard and corrected absolute poverty rates at age 60 + (%), 2012.

	Standard poverty rate 60+			Corrected poverty rate 60+		
Countries	Total	Males	Females	Total	Males	Females
Bulgaria	24.8	17.8	27.0	26.6	21.8	30.6
Czech R.	0.47	0.51	0.43	0.45	0.48	0.42
Denmark	0.49	0.46	0.53	0.48	0.44	0.51
Estonia	3.33	3.49	3.23	3.57	3.89	3.37
Finland	0.16	0.22	0.11	0.16	0.23	0.11
Hungary	1.70	1.54	1.80	1.70	1.56	1.80
Italy	1.20	1.11	1.27	1.33	1.29	1.36
Norway	0.32	0.28	0.36	0.31	0.27	0.34
Poland	3.36	3.53	3.24	3.60	3.90	3.38
Portugal	2.53	2.71	2.41	2.81	3.13	2.56
Romania	29.56	24.11	33.58	30.69	25.97	34.38
Sweden	0.35	0.50	0.22	0.35	0.49	0.22

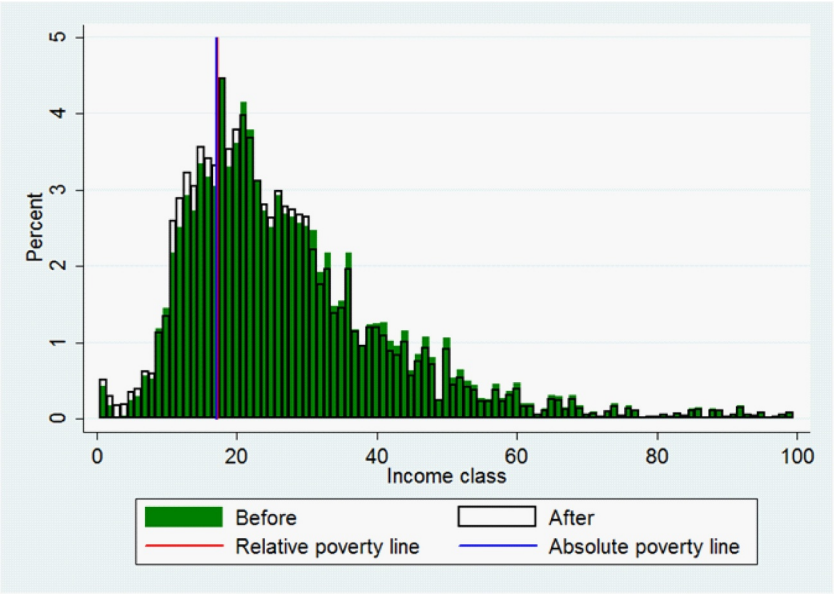

Fig. 12. Income distribution (density) in Bulgaria (men and women aged 60+), 2012, before and after the addition of missing persons. Absolute and relative poverty lines.

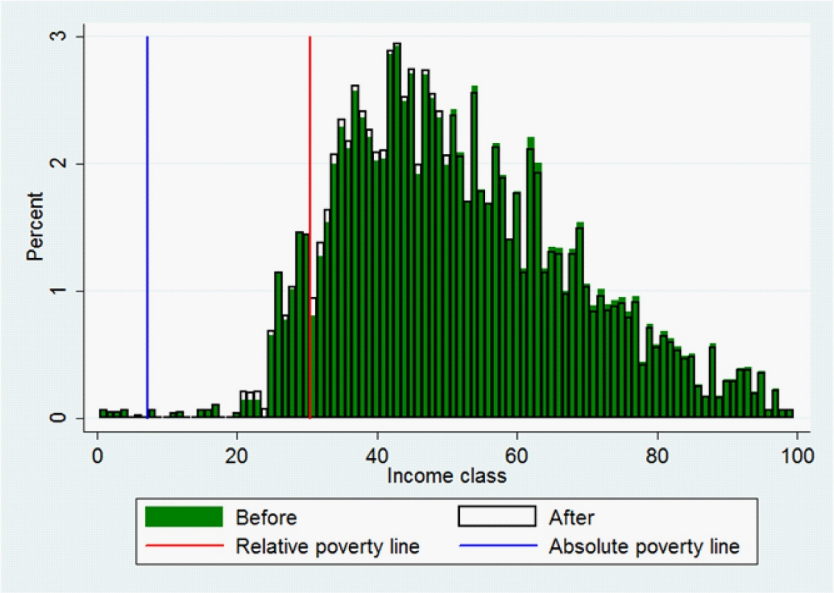

Fig. 13. Income distribution (density) in Norway (men and women aged 60+), 2012, before and after the addition of missing persons. Absolute and relative poverty lines.

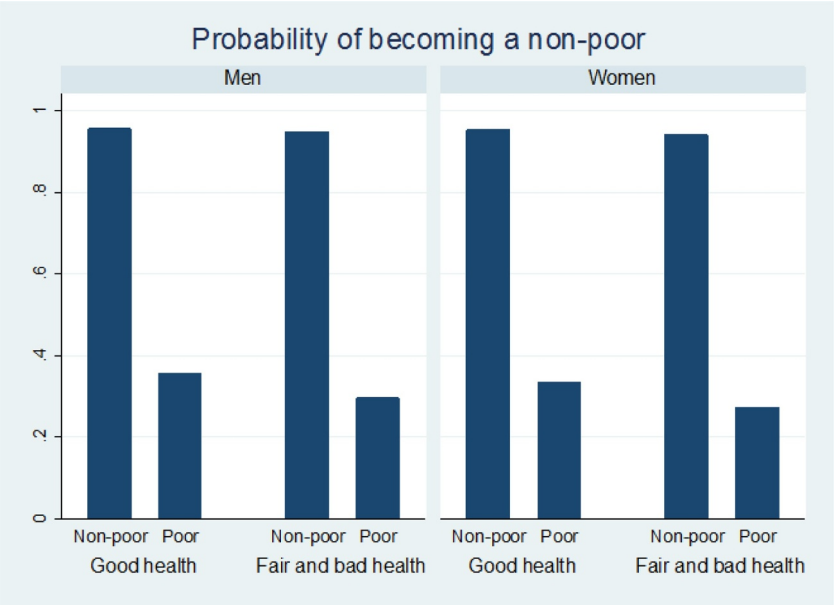

Fig. 14. Income mobility by health status (categories 1 and 2 versus 3, 4 and 5).

income distribution prevailing *after* the adjustment is made. Indeed, adding missing persons in the income distribution is likely to affect the level of the median income, and, hence, may also require to modify the poverty line.

Once we allow for the adjustment of the poverty line to the new income distribution, we obtain different corrected poverty rates. To illustrate this, Fig. 11 shows, for the case of Bulgaria, the income distribution for the population aged 60+ before and after the addition of missing persons, as well as the old and the new poverty lines. Given that the inclusion of missing persons adds more density on the left of the distribution (low income classes), the poverty line moves slightly to the left, which, in the case of Bulgaria, reduces the size of the adjustment of the poverty rate.

Table 5 compares the corrected old-age poverty rates under the income mobility counterfactual, while assuming either the pre-adjustment poverty line or the post-adjustment poverty line.[13]

[13] See the Appendix for the new poverty lines.

Table 7
Standard and corrected poverty rates at age 60+ and 70+ (%), Italy, 2012.

	Standard poverty rates		
	Total	Males	Females
Age 60+	17.0	14.1	19.3
Age 70+	18.2	14.7	20.6
	Corrected poverty rates: income mobility		
	Total	Males	Females
Age 60+	17.5	14.8	19.6
Age 70+	18.4	15.1	20.8
	Corrected poverty rates: no income mobility		
	Total	Males	Females
Age 60+	17.6	15.0	19.7
Age 70+	18.4	15.2	20.8

Relying on the new poverty threshold affects the measured poverty in distinct ways across countries. Whereas this change in the poverty line has no effect on the level of measured poverty in Portugal, this reduces the level of measured poverty in Bulgaria and Estonia. Note, however, that it remains true, whatever the poverty line that is used, that the addition of missing persons still inverts some international poverty rankings. Although Norway exhibits a higher poverty at age 60 + in comparison to Hungary in unadjusted terms, poverty is lower in Norway than in Hungary once the missing persons are added, whatever we use the initial or the new poverty threshold. Thus, although adjusting the poverty line reduces corrected poverty rates, taking the missing persons into account has still an impact on the measurement of old-age poverty.

Comparing Table 5 with Table 3 shows that the impact of changing the poverty line on the adjustment of poverty rates varies across countries. In countries such as Finland, Hungary, Italy, Poland, Portugal and Romania, the adjusted poverty rate remains more or less robust to the poverty line that is used. However, in Bulgaria, the size of the adjustment of the old-age poverty measure, which equals almost two percentage points under the past poverty line, vanishes to 0 under the new poverty line. In Estonia, the change is even larger: once the poverty line is adjusted to its new level, the addition of missing persons turns out not to increase, but to reduce the measured poverty.[14]

6. Absolute poverty line

Up to now, our analysis relied on a concept of *relative* poverty, in the sense that the poverty thresholds were assumed to be equal to 60 percents of the median income in each country under study. But one may also want to check whether the adjustment of old-age poverty measures for the missing poor phenomenon is robust to the underlying concept of poverty. For that purpose, this section relies on a concept of *absolute* poverty. The poverty threshold is now assumed to be equal to 10 euros a day, adjusted for purchasing power parity (PPP).[15]

Table 6 presents the standard absolute poverty rates for the 12 countries under study, as well as the corrected poverty rates (while assuming income mobility as a counterfactual). Relying on a concept of absolute poverty yields a quite different picture of poverty in Europe, with poverty rates that are largely unequal across nations. Some countries, such as Bulgaria and Romania, exhibit a high level of absolute old-age poverty (about 25%), whereas other countries, such as Nordic countries, exhibit poverty rates equal to less than 0.35%.

The extent to which adopting an absolute poverty line rather than a relative poverty line affects the measured old-age poverty varies across countries. In order to illustrate this, Figs. 12 and 13 show the adjustment of the income distributions in, respectively, Bulgaria and Norway, and the associated poverty rates under the relative and the absolute poverty lines. As far as Bulgaria is concerned (Fig. 12), the absolute poverty line is close to the relative one, and the addition of missing persons implies the addition of a substantial density on the left of the two poverty lines. Hence, in the case of Bulgaria, the variation in the old-age poverty rate is robust to whether one uses a relative or an absolute poverty line. However, when considering Norway (Fig. 13), it appears that the absolute poverty line is much more on the left than the relative poverty line. Only very low income classes are in absolute poverty in Norway. Given the small density of those low income classes, the adjustment of the income distribution leaves the absolute poverty rate quasi unchanged, unlike what we have under a relative poverty measure.

Comparing Table 6 with Table 3 reveals that shifting from a concept of relative poverty to a concept of absolute poverty affects the picture. Under a relative poverty line, all countries exhibit a gap between adjusted and standard old-age poverty rates. However, under an absolute poverty line, some countries exhibiting a zero (or even negative) adjustment of poverty measures.

[14] The reason for this surprising result lies in the fact that the income distribution in Estonia is such that there is a strong concentration of the population around the poverty line. Hence, a small decrease in the poverty threshold suffices to cause a strong decrease in the measured poverty.
[15] See the Appendix for the poverty thresholds.

7. Additional robustness checks

7.1. Income mobility and health

When constructing poverty measures corrected for the missing poor problem, we assumed all along (except in Section 4) that prematurely dead individuals would, in case of survival, have enjoyed a fictitious income based on the same income mobility process as the one faced by the surviving population.

One may criticize that assumption, on the grounds that applying income mobility matrices based on the surviving population to *another* population, i.e. the prematurely dead population, may bias our results. The problem goes as follows. Assuming that the prematurely dead would have, in case of survival, enjoyed the same income mobility process as the surviving population may involve a strong simplification, since the surviving and the non-surviving populations may differ on (potentially) many characteristics. But if the income mobility matrices that we use are not applicable to the prematurely dead, then there is a danger of miscalculating the proportion of the population that would have been in poverty in the absence of premature death. It is thus important to test the ”same income mobility” hypothesis.

Given that income mobility can only be estimated on the surviving population (but not on the prematurely dead population), it is hard to test the ”same income mobility process” hypothesis in a direct way. However, it is possible to test that assumption indirectly, by using data on health status in the EU-SILC database. The test consists in dividing the sample in terms of the health status, and in computing separate income mobility matrices by health status, to see how different those income mobility matrices are.

Data on health status consists of individual self-assessment of health, with 5 different possible answers: (1) very good; (2) good; (3) fair; (4) bad; (5) very bad. The data are for year 2012. We first classify people in fair or bad health (3 to 5) and good health (1 to 2). Then we look at the probability to move out of poverty (for those in poverty) and in poverty (for those out of poverty) according to the health status.

Fig. 14 shows, for men and women, the probability of transition to non-poverty for individuals who are initially non-poor and for individuals who are initially poor, according to their health status. Quite interestingly, the probability of remaining outside poverty for the initially non-poor is quite similar across health status groups. The probability of escaping from poverty for initially poor individuals is slightly larger for poor individuals who are in a good health than for those who are in fair or bad health, but the magnitudes are very close.[16]

This exercise suggests that the income mobility process does not strongly differ across groups with unequal health status. One can regard this as providing an indirect support for our methodology. The (quasi) similarity of income mobility matrices based on the health status suggests that applying the income mobility matrix based on the surviving population to the prematurely dead does not strongly bias our results.

7.2. The partition of population in terms of age

As stated at the very beginning of Section 3, our analysis has focused, throughout the paper, on the population aged 60+ taken as a whole. Whereas this focus on the population aged 60+ can be defended on the grounds of data limitations, one may nonetheless wonder whether our results are robust to the particular partition of the population in terms of age.

Ideally, one may want to divide the population into age-groups of small size, and to compute adjusted poverty rates for all those age-groups. The problem is that age-groups of small size lead to too few members in some income classes, which prevents the computation of meaningful income mobility matrices. Moreover, we also face limitations concerning EUROSTAT data on life expectancy by education, which are used for the extrapolation of life expectancy by income class. We only have life expectancy by education level, which allow us to approximate the ratio of survival rates by ratios of life expectancies (given that there is only one population taken as a whole). However, the partition of the population into smaller age-groups would require, for adjustment purposes, to have survival rates to different ages by education level. All those data limitations constrained us to consider the population aged 60+ as a whole.

It is possible to test the robustness of our results to the partition of the population in terms of age by considering an alternative partition of the population. For that purpose, this section proposes to follow the same 5-step methodology as we did in Section 3, but for the population aged 70+ (instead of 60+). This exercise will allow us to see how robust our results are to the age definition of the population under study.

In order to carry out that robustness check, we focus only on the case of Italy, which is the country for which we have the largest number of observations. Concerning Step 1, life expectancies at age 70 by income classes are extrapolated from life expectancies by education level, while using the same procedure as in the benchmark case.[17] Moreover, concerning Step 3, income mobility matrices are also computed for the population aged 70+, while relying, as in the benchmark case, on the Longitudinal EU-SILC database.[18]

Table 7 compares, for Italy, the standard poverty rates and the adjusted poverty rates (under either the income mobility counterfactual, or the no income mobility counterfactual), while focusing either on the population aged 60+ (as in the remaining of this paper), or on the population aged 70+.

[16] Similar results are obtained for alternative partitions of the population in, for instance, bad health (4 to 5) and fair or good health (1 to 3).
[17] See the Appendix for the comparison of life expectancies by income class at age 60 and at age 70.
[18] The computed income mobility matrices are shown in the Appendix.

Table 7 shows that, for both men and women, adjusted poverty rates are larger than standard poverty rates, whatever we consider the population aged 60+ or only the population aged 70+. Thus adding the prematurely dead persons has some impact on old-age poverty measurement, whatever the particular definition of the old age.

Note that the size of adjustments (i.e. the gaps between corrected and standard headcount ratios) is lower when considering the population aged 70+ than when considering the population aged 60+. This result is due to the fact that, as shown in the Appendix, the income/mortality gradient is stronger within the population aged 60+, in comparison to what it is within the population aged 70+. Having stressed this, it remains true, even when considering the population aged 70+, that the inclusion of the prematurely dead affects the measurement of old-age poverty. Thus, even though the quantification of the missing poor phenomenon varies with the population under study, the existence of a missing poor problem for old-age poverty measurement is robust to the particular partition of the population in terms of age.

8. Conclusions

Poor individuals exhibit higher mortality than non-poor individuals, which implies that, when measuring poverty at the old age, the poor are necessarily under-represented with respect to the non-poor within the surviving population. This "missing poor" problem for measuring old-age poverty has attracted substantial attention in the recent years, following the seminal paper by Kanbur and Mukherjee (2007). However, although the existence of an income/mortality gradient is widely documented, the extent to which the missing poor problem affects the measurement of old-age poverty remains a complex empirical issue.

This paper proposed to cast new light on the missing poor problem in old-age poverty measurement, by paying particular attention to the design of counterfactuals used for the correction of poverty measures. In particular, we wanted to examine here the role of the income mobility process. The underlying motivation is that if there is strong upward income mobility, the prematurely dead persons (i.e. "missing persons") would, in case of survival, not have been so poor, so that the correction of poverty measures would then be negligible.

In order to address that issue, we used data on poverty above age 60 in 12 European countries, and computed, for each country and gender, hypothetical poverty rates that would have prevailed if (i) all individuals, whatever their income, had enjoyed the same survival conditions (the ones of the highest income class), and if (ii) all individuals within the same income class had been subject to the same income mobility process. Those hypothetical poverty rates were then compared with the standard ones, to measure the impact of income-differentiated mortality on the measurement of old-age poverty.

Our main findings are threefold. First, our calculations show that income-differentiated mortality affects the measurement of old-age poverty. In the absence of income-differentiated mortality, headcount old-age poverty rates would take values different from the ones taken by standard old-age poverty rates. Second, corrections differ across countries and gender. As a consequence, correcting the influence of income-differentiated mortality on old-age poverty measures affects comparison or ranking, in terms of old-age poverty, between countries and genders. Third, when comparing the correction of poverty rates under the income mobility counterfactual with the ones under the no income mobility counterfactual, we see that income mobility has unequal effects on the measurement of old-age poverty across countries. Thus taking income mobility into account matters for international comparisons of (corrected) old-age poverty measures.

Our study also shows that the correction of old-age poverty rates varies with the poverty line (pre- or post-adjustment, absolute or relative). Thus, in order to measure the impact of income-differentiated mortality on old-age poverty measurement, the choice of a particular poverty line matters as much as the design of counterfactuals. Here again, there is a substantial heterogeneity across countries. Once we adopt an absolute poverty line, corrections become small for Nordic countries, but remain substantial in Eastern Europe.

A major finding of this paper is that the missing poor problem affects old-age poverty measures in a way varying across countries. This heterogeneity across countries is due to differences in the strength of the income/mortality gradient and in income mobility across countries.[19] But one may want to go deeper into the analysis, in order to identify the causal mechanisms at work behind the missing poor problem. This paper being purely descriptive, we did not carry out that exercise here, but it would be interesting to study why the missing poor problem is stronger in Eastern Europe than in Northern Europe. Concerning differences in the income/mortality gradient across European countries, Mackenbach et al. (2017) show that the unequal strength of socioeconomic inequalities in mortality can be related to factors such as higher social transfers and health care expenditures, and also related to variations in behavioral factors (smoking, alcohol).[20] Regarding differences in income mobility across countries, existing studies emphasize that those differences are related to differences in government (income-stabilizing) transfers (Chen, 2009) and in labor market institutions (Sologon and O'Donoghue, 2011). Those studies of causality go far beyond the scope of our - purely descriptive - analysis, whose goal was to quantify the missing poor problem, and not to study its causes. However, examining the causes at work behind the missing poor problem is on our research agenda. This would allow us to better understand the complex articulation between poverty measurement, income-differentiated mortality and income mobility.

[19] Those differences are documented in the literature. Concerning the income/mortality gradient, Mackenbach et al. (2008) underlined that this gradient varies across European countries, and tends to be steeper in Eastern Europe. Regarding income mobility, Van Kerm and Alperin (2013) showed that income mobility varies across countries, based on differences in population composition, household composition dynamics and labor market dynamics.

[20] Other studies on the causal relationship between mortality and income include Snyder and Evans (2006); Lleras-Muney (2005); Lindahl (2005) and Van Kippersluis et al. (2011).

Appendix A

A1. Life expectancy by income class

This section presents the methodology that we use to extrapolate life expectancy by income classes from life expectancy by educational level (sources: EUROSTAT). The method consists in relating both distributions of individuals on the two dimensions (education and income). We estimate lifetables by income class using a weighted ordinary least square regression, as in Bossuyt et al. (2004) and Van Oyen et al. (2005) studies on health expectancy.

We start by transforming the absolute educational status into a relative educational status. In education lifetables provided by EUROSTAT, a three-category classification is used: 1) primary education or less; 2) secondary education and 3) higher education. The educational attainment is used to define a social position that will be related to the level of income.

Among cohorts, the size of educational groups has changed. Young people studied more than older ones, so that the corresponding income level may have changed. Furthermore, since the education sector varies from one country to another, using a relative concept allows the comparison. Fig. A1 shows the method. The horizontal axis represents the distribution of a hypothetical population according to education. Each form below the axis is an education category. The first one represents the % of people with at most a primary degree, the second one is the % of people with a secondary education degree and the third one is the tertiary education. Thus we represent each category of education by its size in the population and order these categories from the lowest level to the highest on a scale from 0 to 100%. That is each category of education represents a percentage of the population. This scale gives us a distribution of the cohort population according to education.

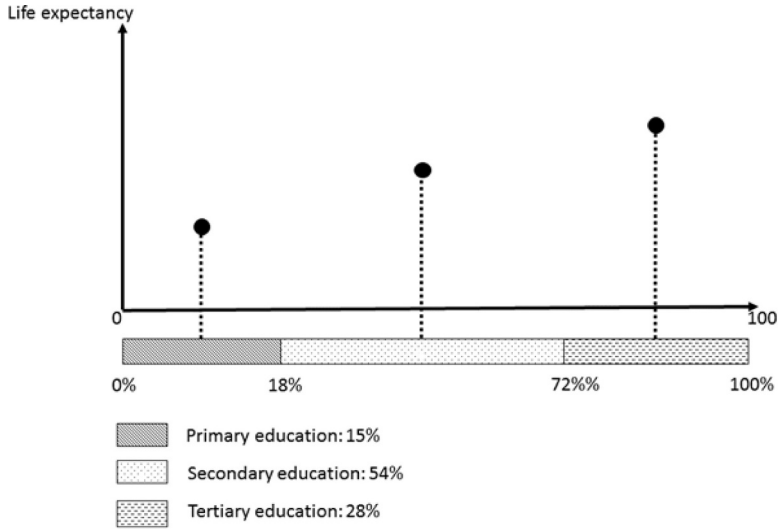

Fig. A1. Mid-point references for education categories.

We assume that the reference of an education category is determined by its relative position, defined as the mid-point of the proportion of the category represented on the ordered scale of 100% (Pamuk, 1985; 1988). For example, if the first category is given by those with at most a primary degree and represents 18% of the cohort, the mid-point reference will be 9%. If those with a secondary degree represent 54% of the population, the bounds of the category in the distribution are 18 and 72% and the mid-point is 45%.

Once we have determined the position of each category of education on the scale, the life expectancy of each category is associated to the point. We regress the life expectancy by education on the reference mid-point of the education category by weighting for the prevalence of the category, i.e. the relative size of the educational level. The slope of the regression line represents the difference in mortality between the bottom and the top of the education hierarchy. Table A1 presents the estimation results for the population aged 65 and for each country and sex separately.

Once estimated, the coefficients can be used to compute life table according to income. This is done by assuming that the social hierarchy given by the income is similar to the one given by education. Here we assume that there are 100 different income categories of equal amount and we assume that both education and income give the same social hierarchy. These categories can obviously change from one country to another. In order to obtain life expectancy by income category, we can thus apply the coefficient of one education category to the corresponding categories of income.

The categories of income change from a country to another, this to reflect the actual distribution of income. We consider 99 categories of 100 euros and the last one is residual in Bulgaria, Poland and Romania. Categories of 150 in Hungary. Categories of 200 euros in Czech R., 400 euros in Portugal, 500 euros in Denmark, Finland, Italy and Sweden and 800 euros in Norway.

Table A1
Mid-point regression of life expectancy by education – age 65.

Dependent variable: Life expectancy						
Men	Bulgaria	Czech R.	Denmark	Estonia	Finland	Hungary
Constant	11.805	12.776	16.738	12.605	16.925	13.032
Mid-point	0.057	0.065	0.019	0.052	0.021	0.047
R^2	0.863	0.855	0.997	0.941	0.966	0.565
Women						
Constant	15.883	18.388	19.674	19.477	21.220	17.411
Mid-point	0.037	0.019	0.017	0.019	0.010	0.022
R^2	0.869	0.604	0.873	0.995	0.977	0.680
Dependent variable: Life expectancy						
Men	Italy	Norway	Poland	Portugal	Romania	Sweden
Constant	17.562	17.373	13.951	16.552	13.771	17.821
Mid-point	0.025	0.023	0.033	0.023	0.022	0.016
R^2	0.828	0.903	0.861	0.862	0.682	0.995
Women						
Constant	21.750	20.308	19.287	20.899	17.391	20.502
Mid-point	0.011	0.019	0.014	0.011	0.012	0.015
R^2	0.784	0.921	0.741	0.629	0.688	0.993

A2. Income mobility matrices

Tables A2–A25

Table A2
Matrix of income mobility across classes (%) for 2012 - men aged 60+, Bulgaria.

Bulgaria - men										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	52.92	39.81	5.11	0.95	0.55	0.00	0.26	0.00	0.00	0.40
cl 2	6.99	58.49	26.53	5.71	1.02	0.68	0.22	0.16	0.10	0.11
cl 3	1.32	14.06	51.99	24.84	5.52	1.32	0.37	0.31	0.09	0.18
cl 4	0.66	4.64	21.96	45.47	18.08	5.64	1.86	0.75	0.16	0.76
cl 5	0.07	2.01	9.56	25.43	38.52	14.46	5.27	2.58	0.97	1.15
cl 6	0.08	1.58	4.45	16.60	25.55	28.88	14.40	4.79	1.91	1.75
cl 7	0.16	2.13	5.25	9.02	16.39	21.89	19.92	11.56	8.44	5.25
cl 8	0.24	0.73	2.18	5.81	7.38	19.85	22.76	19.13	9.69	12.23
cl 9	0.39	0.00	6.04	6.82	5.85	9.94	14.23	13.45	19.69	23.59
cl 10	0.00	2.98	5.64	4.86	5.02	13.17	10.03	11.91	12.07	34.33

Table A3
Matrix of income mobility across classes (%) for 2012 - women aged 60+, Bulgaria.

Bulgaria - women										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	46.47	45.41	5.77	1.35	0.68	0.03	0.21	0.00	0.00	0.09
cl 2	6.32	64.07	22.87	4.63	1.08	0.54	0.18	0.13	0.08	0.10
cl 3	1.31	14.74	51.95	23.93	5.67	1.40	0.37	0.31	0.10	0.23
cl 4	0.72	4.88	22.15	44.75	18.15	5.61	1.77	0.96	0.29	0.72
cl 5	0.00	2.13	9.90	25.72	38.55	14.28	5.14	2.37	0.98	0.93
cl 6	0.35	1.87	4.80	14.95	27.51	26.90	13.30	5.23	2.35	2.75
cl 7	0.18	2.27	4.71	7.80	17.04	24.48	17.86	11.24	9.52	4.90
cl 8	0.37	0.99	2.85	6.95	6.82	16.25	25.19	18.73	9.80	12.03
cl 9	0.18	0.00	5.10	4.75	5.80	10.54	13.53	13.71	22.14	24.25
cl 10	0.00	2.38	5.35	4.46	4.61	17.53	8.47	10.40	15.16	31.65

Table A4
Matrix of income mobility across classes (%) for 2012 - men aged 60+, Czech Republic.

Czech Republic - men										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	9.29	57.14	9.29	17.86	1.43	4.29	0.00	0.00	0.00	0.71
cl 2	2.03	39.53	43.35	10.63	2.39	1.24	0.24	0.21	0.00	0.36
cl 3	0.11	4.91	51.49	36.26	5.68	0.89	0.24	0.23	0.12	0.07
cl 4	0.01	1.30	11.33	57.50	23.72	4.22	1.22	0.28	0.11	0.30
cl 5	0.00	0.50	3.29	19.21	48.96	20.75	4.98	1.23	0.13	0.96
cl 6	0.00	0.32	1.30	6.52	23.18	39.87	19.25	5.97	1.77	1.83
cl 7	0.00	1.04	1.23	5.64	12.23	19.10	34.24	18.71	4.41	3.41
cl 8	0.00	0.00	0.67	4.83	6.91	11.81	18.55	28.95	16.14	12.15
cl 9	0.00	0.00	1.60	3.33	7.07	10.40	6.67	14.67	25.87	30.40
cl 10	0.00	0.00	0.64	5.89	3.32	5.68	6.43	8.47	14.58	54.98

Table A5
Matrix of income mobility across classes (%) for 2012 - women aged 60+, Czech Republic.

Czech Republic - women										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	2.74	52.74	13.01	23.97	4.11	2.05	0.00	0.00	0.00	1.37
cl 2	1.05	39.54	48.01	8.21	1.76	0.67	0.18	0.28	0.12	0.18
cl 3	0.11	4.91	58.15	30.98	4.60	0.70	0.21	0.18	0.07	0.08
cl 4	0.01	1.18	12.31	57.62	22.86	4.13	1.24	0.28	0.10	0.27
cl 5	0.00	0.54	3.82	20.56	47.38	20.55	5.11	1.05	0.14	0.84
cl 6	0.00	0.18	1.37	6.98	22.59	39.64	20.08	5.43	1.50	2.22
cl 7	0.00	0.71	0.80	5.30	12.15	21.48	33.33	19.08	3.99	3.15
cl 8	0.00	0.00	0.46	3.24	6.49	13.07	19.18	28.45	16.68	12.42
cl 9	0.00	0.00	1.67	4.25	8.50	9.10	8.35	16.54	22.15	29.44
cl 10	0.00	1.56	1.44	3.83	3.23	6.10	5.86	6.22	14.95	56.82

Table A6
Matrix of income mobility across classes (%) for 2012 - men aged 60+, Denmark.

Denmark - men										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	17.14	17.14	48.57	8.57	0.00	5.71	2.86	0.00	0.00	0.00
cl 2	1.75	41.98	36.15	9.33	7.87	1.46	0.58	0.87	0.00	0.00
cl 3	0.33	3.58	60.05	27.81	6.47	1.12	0.28	0.23	0.00	0.14
cl 4	0.08	0.69	6.82	60.44	26.02	4.11	1.20	0.10	0.15	0.38
cl 5	0.00	0.36	1.06	11.09	56.28	25.67	3.98	0.73	0.36	0.48
cl 6	0.00	0.17	0.77	1.80	13.01	55.47	22.66	4.29	1.03	0.80
cl 7	0.06	0.15	0.61	1.87	4.40	15.92	49.10	21.49	4.46	1.95
cl 8	0.11	0.38	0.33	0.49	2.58	7.25	15.93	45.25	19.60	8.07
cl 9	0.00	0.00	0.13	0.26	2.95	6.28	8.08	17.95	33.97	30.38
cl 10	0.00	0.11	0.74	0.85	4.02	3.81	5.07	7.51	11.73	66.17

Table A7
Matrix of income mobility across classes (%) for 2012 - women aged 60+, Denmark.

Denmark - women										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	16.67	20.83	25.00	16.67	0.00	8.33	0.00	0.00	0.00	12.50
cl 2	0.27	48.40	33.16	9.63	6.15	1.07	0.53	0.00	0.00	0.80
cl 3	0.16	3.19	61.64	26.47	6.13	1.47	0.37	0.16	0.08	0.33
cl 4	0.04	0.61	5.89	63.80	23.96	3.88	1.23	0.13	0.21	0.25
cl 5	0.01	0.24	1.22	11.09	56.89	24.91	4.07	0.79	0.24	0.55
cl 6	0.05	0.24	0.69	2.06	13.15	54.13	23.54	4.38	0.79	0.96
cl 7	0.06	0.18	0.33	2.14	3.98	16.23	50.27	20.62	4.57	1.63
cl 8	0.00	0.11	0.29	1.03	3.04	7.51	15.59	44.36	20.74	7.34
cl 9	0.00	0.41	0.28	0.55	2.07	7.02	7.30	16.67	35.95	29.75
cl 10	0.00	0.53	1.17	1.27	3.82	3.50	4.56	7.00	11.03	67.13

Table A8
Matrix of income mobility across classes (%) for 2012 - men aged 60+, Estonia.

Estonia - men										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	22.35	42.35	27.06	1.18	1.18	1.18	1.18	0.00	1.18	2.35
cl 2	2.66	40.84	42.31	9.25	2.93	0.73	0.09	0.37	0.46	0.37
cl 3	0.53	9.15	52.72	28.00	7.07	1.62	0.48	0.07	0.02	0.33
cl 4	0.16	1.68	9.97	53.86	27.58	5.36	0.99	0.17	0.06	0.17
cl 5	0.13	0.59	2.42	16.10	51.45	23.71	4.15	1.06	0.27	0.13
cl 6	0.23	0.41	1.48	4.39	21.03	42.94	22.49	4.83	1.22	0.98
cl 7	0.00	0.34	1.09	1.37	6.03	22.43	39.84	21.80	4.85	2.24
cl 8	0.62	0.79	0.96	1.47	2.54	6.44	22.59	32.41	21.74	10.45
cl 9	0.14	0.54	0.82	1.77	1.36	3.81	6.81	21.53	27.93	35.29
cl 10	0.11	1.19	0.00	0.87	0.87	0.65	4.22	7.58	15.69	68.83

Table A9
Matrix of income mobility across classes (%) for 2012 - women aged 60+, Estonia.

Estonia - women										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	10.17	38.98	33.90	5.08	5.08	1.69	0.00	0.00	1.69	3.39
cl 2	1.33	41.05	41.49	11.17	2.75	1.15	0.27	0.18	0.27	0.35
cl 3	0.36	7.84	59.16	24.52	5.78	1.56	0.48	0.12	0.02	0.16
cl 4	0.14	1.74	10.17	55.78	26.05	4.83	0.93	0.14	0.09	0.12
cl 5	0.26	0.67	2.50	16.11	51.19	23.31	4.62	1.03	0.21	0.10
cl 6	0.20	0.61	1.76	4.34	19.73	42.82	23.66	4.93	1.15	0.81
cl 7	0.06	0.35	1.29	1.23	5.59	21.88	40.28	22.38	4.39	2.56
cl 8	0.61	0.97	0.97	1.45	2.48	6.55	22.85	33.52	20.85	9.76
cl 9	0.14	0.42	0.71	1.27	1.84	4.39	5.38	22.38	29.75	33.71
cl 10	0.12	1.08	0.48	0.72	0.96	1.08	4.57	7.45	14.66	68.87

Table A10
Matrix of income mobility across classes (%) for 2012 - men aged 60+, Finland.

Finland - men										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	16.15	43.85	24.62	10.00	1.54	1.54	0.77	0.00	1.54	0.00
cl 2	2.74	44.79	38.74	9.26	2.37	1.05	0.26	0.37	0.26	0.16
cl 3	0.20	6.15	56.49	28.90	5.80	1.47	0.55	0.26	0.15	0.04
cl 4	0.22	1.82	10.56	54.23	25.68	5.09	1.25	0.70	0.24	0.20
cl 5	0.07	0.72	2.26	14.37	52.85	22.56	5.08	1.22	0.38	0.50
cl 6	0.00	0.89	1.74	4.44	15.99	46.84	21.65	5.83	1.59	1.03
cl 7	0.12	0.58	1.49	1.76	6.57	17.40	41.55	22.04	5.57	2.92
cl 8	0.00	0.61	0.61	1.60	2.55	5.94	19.64	35.54	23.28	10.25
cl 9	0.00	1.65	0.52	1.19	2.38	3.83	8.17	18.56	31.95	31.75
cl 10	0.28	0.66	1.13	1.84	1.25	1.41	3.28	4.00	9.47	76.68

Table A11
Matrix of income mobility across classes (%) for 2012 - women aged 60+, Finland.

Finland - women										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	24.81	42.11	15.04	15.04	1.50	0.00	0.00	0.00	1.50	0.00
cl 2	2.67	42.45	40.84	9.45	2.62	0.59	0.27	0.53	0.32	0.27
cl 3	0.14	5.21	60.44	26.57	5.51	1.39	0.38	0.20	0.14	0.02
cl 4	0.17	1.80	10.69	55.77	24.94	4.53	1.19	0.44	0.25	0.22
cl 5	0.17	0.74	2.04	14.07	53.26	22.83	4.89	1.13	0.43	0.44
cl 6	0.00	0.84	1.67	4.02	16.06	46.45	22.58	5.87	1.52	0.99
cl 7	0.12	0.61	1.53	1.55	6.07	16.84	42.48	23.07	5.23	2.49
cl 8	0.00	0.51	0.61	1.59	2.54	5.36	21.00	36.70	23.07	8.62
cl 9	0.00	2.59	0.62	1.30	1.41	3.66	8.00	17.13	33.30	32.00
cl 10	0.37	0.71	0.74	1.82	1.31	1.28	3.27	4.04	9.70	76.77

Table A12
Matrix of income mobility across classes (%) for 2012 - men aged 60+, Hungary.

Hungary - men										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	29.48	51.72	12.07	4.66	0.34	1.21	0.00	0.00	0.00	0.52
cl 2	3.10	63.07	28.11	3.82	1.08	0.48	0.08	0.07	0.13	0.04
cl 3	0.37	14.33	57.46	22.81	3.66	0.84	0.27	0.10	0.10	0.06
cl 4	0.19	2.62	21.09	52.41	17.91	4.04	1.05	0.41	0.25	0.04
cl 5	0.12	0.79	7.09	27.51	42.57	15.07	4.30	1.41	0.81	0.33
cl 6	0.10	1.01	3.78	11.04	29.74	33.02	12.08	5.35	2.17	1.71
cl 7	0.00	0.83	2.04	2.55	12.32	33.08	23.31	14.56	6.96	4.34
cl 8	0.00	0.23	1.15	7.60	8.18	16.01	27.88	16.36	12.21	10.37
cl 9	0.00	0.00	1.74	5.65	8.91	7.17	22.39	15.00	18.04	21.09
cl 10	0.48	1.45	3.62	4.11	6.76	3.62	8.70	12.08	18.60	40.58

Table A13
Matrix of income mobility across classes (%) for 2012 - women aged 60+, Hungary.

Hungary - women										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	22.69	54.32	16.54	3.81	1.02	0.29	0.88	0.00	0.00	0.44
cl 2	2.92	61.23	29.60	4.25	1.29	0.43	0.07	0.03	0.13	0.05
cl 3	0.36	13.87	61.18	20.34	3.12	0.72	0.24	0.08	0.05	0.03
cl 4	0.17	2.68	22.10	53.27	16.78	3.48	0.86	0.35	0.22	0.09
cl 5	0.18	0.96	7.59	26.87	43.06	14.74	4.24	1.39	0.71	0.27
cl 6	0.26	1.68	3.50	11.33	30.15	33.06	11.21	5.44	2.06	1.32
cl 7	0.00	0.44	2.61	3.11	12.82	30.18	25.14	16.49	5.35	3.86
cl 8	0.00	0.22	1.09	5.25	9.07	14.43	26.01	17.70	13.66	12.57
cl 9	0.00	0.00	2.34	4.04	7.02	5.96	20.64	19.57	17.23	23.19
cl 10	0.49	0.73	3.17	3.41	5.37	5.12	7.32	13.17	20.24	40.98

Table A14
Matrix of income mobility across classes (%) for 2012 - men aged 60+, Italy.

Italy - men										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	43.13	36.67	12.97	4.72	0.87	0.72	0.28	0.36	0.00	0.28
cl 2	7.54	55.17	27.86	6.25	1.95	0.64	0.28	0.05	0.17	0.08
cl 3	1.92	14.62	57.27	19.26	4.57	1.37	0.45	0.22	0.13	0.18
cl 4	0.65	3.78	16.74	52.28	19.23	4.52	1.66	0.49	0.32	0.33
cl 5	0.43	1.71	6.86	21.01	45.21	16.53	4.48	1.70	0.95	1.12
cl 6	0.30	1.43	4.12	11.02	22.82	36.69	13.83	5.39	1.97	2.44
cl 7	0.12	0.66	3.07	6.72	12.24	20.73	30.90	14.22	5.36	5.97
cl 8	0.25	0.48	1.85	7.10	8.56	12.16	19.13	25.88	12.51	12.07
cl 9	0.16	0.48	2.36	5.05	6.12	12.03	16.00	18.21	16.86	22.72
cl 10	0.28	0.62	0.99	3.06	5.16	7.60	8.28	11.09	12.79	50.12

Table A15
Matrix of income mobility across classes (%) for 2012 - women aged 60+, Italy.

Italy - women										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	43.52	36.41	13.12	3.96	0.93	1.12	0.35	0.35	0.02	0.21
cl 2	7.32	58.61	26.07	5.49	1.55	0.57	0.18	0.07	0.07	0.06
cl 3	1.98	13.92	59.53	18.10	4.27	1.23	0.45	0.20	0.11	0.21
cl 4	0.69	4.17	16.54	53.53	18.49	3.94	1.49	0.55	0.27	0.33
cl 5	0.46	1.80	6.70	20.51	46.20	16.38	4.22	1.65	1.06	1.02
cl 6	0.21	1.26	3.89	10.34	23.66	36.84	14.60	5.08	2.07	2.04
cl 7	0.18	0.52	3.35	7.31	12.13	20.28	31.12	13.38	5.58	6.15
cl 8	0.27	0.37	2.24	6.01	11.03	12.11	18.80	24.26	13.61	11.30
cl 9	0.23	0.35	2.71	6.00	5.66	12.12	15.65	17.90	16.92	22.46
cl 10	0.23	1.01	1.17	3.62	5.15	7.10	7.82	10.00	11.96	51.94

Table A16
Matrix of income mobility across classes (%) for 2012 - men aged 60+, Norway.

Norway - men										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	5.13	24.36	6.41	21.79	16.67	6.41	16.67	0.00	0.00	2.56
cl 2	0.65	23.91	30.22	17.17	6.96	8.70	3.48	6.09	1.52	1.30
cl 3	1.05	6.87	37.19	29.99	14.39	4.37	2.91	1.46	0.40	1.37
cl 4	0.03	1.19	7.62	42.38	34.95	8.39	3.20	1.35	0.58	0.32
cl 5	0.06	0.62	1.46	7.69	46.43	33.76	7.04	1.84	0.38	0.73
cl 6	0.02	0.91	1.14	1.65	12.51	44.40	30.03	6.70	1.70	0.94
cl 7	0.08	0.94	0.37	0.91	3.20	16.28	37.91	29.73	7.40	3.17
cl 8	0.17	0.34	0.23	0.66	1.32	4.01	17.40	36.22	28.24	11.41
cl 9	0.00	0.20	0.10	0.33	0.26	3.53	6.41	17.27	32.77	39.14
cl 10	0.02	0.80	0.35	0.40	0.47	1.84	2.77	6.45	11.41	75.50

Table A17
Matrix of income mobility across classes (%) for 2012 - women aged 60+, Norway.

Norway - women										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	0.00	22.22	9.26	22.22	14.81	5.56	18.52	0.00	3.70	3.70
cl 2	2.70	23.65	36.93	12.66	7.26	5.19	1.66	3.73	3.53	2.70
cl 3	0.33	4.60	38.90	32.00	11.30	6.57	3.29	1.84	0.20	0.99
cl 4	0.00	0.79	6.92	46.21	34.04	7.36	2.82	1.37	0.33	0.16
cl 5	0.15	0.76	1.67	6.85	47.36	33.15	7.20	1.66	0.39	0.80
cl 6	0.00	0.70	0.98	1.48	12.05	44.86	30.31	6.56	1.80	1.28
cl 7	0.03	0.59	0.44	0.93	3.48	15.21	39.77	29.20	6.84	3.51
cl 8	0.24	0.66	0.34	0.76	1.39	3.54	17.19	36.08	27.76	12.04
cl 9	0.00	0.10	0.50	0.50	0.37	2.76	6.18	17.74	34.04	37.80
cl 10	0.00	0.93	0.62	0.74	0.26	1.55	2.39	5.80	11.83	75.88

Table A18
Matrix of income mobility across classes (%) for 2012 - men aged 60+, Poland.

Poland - men										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	18.65	40.09	18.07	14.22	2.91	3.50	0.23	1.28	0.47	0.58
cl 2	3.96	39.93	34.64	10.94	4.75	2.31	1.90	0.88	0.25	0.44
cl 3	0.73	10.97	40.55	30.54	10.24	3.83	1.56	0.78	0.22	0.58
cl 4	0.32	3.11	17.02	37.83	26.51	9.50	2.73	1.61	0.54	0.84
cl 5	0.04	1.33	4.90	19.10	32.67	25.19	9.58	3.75	1.49	1.96
cl 6	0.13	0.93	2.36	7.01	20.53	28.36	22.83	8.92	4.44	4.49
cl 7	0.11	0.40	2.14	4.58	9.81	21.03	24.56	18.34	9.71	9.32
cl 8	0.07	0.36	1.60	2.33	5.97	9.96	20.18	20.44	18.12	20.97
cl 9	0.07	0.43	1.21	2.07	4.68	6.15	11.53	19.57	20.31	33.97
cl 10	0.09	0.37	0.79	2.00	2.66	3.26	6.06	9.36	9.91	65.51

Table A19
Matrix of income mobility across classes (%) for 2012 - women aged 60+, Poland.

Poland - women										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	15.09	39.65	21.45	13.84	3.99	2.49	0.25	1.50	1.25	0.50
cl 2	3.20	39.35	35.47	11.32	4.82	2.28	1.57	1.03	0.33	0.62
cl 3	0.74	9.70	42.50	30.87	10.29	2.99	1.49	0.61	0.26	0.56
cl 4	0.34	2.77	16.69	39.54	26.53	8.93	2.58	1.29	0.59	0.74
cl 5	0.07	1.27	4.73	19.31	34.12	25.10	8.52	3.60	1.46	1.82
cl 6	0.17	0.75	2.23	6.32	21.82	28.60	23.23	8.72	4.15	4.01
cl 7	0.15	0.38	2.32	4.66	9.82	20.70	25.87	18.55	9.25	8.30
cl 8	0.02	0.37	1.57	2.44	6.51	9.88	19.40	21.18	18.20	20.43
cl 9	0.05	0.29	0.94	2.29	4.61	7.56	11.47	19.11	19.81	33.86
cl 10	0.03	0.26	0.93	1.91	2.94	3.58	5.92	9.58	9.71	65.13

Table A20
Matrix of income mobility across classes (%) for 2012 - men aged 60+, Portugal.

Portugal - men										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	58.72	35.89	3.50	1.24	0.38	0.05	0.13	0.08	0.00	0.00
cl 2	8.64	72.21	16.63	1.98	0.31	0.10	0.03	0.07	0.02	0.02
cl 3	1.53	20.48	62.48	12.84	1.62	0.43	0.34	0.09	0.12	0.06
cl 4	0.57	4.85	25.89	52.46	12.83	2.30	0.45	0.50	0.09	0.07
cl 5	0.21	2.29	5.52	25.78	45.63	15.94	2.86	1.25	0.16	0.36
cl 6	0.40	1.88	4.55	8.31	24.43	37.19	16.12	4.85	0.59	1.68
cl 7	0.30	0.91	2.57	4.54	10.29	23.60	33.74	15.89	5.75	2.42
cl 8	0.81	0.54	3.25	3.25	4.34	9.21	22.76	31.71	16.26	7.86
cl 9	0.00	3.41	1.46	0.98	8.29	6.83	6.83	20.00	31.71	20.49
cl 10	0.00	1.14	1.70	1.42	3.69	5.97	6.53	5.97	15.34	58.24

Table A21
Matrix of income mobility across classes (%) for 2012 - women aged 60+, Portugal.

Portugal - women										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	57.52	37.14	3.63	1.35	0.27	0.05	0.05	0.00	0.00	0.00
cl 2	7.68	74.55	15.52	1.73	0.28	0.05	0.06	0.07	0.03	0.03
cl 3	1.40	20.33	63.92	12.14	1.28	0.44	0.20	0.08	0.12	0.10
cl 4	0.53	5.11	23.47	53.77	13.25	2.73	0.36	0.49	0.22	0.07
cl 5	0.20	2.66	6.35	25.84	45.19	15.10	3.02	0.92	0.10	0.61
cl 6	0.27	3.03	2.85	6.32	23.60	36.95	20.21	4.72	1.16	0.89
cl 7	1.13	0.85	1.83	3.52	8.17	27.04	32.82	17.04	4.93	2.68
cl 8	1.37	1.59	2.73	2.73	4.78	8.88	20.73	35.31	13.90	7.97
cl 9	0.00	2.14	3.42	0.85	11.54	5.56	6.41	17.95	32.05	20.09
cl 10	0.00	1.59	1.85	0.79	2.12	4.76	4.50	10.58	14.02	59.79

Table A22
Matrix of income mobility across classes (%) for 2012 - men aged 60+, Romania.

Romania - men										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	72.54	23.65	2.87	0.48	0.30	0.05	0.05	0.05	0.00	0.00
cl 2	7.72	75.26	14.85	1.24	0.58	0.27	0.05	0.01	0.03	0.00
cl 3	1.04	15.61	69.99	11.60	1.11	0.41	0.13	0.05	0.07	0.00
cl 4	0.15	3.24	23.60	61.34	9.48	1.52	0.29	0.25	0.13	0.00
cl 5	0.07	1.52	5.26	29.49	51.25	9.59	1.76	0.46	0.28	0.32
cl 6	0.22	0.89	2.88	11.59	32.25	39.93	8.27	2.51	0.66	0.81
cl 7	0.31	1.23	2.45	3.06	13.94	29.86	41.81	5.51	1.38	0.46
cl 8	0.00	3.11	4.15	4.50	8.30	13.84	38.75	15.22	10.03	2.08
cl 9	0.00	1.43	7.86	0.00	7.86	10.00	30.00	21.43	17.86	3.57
cl 10	0.00	0.00	0.00	0.00	4.29	25.71	18.57	18.57	14.29	18.57

Table A23
Matrix of income mobility across classes (%) for 2012 - women aged 60+, Romania.

Romania - women										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	71.28	25.77	2.22	0.35	0.24	0.06	0.05	0.03	0.00	0.00
cl 2	7.61	76.91	13.82	0.98	0.44	0.18	0.03	0.02	0.02	0.00
cl 3	0.74	16.33	69.62	11.52	1.23	0.43	0.05	0.04	0.03	0.00
cl 4	0.20	3.06	24.57	59.66	10.21	1.61	0.25	0.31	0.13	0.00
cl 5	0.07	1.58	4.86	30.68	49.68	10.29	1.73	0.61	0.40	0.11
cl 6	0.00	0.82	2.52	11.42	35.68	37.76	7.64	2.97	0.37	0.82
cl 7	0.47	1.10	2.84	2.68	12.30	33.44	40.22	4.89	1.58	0.47
cl 8	0.00	2.31	2.97	2.31	9.57	15.18	37.29	16.50	12.54	1.32
cl 9	0.00	5.74	4.92	0.00	9.02	7.38	27.87	23.77	13.93	7.38
cl 10	0.00	0.00	0.00	1.39	2.78	23.61	13.89	27.78	12.50	18.06

Table A24
Matrix of income mobility across classes (%) for 2012 - men aged 60+, Sweden.

Sweden - men										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	8.08	30.30	32.32	17.17	3.03	3.03	2.02	1.01	0.00	3.03
cl 2	4.23	41.01	30.51	9.03	7.73	3.42	0.57	1.38	0.57	1.55
cl 3	1.17	15.74	35.07	27.41	10.22	4.63	2.88	0.89	0.61	1.39
cl 4	0.94	2.96	12.33	38.96	27.52	8.68	3.48	2.68	1.09	1.37
cl 5	0.07	1.45	4.90	15.42	40.11	22.47	7.98	3.11	1.84	2.65
cl 6	0.00	0.64	3.09	9.36	19.18	32.81	18.09	8.30	3.71	4.82
cl 7	0.05	0.41	1.60	3.93	10.84	19.51	30.62	17.08	6.81	9.14
cl 8	0.19	0.44	0.90	2.96	5.30	10.48	19.27	25.10	15.34	20.02
cl 9	0.20	0.00	0.93	1.67	4.55	6.17	13.76	19.29	22.53	30.90
cl 10	0.03	0.11	0.82	1.24	3.17	4.84	5.82	8.03	10.50	65.43

Table A25
Matrix of income mobility across classes (%) for 2012 - women aged 60+, Sweden.

Sweden - women										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	5.52	38.67	23.20	24.86	3.87	1.66	1.10	0.00	0.00	1.10
cl 2	3.31	37.83	32.42	11.24	6.71	2.59	2.43	1.21	0.40	1.86
cl 3	1.21	12.29	36.15	33.23	9.48	3.44	2.03	0.60	0.36	1.21
cl 4	1.00	2.35	10.26	48.79	23.89	7.44	2.63	2.02	0.78	0.84
cl 5	0.03	1.69	4.60	15.70	41.51	21.69	7.14	2.94	1.67	3.03
cl 6	0.00	0.63	2.56	8.08	18.37	36.10	18.11	8.69	3.43	4.02
cl 7	0.07	0.53	1.54	4.13	10.26	18.38	30.06	19.37	6.58	9.08
cl 8	0.18	0.39	1.30	3.36	6.21	10.63	19.69	24.14	16.00	18.09
cl 9	0.00	0.13	0.62	1.91	3.83	7.79	12.82	17.99	22.44	32.46
cl 10	0.05	0.18	0.99	1.11	3.14	4.14	4.83	8.00	10.76	66.82

Figs. A2–A14

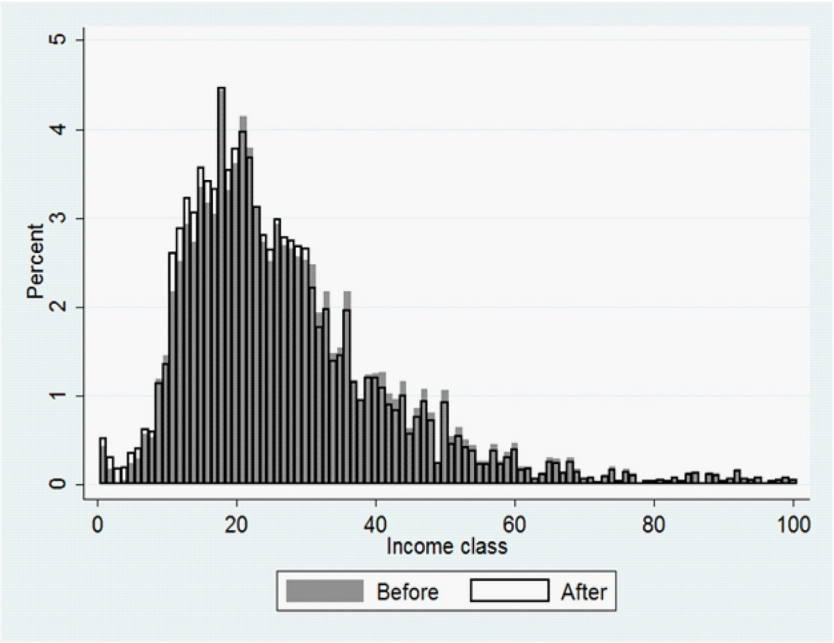

Fig. A2. Income distribution (density), before and after correction, Bulgaria, population aged 60+, 2012 (income classes are increasing by 100 euros until class 100).

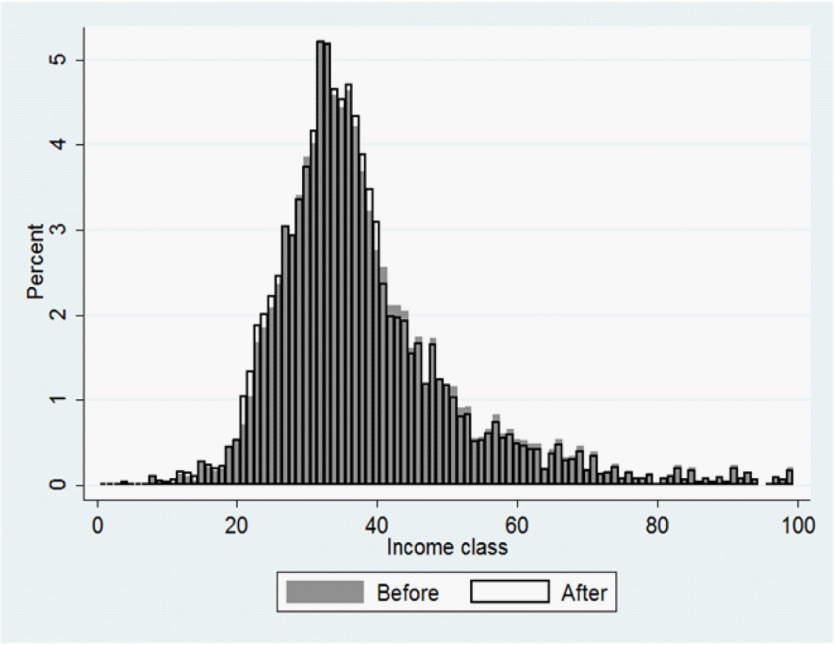

Fig. A3. Income distribution (density), before and after correction, Czech Rep., population aged 60+, 2012 (income classes are increasing by 200 euros until class 100).

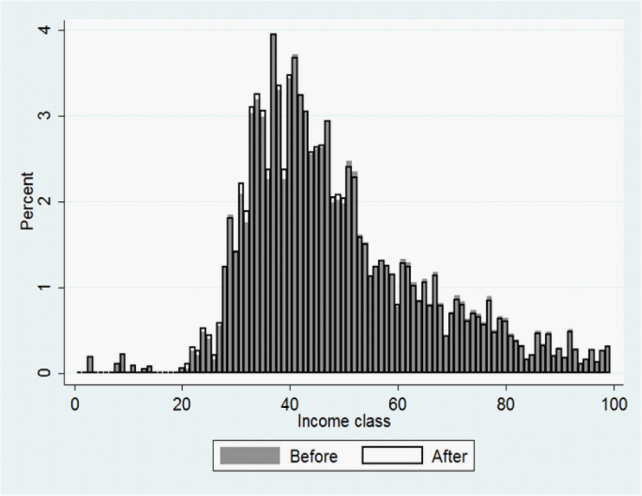

Fig. A4. Income distribution (density), before and after correction, Denmark, population aged 60 + , 2012 (income classes are increasing by 500 euros until class 100).

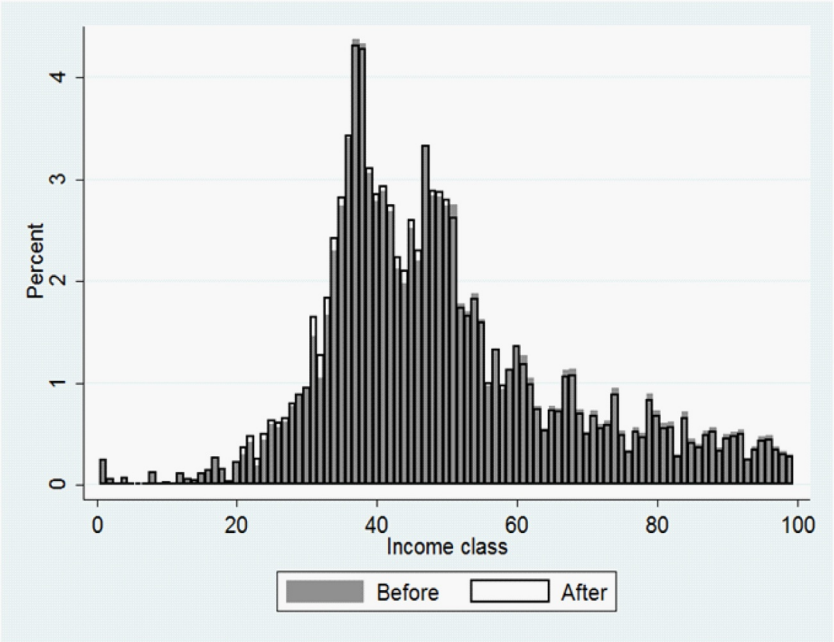

Fig. A5. Income distribution (density), before and after correction, Estonia, population aged 60 + , 2012 (income classes are increasing by 100 euros until class 100).

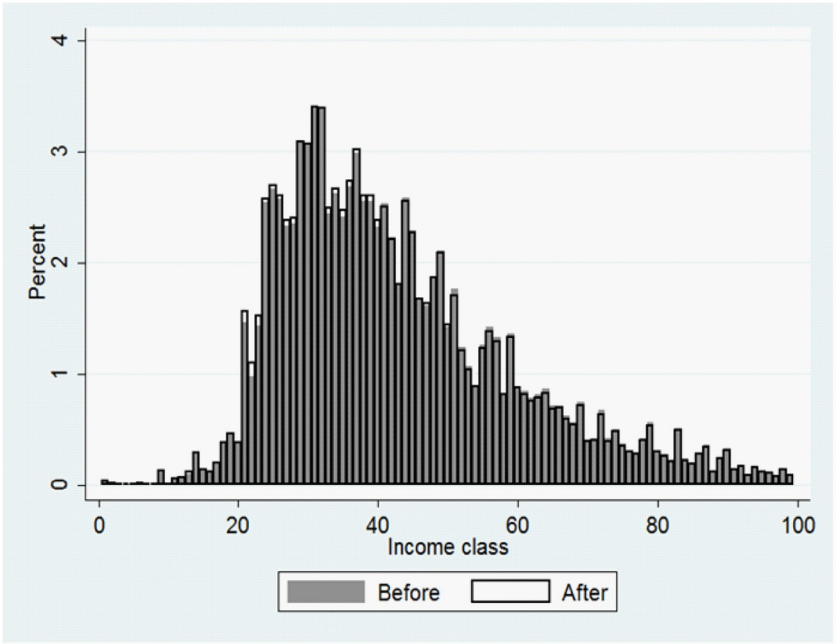

Fig. A6. Income distribution (density), before and after correction, Finland, population aged 60 + , 2012 (income classes are increasing by 500 euros until class 100).

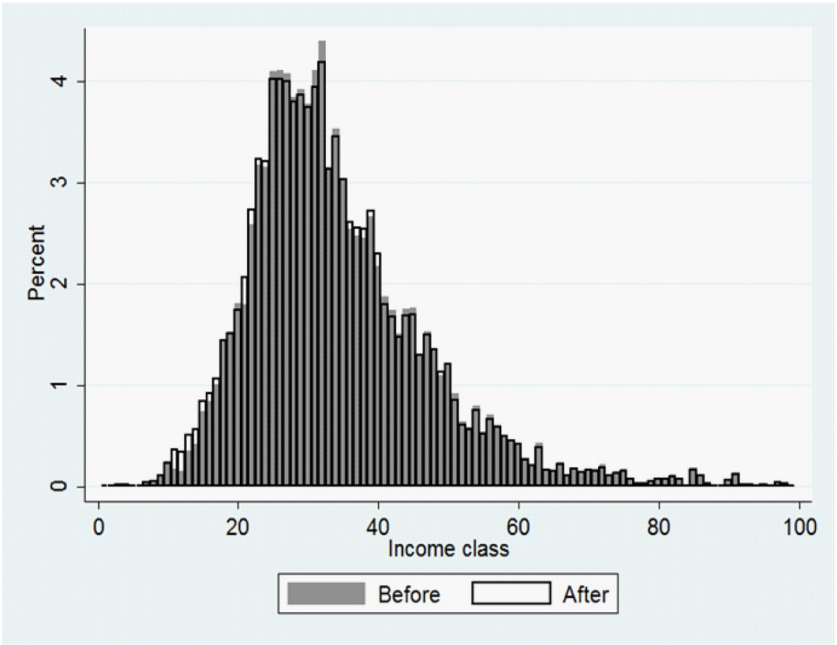

Fig. A7. Income distribution (density), before and after correction, Hungary, population aged 60 + , 2012 (income classes are increasing by 150 euros until class 100).

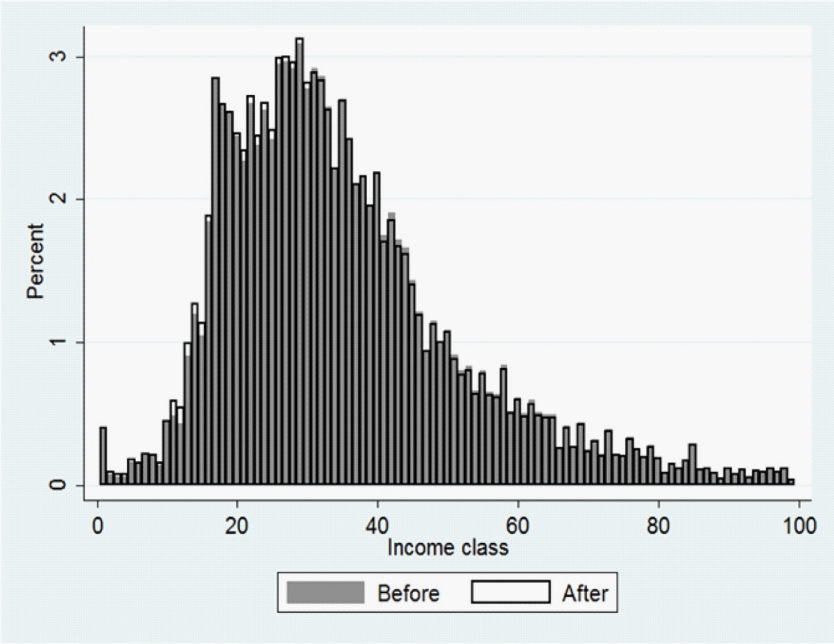

Fig. A8. Income distribution (density), before and after correction, Italy, population aged 60+, 2012 (income classes are increasing by 500 euros until class 100).

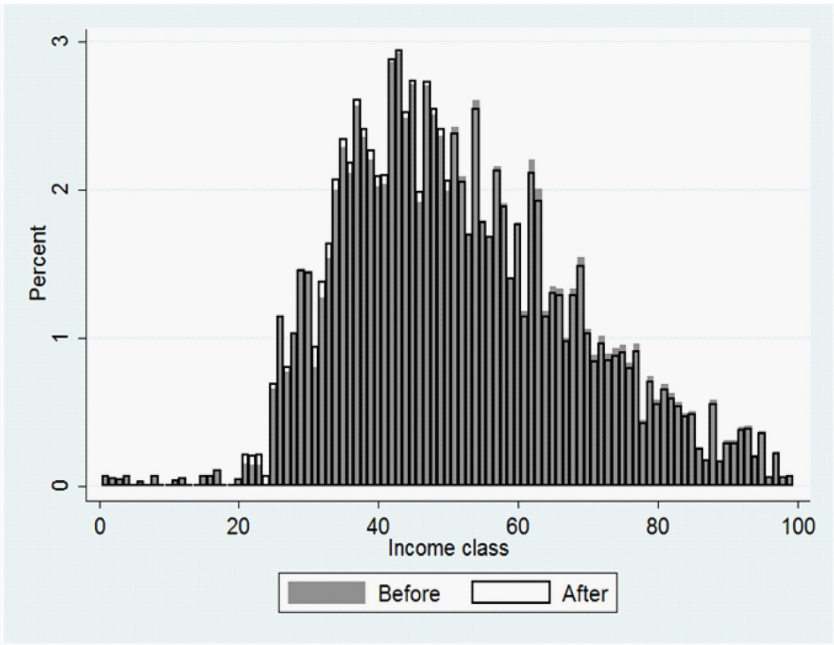

Fig. A9. Income distribution (density), before and after correction, Norway, population aged 60+, 2012 (income classes are increasing by 800 euros until class 100).

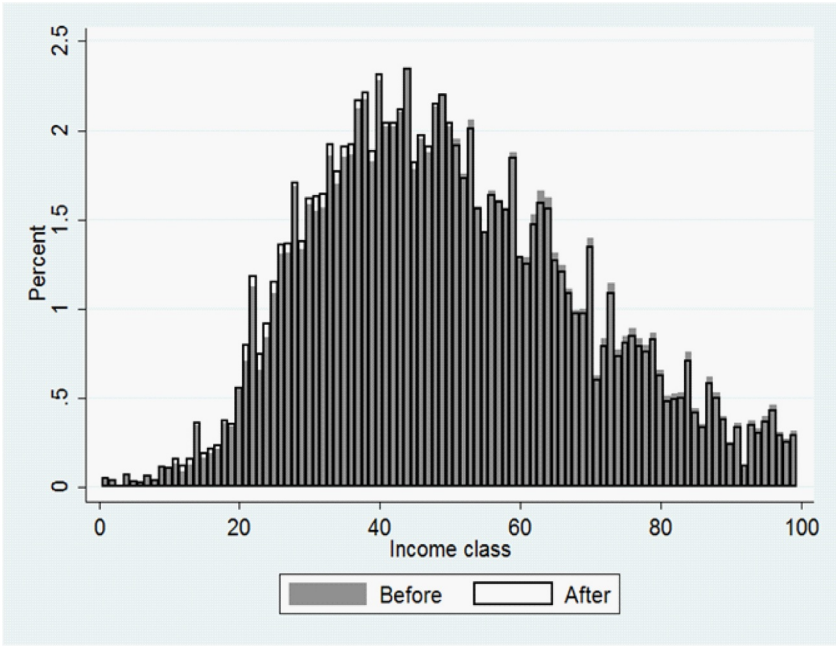

Fig. A10. Income distribution (density), before and after correction, Poland, population aged 60+, 2012 (income classes are increasing by 100 euros until class 100).

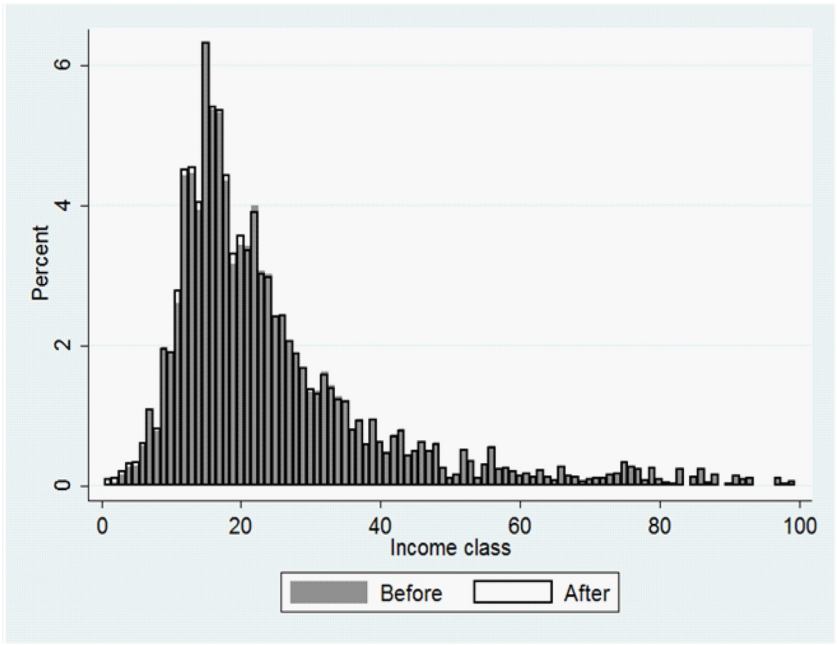

Fig. A11. Income distribution (density), before and after correction, Portugal, population aged 60+, 2012 (income classes are increasing by 400 euros until class 100).

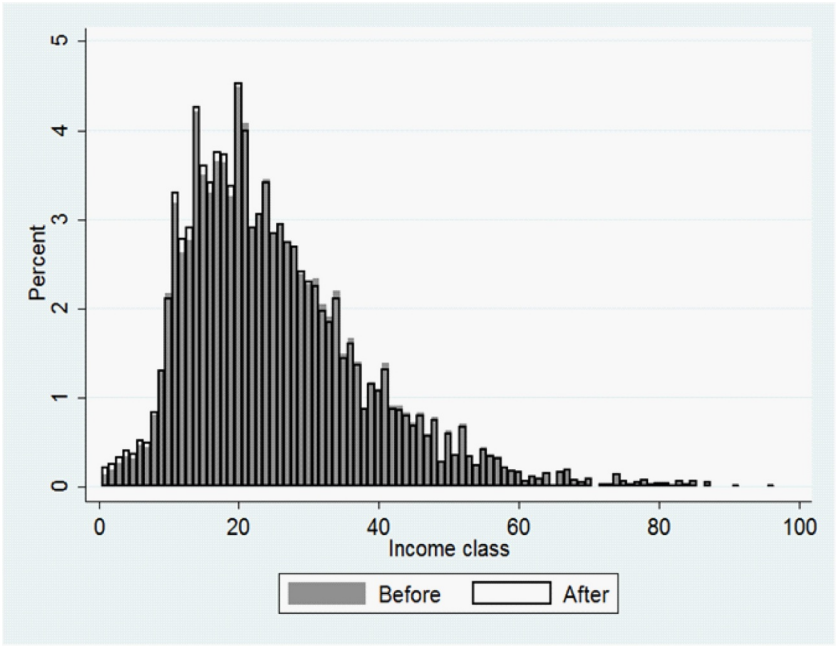

Fig. A12. Income distribution (density), before and after correction, Romania, population aged 60 + , 2012 (income classes are increasing by 100 euros until class 100).

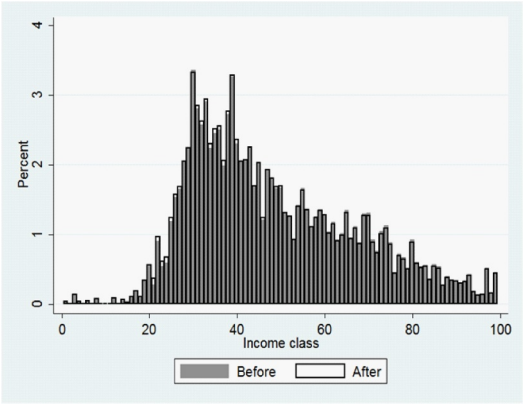

Fig. A13. Income distribution (density), before and after correction, Sweden, population aged 60 + , 2012 (income classes are increasing by 500 euros until class 100).

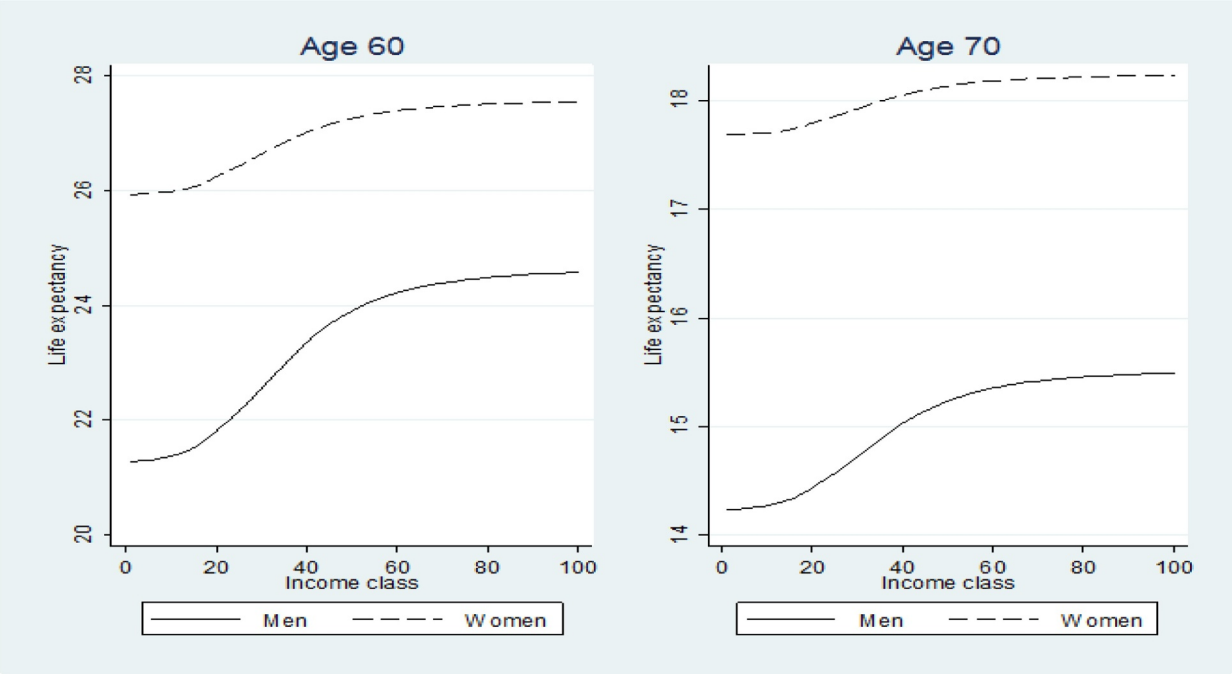

Fig. A14. Life expectancy by income class, Italy, 2012.

A3. Poverty thresholds

In Sections 3 to 5, we use relative poverty thresholds, fixed at 60% of the median income in the country under study. Given that our correction for selection biases amounts to add some "missing persons" in the population, one can, as discussed in Section 5, derive a relative poverty threshold before or after the adjustment. Section 6 relies, on the contrary, on absolute poverty lines equal to 10 euros a day in PPP. All these poverty lines are presented in Table A26.

Table A26
Poverty lines.

	Poverty threshold (euros)			
	Relative poverty line			Absolute poverty line
	before adjustement	after adjustment (income mobility)	after adjustement (no income mobility)	(10 euros a day in PPP)
Bulgaria	1730	1693	1676	1712
Czech Rep.	4708	4673	4650	2570
Denmark	15946	15883	15851	4935
Estonia	3555	3501	3487	2533
Finland	13663	13601	13574	4406
Hungary	2884	2876	2866	2121
Italy	9825	9796	9768	3643
Norway	24389	24331	24319	5833
Poland	3093	3079	3068	2091
Portugal	5053	5050	5050	2851
Romania	1316	1301	1305	1697
Sweden	14988	14953	14969	4829

A4. Distributions in density

A5. Robustness to the age-partition

Table A27
Income mobility matrix for 2012 - men aged 70+, Italy.

Italy - men										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	55,02	33,73	7,63	1,20	0,80	0,00	1,61	0,00	0,00	0,00
cl 2	1,78	68,83	25,14	3,10	0,76	0,13	0,07	0,00	0,10	0,10
cl 3	0,81	9,35	72,46	14,09	2,27	0,67	0,15	0,09	0,03	0,07
cl 4	0,24	2,57	12,55	67,89	13,25	1,95	0,94	0,14	0,35	0,12
cl 5	0,39	1,34	6,04	17,75	53,80	14,38	3,32	1,47	0,69	0,82
cl 6	0,25	1,35	3,12	10,21	18,06	42,45	16,54	4,64	1,60	1,77
cl 7	0,14	1,26	2,53	6,60	7,87	15,59	40,45	16,15	5,06	4,35
cl 8	0,00	0,00	1,63	10,30	4,07	10,84	21,14	30,08	13,28	8,67
cl 9	0,00	0,00	3,59	3,59	3,59	7,18	16,41	23,59	17,95	24,10
cl 10	0,50	0,50	1,24	4,70	3,22	5,69	5,20	8,17	11,39	59,41

Table A28
Income mobility matrix for 2012 - women aged 70+, Italy.

Italy - women										
	cl 1	cl 2	cl 3	cl 4	cl 5	cl 6	cl 7	cl 8	cl 9	cl 10
cl 1	39,84	37,13	16,53	3,79	0,00	1,36	0,54	0,81	0,00	0,00
cl 2	1,50	72,88	20,93	3,38	0,69	0,24	0,19	0,02	0,06	0,11
cl 3	0,78	8,66	73,22	13,91	2,26	0,82	0,09	0,13	0,03	0,09
cl 4	0,33	3,47	12,53	66,74	13,07	2,15	0,97	0,33	0,12	0,29
cl 5	0,18	1,12	5,82	14,93	59,00	13,23	3,07	1,41	0,83	0,40
cl 6	0,00	1,38	4,21	10,04	19,43	43,40	14,82	3,56	1,70	1,46
cl 7	0,27	1,10	1,79	7,28	11,95	15,25	40,52	15,38	4,26	2,20
cl 8	0,00	1,06	1,06	8,71	9,23	10,55	16,09	29,82	14,78	8,71
cl 9	0,00	0,00	4,42	6,63	3,31	5,52	8,29	26,52	13,26	32,04
cl 10	0,54	1,90	2,72	6,79	3,26	6,25	4,89	9,24	12,77	51,63

Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jce.2018.12.002.

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