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Aristondo, Oihana; d'Ambrosio, Conchita; Lasso de la Vega, Casilda

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Decomposing the changes in poverty: Poverty line and distributional effects

Oihana Aristondo[1] | **Conchita D'Ambrosio**[2] | **Casilda Lasso de la Vega**[3]

[1]Department of Applied Mathematics, University of the Basque Country, Eibar, Gipuzkoa, Spain

[2]Department of Behavioural and Cognitive Sciences, University of Luxembourg, Esch-sur-Alzett, Luxembourg

[3]Department of Quantitative Methods, University of the Basque Country, Bilbao, Vizcaya, Spain

Correspondence
Oihana Aristondo, University of the Basque Country.
Email: oihana.aristondo@ehu.es

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Abstract

When measuring poverty in developed countries, the poverty line used to identify the poor is usually relative and set as a percentage of the median (or of the mean) of the total income. In consequence, when poverty is analyzed over a period of time, changes in the poverty level depend on the impact of evolving standards. To eliminate this effect, sometimes, an anchored poverty line is used. Furthermore, changes in the mean of the distribution and in the inequality among the poor may also affect the poverty levels. This note proposes a decomposition of the changes in poverty as the sum of four terms. The first two reflect the impact in poverty of changes in living standards and the other two measure the effect of the distributional growth and redistribution. This decomposition will help policymakers in the implementation of a more specific antipoverty agenda. An application with data from the European Union Survey on Income and Living Conditions shows the potential of the decomposition proposed.

KEYWORDS
changes in poverty, growth-equity decomposition, identification of the poor, relative poverty lines, shapley decomposition

1 | INTRODUCTION

Poverty is still a social and economic concern, and plenty of information is made regularly available to assess its level and evolution. However, it is not always clear what forces are driving changes in poverty. This note aims to identify the contribution of some components to the evolution of poverty over time in developed countries. This is an important issue that may help policymakers to better understand how different policies affect the conditions of the poor.

Since Sen (1976)'s seminal paper, the measurement of poverty follows a two-stage procedure. First, the poor people are identified through a poverty line, and then their income is aggregated into an indicator. The poverty line should represent *the estimated level of income needed to secure the necessities of life*, but there is no normative procedure for establishing this income threshold. In developed countries, as poverty status is related to living standards embedding an evaluation of social inclusion, the poverty measurement uses *relative* poverty lines, which are defined as a percentage of the median (or mean) income level of the whole population. When poverty is analyzed over a period of time using relative lines, the evolution of poverty depends not only on changes in the conditions of the poor people but also on any changes in the median income that imply changes in the poverty line. To better capture only the changes in the poor people's situation, it is common to define the initial poverty line as a percentage of the median income and then to adjust the line over time according to prices, giving an *anchored relative* poverty line.[1] The drawback of this methodology is that, since the poverty line remains constant, in real terms, over time, the poverty assessment no longer captures social exclusion. As a result, for each year in a given period, researchers may choose between two poverty lines, the relative and the anchored, which are likely to be different and, as such, will yield different results.

The goal of this note is to propose a simple procedure to quantify the impact of different components on the dynamic changes in poverty when relative poverty lines are used. In the literature, there are two main frameworks to decompose (dynamic) changes in poverty. On the one hand, there is the Shapley-type decomposition as discussed by Shorrocks (2013), which considers the marginal effect on poverty of eliminating each of the contributory factors in sequence, and then assigns to each factor the average of its marginal contributions in all possible elimination sequences. More recently, the *integral-based approach* developed by Müller (2006) is playing an increasing role in order to decompose the dynamic changes of a given index into its underlying components. This approach relies on integral approximation and is founded on the (second) fundamental theorem of calculus. The procedure is as follows. First, the relevant components are selected. Second, the difference of the value of the index between two periods of time is calculated as the definite integral between these periods of the derivative of the index with respect to

[1] This is, for instance, the approach followed by the OECD. To analyze the evolution of poverty in a given period, Förster and d'Ercole (2012) propose using a relative poverty line set at 50% of the median income in each country, and also an anchored poverty threshold that is set at 50% of the median income observed in a given reference year in the past. This threshold is inflation-adjusted each year so as to remain constant, in real terms, over time. The authors observe that the evolution of poverty in some countries differs a lot depending on whether the relative or the anchored line is used.

the time. Third, the derivative of the index with respect to the time is calculated using the partial derivatives of the index with respect to the chosen components. Finally, the integral of each of the partial derivatives will give the contribution of the respective component to the changes in the index. Müller (2006) and Bresson (2008) have applications of this approach when the poverty lines are fixed in the period, Okamoto (2011) applies it to the inequality field, and Fujii (2017) also bases on this method to propose a decomposition of the changes in poverty when absolute poverty lines are used. The main difficulty in the implementation of the integral-based method is the need for information in continuous time, which forces the assumption of linear approximations. Interestingly, as shown by Müller (2006), the Shapley-type decomposition is a consistent approach to approximate the underlying integrals when only two components are at stake.

In this context, this note proposes a two-stage hierarchical procedure to decompose the dynamic changes in poverty when relative poverty lines are used. In the first stage, we propose a decomposition of changes into two primary components. The first primary component analyzes the impact derived from changes in the underlying living standard through the differences between the relative and the anchored poverty lines, assuming that the relative incomes of the poor people do not change.[2] Thus, if the relative line at the end of the period is higher than the anchored one, this means that the living standard has increased, and provided that other things remain the same among the poor people, the poverty line's contribution to the change in poverty will be positive. The second primary component captures the direct impact of the change in the relative distribution of the poor people, assuming fixed poverty lines. We will refer to these two components as *poverty line* effect and *distributional* effect, respectively.

In a second stage, we further disentangle each of these two terms. On the one hand, the impact on poverty of changes in the poverty lines has two sources: the first one is due to the changes in the set of the poor people, which we will refer to as *new-poor effect*, and the other component measures the changes of poverty within the poor because of the changes in the distances of the poor people from the poverty line, which we will refer to as *old-poor effect*. On the other hand, with respect to the impact of changes in the distribution, it is important to understand to what extent economic *growth* linked to the mean income of the whole distribution, and/or *redistribution* affect poor people's conditions and may lead to poverty changes. The relationship between poverty, growth, and inequality has already attracted a lot of attention. Following the integral approach under linear assumptions as in the previous stage, the resulting decomposition coincides with the decomposition already proposed by Shorrocks (2013) and Kakwani (2000), that is, the *growth component* captures the impact of the changes in the mean income, assuming that inequality of the distribution does not change; and the *redistribution term* measures the effect of the variations in the Lorenz curves of the distributions, assuming that the mean incomes remain unchanged.

Finally, we illustrate the proposed decomposition analyzing changes in poverty between 2007 and 2016 in six European countries, Cyprus, Iceland, Italy, Portugal, Slovakia and United Kingdom, using the European Union Survey on Income and Living Conditions (EU-SILC) dataset. These countries have been chosen because they best illustrate the contributions of the proposed components to the decomposition of poverty in the period of study. We find that the poverty level has increased in Slovakia and in Portugal and that the poverty line effect is positive in these two countries, meaning that the standard of living has increased. Slovakia is the only selected country in which the (inflation-adjusted) income mean has increased in the period. Although poverty has increased, the growth contribution is negative and highly dominates the redistribution term,

[2] *Relative income distribution* refers to the income distribution divided by the mean income.

leading to a reduction in the distributional effect and to an improvement in the conditions of the poor people. Thus, we may conclude that economic growth has been pro-poor and that the increment in poverty in Slovakia is only due to an increase in social exclusion. In this case, activities promoting social inclusion will provide poor people with opportunities to overcome exclusion. By contrast, the redistribution component is the main source in the increase in poverty in Italy, meaning that the change in the distribution has benefited the rich more than the poor. Consequently, redistribution policies could lead to an improvement in the poor's lives. We also find that the high decrement in the standard of living in the United Kingdom is the main source of its decrease in poverty. Iceland shows no significant changes in the poverty level. However, we find that although the standard of living has abruptly decreased, the distributional component is positive. Hence, social inclusion has improved although the conditions of the poor people have worsened. The governments in these two countries should provide financial support, improve public services, and create new job opportunities to help poor households.

The rest of the paper is organized as follows. The next section introduces the notation and reviews some poverty indices and existing poverty decompositions. Section 3 introduces our proposal, and finally, the mentioned empirical application illustrates the decomposition proposed.

2 | POVERTY INDICES AND POVERTY DECOMPOSITIONS

2.1 | Poverty indices

We assume that income x is a random nonnegative variable with density function $f(x)$. We denote by $\mu = \mu(x)$ the mean income, that is, $\mu(x) = \int_0^\infty x f(x) dx$. For a given poverty line $z > 0$, the poverty value of distribution f is given by a poverty measure $P(f(x), z)$.[3] A decomposable poverty measure is given by[4]

$$P(f, z) = \int_0^z p(x, z) f(x) dx$$

where $p(x, z)$ is a homogenous function of degree zero, decreasing in x (monotonicity axiom), convex in x (transfer axiom), and increasing in z. This function satisfies that $p(x, z) > 0$ if $x < z$ and $p(x, z) = 0$ if $x \geq z$ (focus axiom), and represents the individual-level poverty measure.

Some of the most popular decomposable measures are the $FGT-$ indices proposed by Foster et al. (1984) given by

$$FGT^{\alpha}(f(x), z) = \int_0^z \left(1 - \frac{x}{z}\right)^{\alpha} f(x) dx, \ \alpha \geq 0. \tag{1}$$

Note that FGT_0 corresponds to the *headcount ratio*, which takes into account only the incidence of poverty and FGT_1 is the *poverty gap ratio*, which considers the incidence and the intensity of poverty.

[3] See Zheng (1997) for a survey on poverty indices.

[4] For ease of exposition, we focus on decomposable indices, although the decomposition obtained can be easily extended to any poverty measure.

We will also use in the paper the Watts index (Watts, 1968). In addition to being the first decomposable poverty index introduced in the literature, it is also continuous, relative, and satisfies all the dominance and sensitivity axioms.[5] The Watts index is given by

$$W(f(x), z) = \int_0^z ln(z/x) f(x) dx. \tag{2}$$

This index takes into account the incidence, the intensity, and the inequality among the poor.

As long as the population is split into groups, all the decomposable indices satisfy that total poverty is the population-weighted average of poverty within each group.

2.2 | Poverty decompositions

The aim of a poverty (dynamic) decomposition is to analyze the contributions of different components to the changes in poverty over time. Since time is included in the analysis, we denote by x_t and $z_t = z(x_t)$, respectively, the income function and the poverty line in time t. The density function $f(x_t)$ is completely determined by the Lorenz curve of the income distribution x_t and by its mean, which will be denoted by $L(x_t)$ and by $\mu_t = \mu(x_t)$, respectively. Then, as needed, we will alternatively consider $P(f(x_t), z_t) = P(L(x_t), \mu_t, z_t)$. We get

$$P(f(x_t), z_t) = \int_0^{z_t} p(x_t, z_t) f(x_t) dx_t. \tag{3}$$

Given two time points: the initial point, $t = 0$, and the final one, $t = 1$, will be denoted, as needed, by t_0 and t_1, respectively. The change in poverty between t_0 and t_1 will be denoted by $\Delta P_{01} = P(f(x_1), z_1) - P(f(x_0), z_0)$. Let C be the set of components of interest. And let ΔP_{01}^c be the contribution of component $c \in C$ to the change in poverty. We will refer to a poverty decomposition in terms of C if we get that $\Delta P_{01} = \sum_{c \in C} \Delta P_{01}^c$. A poverty decomposition is *time-reversion consistent* if $\Delta P_{01}^c = -\Delta P_{10}^c$ for all $c \in C$. This property requires that the change in each component from t_0 to t_1 is the same but with the opposite sign to the change from t_1 to t_0. Thus, all the components' effects must be symmetric with respect to the initial and the final periods. If there are several periods of time, $t_0, t_1, \ldots, t_k$, we will say that the decomposition is *transitive in time* if for each component $c \in C$, the contribution of component c in the whole period is the sum of the contributions in each of the subperiods, that is, $\Delta P_{0k}^c = \sum_{i=0}^{k-1} \Delta P_{i(i+1)}^c$.

2.3 | Existing poverty decompositions

A number of poverty decompositions in terms of growth and redistribution have been proposed in the literature. The decomposition proposed by Datt and Ravallion (1992) is one of the most used. They propose a decomposition into a growth and a redistribution component with a residual term that aims to capture, according to Datt and Ravallion (1992), the interrelation between

[5] Moreover, Zheng (1993) points out that Watts can be interpreted as the per capita absolute social welfare loss due to poverty when the utility function is $u(x) = \ln x$ and shows that, under some assumptions, Watts is the only poverty index within this approach.

growth and redistribution. It uses the initial time point as the reference point and applies to measures of absolute poverty in which the poverty line is kept fixed in real terms. Datt and Ravallion's decomposition is as follows:

$$\begin{aligned}\Delta P_{01} &= P(f(x_1), z) - P(f(x_0), z)\\ &= \underbrace{P(L(x_0), \mu_1, z) - P(L(x_0), \mu_0, z)}_{\text{growth effect}} + \underbrace{P(L(x_1), \mu_0, z) - P(L(x_0), \mu_0, z)}_{\text{redistribution effect}} + \text{residual.}\end{aligned}$$

The growth-effect component captures the changes in poverty assuming that only the mean changes from the beginning to the end of the period, whereas the shape of the initial distribution does not change. Similarly, the redistribution-effect term captures the changes in the shapes of the distributions holding the initial mean constant. The residual term may be large and the treatment of the initial and final periods is not symmetric.

Kakwani (2000) derives an exact decomposition based on a set of reasonable axioms. This decomposition is also applied to absolute poverty measures. The way Kakwani (2000) proposes to interpret the growth and the redistribution terms is similar to Datt and Ravallion (1992)'s one. According to Kakwani (2000), the pure growth effect is defined as the change in poverty if the mean income were to change but the relative income distribution remained unchanged, that is, the growth term is based on the comparisons between distributions of equal shapes and different means. Similarly, the pure inequality effect is defined as the change in poverty if the relative income distribution were to change but the mean income, in real terms, remained the same. In other words, the redistribution component captures the changes in the distributions holding the means constant. The decomposition introduced by Kakwani (2000) can be written as follows:

$$\begin{aligned}\Delta P_{01} &= P(f(x_1), z) - P(f(x_0), z) =\\ &= \underbrace{\frac{1}{2}[(P(L(x_1), \mu_1, z) - P(L(x_1), \mu_0, z)) + (P(L(x_0), \mu_1, z) - P(L(x_0), \mu_0, z))]}_{\text{growth effect}} \quad (4)\\ &+ \underbrace{\frac{1}{2}[(P(L(x_1), \mu_1, z) - P(L(x_0), \mu_1, z)) + (P(L(x_1), \mu_0, z) - P(L(x_0), \mu_0, z))]}_{\text{redistribution effect}}. \quad (5)\end{aligned}$$

The advantages of Kakwani's decomposition are that it is exact, without residual, and time-reversion consistent because it treats initial and final time points symmetrically. Indeed, his decomposition can be interpreted in terms of the Shapley value as shown by Shorrocks (2013).

Based on Kakwani (2000), Son (2003) proposes a four-component decomposition that allows the analysis of the growth-inequality change within each group when a decomposable poverty measure is used.

More recently, Müller (2006) introduces a novel procedure to decompose the changes of poverty over time based on integrals as follows. Let $c^1, \dots, c^m \in C$ be the components whose contribution to the change in poverty we are interested in analyzing, and we denote by $c_t^i = c_i(t)$, with $i = 1, \dots, m$, the corresponding component in time t. We consider that $P(f(x_t), z_t) = P(c_t^1, \dots, c_t^m)$.

First, note that[6]

$$\Delta P_{01} = P(c_1^1, \ldots, c_1^m) - P(c_0^1, \ldots, c_0^m) = \int_{t_0}^{t_1} \frac{\partial P}{\partial t}(c_t^1, \ldots, c_t^m)dt. \tag{6}$$

We also have that

$$\frac{\partial P}{\partial t}(c_t^1, \ldots, c_t^m) = \sum_{i=1}^{m} \frac{\partial P}{\partial c^i}(c_t^1, \ldots, c_t^m)\frac{\partial c^i}{\partial t}(t). \tag{7}$$

Inserting Equation (7) into Equation (6), we find that

$$\Delta P_{01} = \int_{t_0}^{t_1} \sum_{i=1}^{m} \frac{\partial P}{\partial c^i}(c_t^1, \ldots, c_t^m)\frac{\partial c^i}{\partial t}(t)dt = \sum_{i=1}^{m} \int_{t_0}^{t_1} \frac{\partial P}{\partial c^i}(c_t^1, \ldots, c_t^m)\frac{\partial c^i}{\partial t}(t)dt. \tag{8}$$

Assuming that the components are pairwise independent, then the contribution of each of the components to the total change in poverty is defined as follows:

$$\Delta P_{01}^{c^i} = \int_{t_0}^{t_1} \frac{\partial P}{\partial c^i}(c_t^1, \ldots, c_t^m)\frac{\partial c^i}{\partial t}(t)dt. \tag{9}$$

The main drawback of this approach is the lack of information needed to compute the integrals. Müller (2006) proposes a number of linear approximations to overcome this difficulty. One of them is to replace the integral by the trapezoid given by joining the upper and lower end points with a straight line, and approximating the derivatives of the components by the slope of the straight line joining the end-points as follows:

$$\begin{aligned}
\Delta P_{01}^{c_i} &= \int_{t_0}^{t_1} \frac{\partial P}{\partial c^i}(c_t^1, \ldots, c_t^m)\frac{\partial c^i}{\partial t}(t)dt \\
&\approx \int_{t_0}^{t_1} \frac{\partial P}{\partial c^i}(c_t^1, \ldots, c_t^m)\frac{c_1^i - c_0^i}{t_1 - t_0}dt \\
&\approx \frac{1}{2}\left(c_1^i - c_0^i\right)\left(\frac{\partial P}{\partial c^i}(c_1^1, \ldots, c_1^m) + \frac{\partial P}{\partial c^i}(c_0^1, \ldots, c_0^m)\right).
\end{aligned} \tag{10}$$

Müller (2006) shows that when only two components are involved, computing the respective contributions according to Equation (10) is equivalent to obtaining the corresponding Shapley value. Müller (2006) also shows that Datt and Ravallion (1992)'s decomposition can also be seen as a special case of integral approximation. He illustrates his results in the poverty field assuming that the poverty line is fixed and the poverty index can be particularly written as $P(L, \mu, z) = \overline{P}(L/z, \mu/z)$. Following Müller (2006), Bresson (2008) proposes an alternative decomposition consistent with definitions of growth and inequality effects. Fujii (2017) also relies on the integral-based approach to propose a decomposition of the changes in poverty into a growth and a redistribution component when the poverty line is absolute, which is specially well suited for the analysis of poverty in developing countries. He considers $P(f, \mu, z) = \widetilde{P}(\widetilde{f}, \widetilde{z})$, denoting by $\widetilde{f} = f/\mu$ and $\widetilde{z} = z/\mu$.

[6] All functions are assumed to be integrable.

3 | PROPOSAL OF A POVERTY DECOMPOSITION

3.1 | Primary components: Poverty line and distributional effects

We consider a period of time from t_0 to t_1. Following Förster and d'Ercole (2012), the poverty line at the beginning of the period, z_0, is set as a percentage of the median. At the end of the period, we can choose between the corresponding relative line, denoted by z_1, or the anchored (inflation-adjusted) relative line, z_0. We are interested in analyzing the contribution to poverty of the changes in the poverty lines and the changes in the poor's income distribution. Following the integral-based approach developed in the previous section, and considering that the poverty line and the distribution are the two components of interest,[7] from Equation (6) and using Equation (3), we get

$$\Delta P_{01} = P(f(x_1), z_1 - P(f(x_0), z_0) = \int_{t_0}^{t_1} \frac{\partial P}{\partial t}(f(x_t), z_t)dt$$

$$= \int_{t_0}^{t_1} \frac{\partial P}{\partial z}(f(x_t), z_t)z'(t)dt \tag{11}$$

$$+ \int_{t_0}^{t_1} \frac{\partial P}{\partial f}(f(x_t), z_t)\frac{\partial f}{\partial t}(x_t)dt. \tag{12}$$

Expression (11) captures changes in the poverty lines through the derivative $z'(t)$, whereas changes in the distribution are captured by expression (12). If we assume the linear approximations introduced by Müller (2006) that lead to Equation (10), and denoting by ΔP_{01}^{PL} and ΔP_{01}^{DI} the respective changes, we find that

$$\Delta P_{01}^{PL} \approx \frac{1}{2}[(P(f(x_1), z_1) - P(f(x_1), z_0)) + (P(f(x_0), z_1) - P(f(x_0), z_0))] \tag{13}$$

$$\Delta P_{01}^{DI} \approx \frac{1}{2}[(P(f(x_1), z_1) - P(f(x_0), z_1)) + (P(f(x_1), z_0) - P(f(x_0), z_0))]. \tag{14}$$

Equation (13) captures the change in poverty if the poverty line were to change but the income distribution among the poor remained the same. Specifically, for each pair of distributions f_0 and f_1, it measures to what extent changes in the living standards affect the differences in poverty. Since poverty is increasing in the poverty line, that contribution will be positive if $z_1 > z_0$, that is, if the relative line is higher than the anchored one, and negative otherwise. If $z_1 = z_0$ the poverty line effect is equal to zero. We propose to interpret Equation (13) as *poverty line effect*.

In turn, Equation (14) takes into account the changes in poverty if distribution among the poor were to change but the poverty line remained unchanged. When f_1 and f_0 restricted to the set of the poor are equal, this component is equal to zero. We interpret this term as *distributional effect*.[8]

[7] In order to apply the integral-based approach, the selected components should be independent. In our framework, the poverty line is set as a percentage of the median of the whole population. Then, it is possible to assume that the poor's income distribution does not change while the median of the whole population does because of the changes of the non-poor's income. Similarly, it is also possible to assume that the poor's income distribution may change without affecting the median.

[8] In fact, these two terms may be obtained following the Shapley allocation method (see Shapley, 1953).

The decomposition we propose is exact and time-reversion consistent because the initial and final time points are treated symmetrically. Although the decompositions based on the integrals guarantee subperiod additivity, since the linear conditions assumed are not transitive in general, the final decomposition is likely to fail subperiod additivity.

In the following, we will examine how to further decompose the poverty line and the distribution effects for the decomposable poverty indices.

3.2 | Decomposition of the poverty line effect

Now we propose to further decompose the poverty line effect given by Equation (13). Let us assume first that the relative line at the end of the period, z_1, is greater than the anchored line, z_0. Then the difference in poverty if we use z_1 instead of using z_0 has two sources. It is due, on the one hand, to the shift in the set of the poor because there are "new poor" and, on the other hand, to the changes within the poor as the "old poor" are poorer because their gaps are higher. For the subgroup decomposable indices, that poverty level can be easily decomposed into these two components as follows:

$$P(f(x), z_1) = \int_0^{z_0} p(x, z_1) f(x) dx + \int_{z_0}^{z_1} p(x, z_1) f(x) dx. \tag{15}$$

The first term on the right-hand of Equation (15) gives the contribution to poverty of the poor identified by z_0, who are poorer under z_1 since they are farther from z_1 than from z_0. The second term computes the contribution of the "new poor," those people not identified under z_0 that are poor under z_1. If $z_1 < z_0$, we can interpret the change in poverty as before but with the opposite signs: there are fewer poor and the old poor are now less poor.

The next claim shows how these two effects are incorporated in the evaluation of the changes in poverty.

Claim 1. Let P be a decomposable poverty index and let z_0 and z_1 be two poverty lines. Then

$$P(f(x), z_1) - P(f(x), z_0) = \underbrace{\int_0^{z_0} [p(x, z_1) - p(x, z_0)] f(x) dx}_{\text{old-poor contribution}} + \underbrace{\int_{z_0}^{z_1} p(x, z_1) f(x) dx}_{\text{new-poor contribution}}. \tag{16}$$

If we rewrite Equation (13) taking into account Equation (16), we get that the total contribution of the poverty lines to the change of poverty is given by

$$\begin{aligned} \Delta P_{01}^{PL} &= \frac{1}{2}[(P(f(x_1), z_1) - P(f(x_1), z_0)) + (P(f(x_0), z_1) - P(f(x_0), z_0))] \\ &= \underbrace{\frac{1}{2}\left[\int_0^{z_0} [p(x_1, z_1) - p(x_1, z_0)] f(x_1) dx_1 + \int_0^{z_0} [p(x_0, z_1) - p(x_0, z_0)] f(x_0) dx_0\right]}_{\text{old-poor contribution}} \end{aligned}$$

$$+\underbrace{\frac{1}{2}\left[\int_{z_0}^{z_1} p(x_1,z_1)f(x_1)dx_1+\int_{z_0}^{z_1} p(x_0,z_1)f(x_0)dx_0\right]}_{\text{new-poor contribution}}. \tag{17}$$

The two terms on the right-hand side of Equation (17) are greater than zero if z_1 is greater than z_0. Otherwise, the two terms are less than zero.

3.3 | Decomposition of the distributional effect

Even if the poverty line remains fixed, poverty may vary due to changes in the income distribution, specifically in its mean and in its inequality. In this section, we further disentangle the contribution of the distribution to the changes in poverty as a sum of growth and redistribution effects. For doing so, we consider first that the poverty line is fixed and, as mentioned, that the density function is completely determined by its mean, and by its shape, given by the associated Lorenz curve. We analyze the contributions of these two components, respectively, denoted by $\Delta P(z)_{01}^{\mu}$ and $\Delta P(z)_{01}^{L}$, to the changes in poverty. We get that

$$P(L(x_1),\mu_1,z)-P(L(x_0),\mu_0,z)=\int_{t_0}^{t_1}\frac{\partial P}{\partial t}(L(x_t),\mu_t,z)dt$$

$$=\int_{t_0}^{t_1}\frac{\partial P}{\partial \mu}(L(x_t),\mu_t,z)\frac{\partial \mu}{\partial t}(x_t)dt \tag{18}$$

$$+\int_{t_0}^{t_1}\frac{\partial P}{\partial L}(L(x_t),\mu_t,z)\frac{\partial L}{\partial t}(x_t)dt. \tag{19}$$

If we apply Müller (2006)'s approach jointly with the linearity approximation (Equation (10)) when the poverty line is fixed, we find that

$$\Delta P(z)_{01}^{\mu}\approx\frac{1}{2}[(P(L(x_1),\mu_1,z)-P(L(x_1),\mu_0,z))+(P(L(x_0),\mu_1,z)-P(L(x_0),\mu_0,z))] \tag{20}$$

$$\Delta P(z)_{01}^{L}\approx\frac{1}{2}[(P(L(x_1),\mu_1,z)-P(L(x_0),\mu_1,z))+(P(L(x_1),\mu_0,z)-P(L(x_0),\mu_0,z))]. \tag{21}$$

Note that Equations (20) and (21) are identical to the equations proposed by Kakwani (2000) (Equations (4) and (5)). Inserting Equations (20) and (21) into Equation (14), we get the corresponding growth and redistribution effects when we allow the poverty lines to change.

Specifically the *growth component* contribution is as follows:

$$\Delta P_{01}^{GR}=\frac{1}{4}[(P(L(x_1),\mu_1,z_1)-P(L(x_1),\mu_0,z_1))+(P(L(x_0),\mu_1,z_1)-P(L(x_0),\mu_0,z_1))]$$

$$+\frac{1}{4}[(P(L(x_1),\mu_1,z_0)-P(L(x_1),\mu_0,z_0))+(P(L(x_0),\mu_1,z_0)-P(L(x_0),\mu_0,z_0))]. \tag{22}$$

The comparison of poverty in $(L(x_1),\mu_0)$ with poverty in $(L(x_1),\mu_1)$ reflects the contribution of growth. By symmetry, the same happens when comparing poverty in $(L(x_0),\mu_0)$ with poverty in $(L(x_0),\mu_1)$. Hence, for any poverty line, if $\mu_1>\mu_0$, that is, if there is growth from t_0 to t_1, then

TABLE 1 Mean incomes and relative poverty lines (inflation-adjusted with prices of 2007) for 2007 and 2016.

Country	μ^{2007}	μ^{2016}	z_R^{2007}	z_R^{2016}
Cyprus	18,502	15,264	9,590	7,578
Iceland	33,753	19,189	17,268	10,323
Italy	17,412	16,264	9,100	8,662
Portugal	9,925	9,515	4,537	4,747
Slovakia	4,260	5,932	2,328	3,352
United Kingdom	24,614	20,174	12,536	10,352

8*Note*: Mean income and poverty line are expressed in PPP$ per capita and per year adjusted with prices of 2007.
8*Source*: Own elaboration from EU-SILC data and using HICP from EUROSTAT web page.

all the four terms in the growth component given in Equation (22) are negative. It is clear that if $\mu_1 = \mu_0$, the growth component is equal to zero.

In turn, we get that the *redistribution component* contribution is as follows:

$$\Delta P_{01}^{RD} = \frac{1}{4}[(P(L(x_1), \mu_1, z_1) - P(L(x_0), \mu_1, z_1)) + (P(L(x_1), \mu_0, z_1) - P(L(x_0), \mu_0, z_1))] + \frac{1}{4}[(P(L(x_1), \mu_1, z_0) - P(L(x_0), \mu_1, z_0)) + (P(L(x_1), \mu_0, z_0) - P(L(x_0), \mu_0, z_0))]. \quad (23)$$

Now, comparing poverty in $(L(x_1), \mu_0)$ and $(L(x_0), \mu_0)$, and, respectively, $(L(x_1), \mu_1)$ and $(L(x_0), \mu_1)$, means comparing distributions with equal means and different shapes. Their differences in poverty are due to redistribution issues. A positive redistribution component means that the changes in the distributions have benefited the rich more than the poor.

4 | ILLUSTRATION

This section analyzes the changes in poverty for six European countries, Cyprus, Iceland, Italy, Portugal, Slovakia, and the United Kingdom, between 2007 and 2016, using the EU-SILC. The analysis unit is the individual. We consider household disposable income and use the modified OECD equivalence scale to account for differences in household needs. Monetary values are converted to Purchasing Power Parity (PPP) and deflated by the Harmonized Index of Consumer Prices (HICP) for 2007. Following OECD's proposal, we use two poverty lines for each country. One relative line set at 60% of the median national equivalent household income, and the anchored relative poverty line set at 60% of the median income observed in 2007.

Table 1 shows the mean values and the corresponding poverty lines for the selected countries in 2007 and 2016. As shown in the table, the tendency differs depending on the country. Thus, we find that both the mean income and the poverty line have decreased in Cyprus, Iceland, Italy, and the United Kingdom. The opposite is true in Slovakia where the two values have increased. Finally, in Portugal, the mean income has decreased, whereas the poverty line has increased.

In order to analyze the evolution of poverty, we have computed the headcount ratio, FGT_0, the poverty gap ratio, FGT_1, according to Equation (1) and the Watts index, W, Equation (2), for the corresponding relative poverty lines. In parentheses, the standard errors are added. Standard

TABLE 2 FGT_0, FGT_1, and Watts index in 2007 and 2016.

	$t_0 = 2007$			$t_1 = 2016$		
Country	FGT_0	FGT_1	W	FGT_0	FGT_1	W
Cyprus	15.54 (0.64)	3.51 (0.17)	4.40 (0.23)	16.13 (0.78)	3.44 (0.22)	4.37 (0.37)
Iceland	10.08 (0.61)	2.26 (0.19)	3.48 (0.42)	8.73 (0.60)	1.92 (0.18)	2.67 (0.30)
Italy	19.18 (0.37)	5.45 (0.14)	8.21 (0.26)	20.17 (0.47)	7.06 (0.22)	12.42 (0.50)
Portugal	18.30 (0.75)	5.11 (0.26)	6.92 (0.40)	18.95 (0.55)	5.92 (0.22)	8.92 (0.41)
Slovakia	10.56 (0.50)	2.79 (0.18)	4.04 (0.31)	12.65 (0.67)	3.88 (0.27)	6.03 (0.55)
United Kingdom	18.86 (0.53)	5.12 (0.18)	7.50 (0.33)	15.46 (0.48)	4.22 (0.18)	6.13 (0.31)

9*Note*: FGT_0, FGT_1, and W are expressed in percentage points. Standard error in parentheses.
9*Source*: Own elaboration from EU-SILC data and HICP from Eurostat web page.

TABLE 3 Decomposition of the change in poverty between 2007 and 2016 into poverty line and distributional effects.

		Cyprus	Iceland	Italy	Portugal	Slovakia	United Kingdom
FGT_0	ΔP_{01}	0.59**	−1.36	0.99	0.65	2.09**	−3.25**
	ΔP_{01}^{PL}	−11.75**	−25.06**	−2.19**	1.78*	15.71**	−9.38**
	ΔP_{01}^{DI}	12.34**	23.70**	3.18**	−1.13	−13.62**	6.13**
FGT_1	ΔP_{01}	−0.07	−0.34	1.61**	0.80**	1.09**	−0.87**
	ΔP_{01}^{PL}	−3.17**	−5.99**	−0.66**	0.59**	3.85**	−2.51**
	ΔP_{01}^{DI}	3.11**	5.65**	2.27**	0.21	−2.76**	1.64**
Watts	ΔP_{01}	−0.03	−0.81	4.21**	2.00**	1.99**	−1.33**
	ΔP_{01}^{PL}	−4.08**	−7.77**	−0.97**	0.84**	5.27**	−3.42**
	ΔP_{01}^{DI}	4.05**	6.96**	5.18**	1.15**	−3.28**	2.09**

9*Note*: All the figures for poverty decomposition are expressed in percentage points. Asterisks ** and * denote significance at the 95% and 90% levels, respectively.
9*Source*: Own elaboration from EU-SILC data.

errors have been estimated using bootstrapping and accounting for sample design.[9] The results are displayed in Table 2.

The three indicators show a decrease in poverty for the United Kingdom, whereas in Slovakia, the trend is upward. In Iceland, the changes are almost negligible. However, the conclusions in Portugal, Italy, and Cyprus depend on the measure chosen.

Italy and Portugal show similar patterns, whereas the incidence of poverty has not significantly changed, poverty as measured by FGT_1 and $Watts$ indices has increased. On the other hand, for Cyprus, a small increase in the number of poor individuals can be observed, whereas the other two measures do not change significantly.

Now we decompose the changes in poverty in two steps, according to the decomposition proposed in the previous section. In the first step, we analyze the poverty line and the distributional effect presented in Table 3. As shown in the table, the contributions of these two effects are very similar regardless of the measure chosen. Therefore, Figure 1 illustrates the decomposition of the Watt index and helps to identify the different patterns.

[9] Bootstrapped standard errors have been estimated using DASP software taking full account of the survey design including population weights (see Araar & Duclos, 2007).

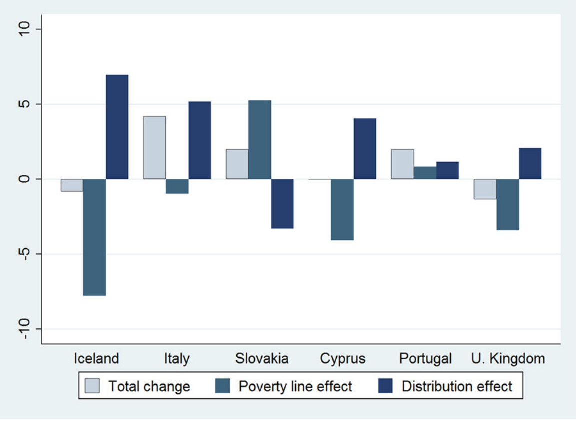

FIGURE 1 Poverty line and distributional effects for the changes in the Watts index between 2007 and 2016.
[Colour figure can be viewed at wileyonlinelibrary.com]
Note: Own elaboration from EU-SILC data.

Remember that the poverty line effect captures the changes in poverty due to the changes in the living standard. For example, when $z_R^{2016} > z_R^{2007}$, the living standard between 2007 and 2016 increases, and the poverty line effect is positive. For Portugal and Slovakia, the poverty line contribution is positive, whereas it is negative for the rest of the selected countries. Hence, we can conclude that the living standard has improved only for Portugal and Slovakia. The distributional effect tells us about the conditions of the poor people when the effect of the living standards is removed. When it is positive, as is the case in Cyprus, Iceland, Italy, and the United Kingdom, the poor people's conditions have worsened. In Portugal and Slovakia, the joint effect of the poverty lines and of the distributions lead to an increase in the poverty level.

The case of the United Kingdom is noteworthy, with a high decrement in the standard of living and consecutively with a high negative poverty line effect that has eventually led to a decrease in poverty. Iceland shows similar results with very high positive distributional effects and very negative poverty line effects with the conclusion that there are not significant differences in poverty between 2007 and 2016.

Now we move to the second decomposition step. The old poor and new poor contributions, jointly with the growth and inequality effects, are displayed in Table 4. Focusing on the FGT_0, since it is only sensitive to the proportion of people below the poverty line, the poverty line effect is exactly the increment or the decrement in the percentage of poor individuals. As mentioned, the number of poor individuals has increased in Portugal and Slovakia and decreased for the other countries. With respect to the growth and the redistribution effects, all the countries, except Slovakia, have suffered a significant increase in the growth effect, that is, the decrement in the mean income of the whole population has increased the number of poor individuals. On the other hand, the redistribution effect increases for Cyprus and decreases for Iceland, Portugal, and the United Kingdom, concluding that the number of poor relative to the total mean has grown only for Cyprus.

Now, we focus on the other two poverty indices. Remember that the FGT_1 index does not take into account the inequality among the poor individuals. However, since the results for the two measures are very similar, the results for the $Watts$ index are graphically represented in Figure 2.

Figure 2 represents the decomposition of the poverty line effect into old-poor and new-poor contributions. It can be observed that in Cyprus and the United Kingdom, the contribution of the new-poor is higher, whereas in Slovakia, the two effects are balanced. In contrast, in Iceland, where the poverty line has significantly decreased, the percentage of poor people has decreased and, specially, the old poor are less poor.

TABLE 4 Decomposition of the change in poverty between 2007 and 2016 into poverty line and distributional effects.

		Cyprus	Iceland	Italy	Portugal	Slovakia	UK
FGT_0	ΔP_{01}	0.59**	−1.36	0.99	0.65	2.09**	−3.25**
	ΔP_{01}^{new}	−11.75**	−25.06**	−2.19**	1.78**	15.71**	−9.38**
	ΔP_{01}^{GR}	9.44**	26.69**	3.03**	1.65**	−13.91**	9.11**
	ΔP_{01}^{RD}	2.90**	−2.99**	0.15	−2.78**	0.29	−2.98**
FGT_1	ΔP_{01}	−0.07	−0.34	1.61**	0.80**	1.09**	−0.87**
	ΔP_{01}^{old}	−1.94**	−1.57**	−0.61**	0.56**	1.76**	−1.70
	ΔP_{01}^{new}	−1.23**	−4.42**	−0.05**	0.04**	2.09**	−0.81**
	ΔP_{01}^{GR}	2.50**	6.71**	0.92**	0.55	−3.45**	2.58**
	ΔP_{01}^{RD}	0.60**	−1.06**	1.35**	−0.34*	0.69**	−0.94**
Watts	ΔP_{01}	−0.03	−0.81	4.21**	2.00**	1.99**	−1.33**
	ΔP_{01}^{old}	−2.75	−2.67**	−0.92**	0.81*	2.95	−2.57**
	ΔP_{01}^{new}	−1.33**	−5.10**	−0.05**	0.04**	2.32**	−0.86**
	ΔP_{01}^{GR}	3.23**	8.77**	1.34**	0.79**	−4.75**	3.55**
	ΔP_{01}^{RD}	0.82	−1.81**	3.83**	0.37	1.47**	−1.46**

9*Note*: All the figures for poverty decomposition are expressed in percentage points. Asterisks ** and * denote significance at the 95% and 90% levels, respectively.
9*Source*: Own elaboration from EU-SILC data.

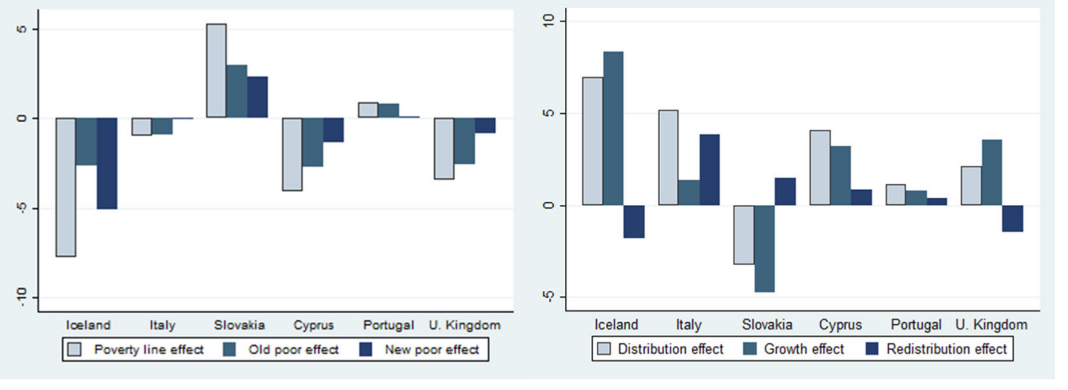

FIGURE 2 Old poor, new poor, growth, and redistribution effects for the changes in the Watts index between 2007 and 2016.
[Colour figure can be viewed at wileyonlinelibrary.com]
Note: Own elaboration from EU-SILC data.

Analyzing the growth and redistribution effects, we find that in Cyprus, Italy, and Slovakia, the redistribution effect is positive. This means that the changes in the shapes of the distributions have benefited the rich more than the poor. Consequently, a policy agenda that addresses redistribution concerns may help to decrease the poverty level in these countries. The opposite occurs in Iceland and the United Kingdom, in which the (negative) growth has affected the rich people more. Policies focused on growth-enhancing will help the poor households. In all the countries but Slovakia, the growth component is positive because the (inflation-adjusted) income means have decreased in the period. In Slovakia, the growth contribution is negative and highly dominates the redistribution term leading to a reduction in the distributional effect. It is clear that policies focused on keeping a low and stable unemployment rate, jointly with better unemployment insurance schemes would improve economic welfare and help the poor households.

5 | CONCLUDING REMARKS

This note has proposed a Shapley-type decomposition of the changes in poverty in order to identify the impact of changes on the living standard, on the mean income, or on the Lorenz curve of the distribution. The proposed decomposition is exact, time-reversion consistent, and although we have focused on decomposable indices, it can be extended to any poverty measure. The contribution assigned to each of the components may be easily interpreted and may help in the design of specific antipoverty policies.

The decomposition follows a two-step hierarchical procedure. In the first step, the evolution in poverty is decomposed in two primary components: the impacts due to changes in the living standard and in the distribution. Then, we further disentangle these two components to study more deeply what happens with the set of the poor and the impacts of growth and redistribution. The decomposition is twice Shapley-type, and we have justified its development based on the integral approximation approach.

The proposed decomposition identifies to what extent an increase in the living standard has led to an increment in poverty. In fact, we find that this is the main source in the increment in poverty in Slovakia. In this case, policies that improve social inclusion will lead to a decrease in the poverty levels. In contrast, in Iceland, the distributional effect is highly positive, which means that the conditions of the poor people have worsened. This has been due to a decrease in growth that has mainly affected the poor people. In this case, growth-enhancing policies would be needed to reduce poverty effectively. Finally, the redistribution component may be the main factor in the increase in poverty, as is the case in Italy, which may require specific redistribution policies.

These results entail that appropriate and specific poverty reduction policies should be applied for each country. Therefore, the decomposition proposed in the paper will provide policymakers with more information in order to implement more effective antipoverty policies.

ORCID

Oihana Aristondo https://orcid.org/0000-0001-6446-235X
Conchita D'Ambrosio https://orcid.org/0000-0002-8469-6126
Casilda Lasso de la Vega https://orcid.org/0000-0002-4326-0457

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