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## **SOME ALTERNATIVES TO THE POVERTY GAP FOR INTERNATIONAL COMPARISONS**

*The mean poverty gap, defined as the country's average shortfall of the (equivalised) household income with respect to a set threshold, is generally regarded as an important measure of monetary poverty. We show that it is not suitable for international comparisons and propose two related alternatives, one based on the log-transformation of income. The methods are applied to the cross-sectional component of the EU-SILC database from 2007.*

**Key words:** *equivalised household income; EU-SILC database; poverty gap; sampling weights.*

**JEL:** *I32 — Measurement and analysis of poverty; C83 — Survey methods; sampling methods.*

1. INTRODUCTION. Poverty and deprivation, of an individual or a household, have a multitude of aspects, some of which are difficult to capture by any (survey) questionnaire instrument or in an administratively collected database. Even some aspects of monetary poverty are problematic because of the variety of circumstances and needs that individuals and households have, as well as the ambiguity about the details of what should be regarded as a genuine need and how the poverty threshold or a standard should be set. As a consequence, many definitions used when studying poverty involve conventions with varying levels of arbitrariness in their construction. The calculation of the household income (the contributing components), as well as the adjustment for the household composition (equivalisation), are subject to such conventions. Adopting them is essential for any analysis and for comparability of results, but we should always bear in mind that, at least in principle, other conventions could (almost) equally well have been adopted, and they might have led to different conclusions. By the same token, we should look back and assess, in the light of new evidence, whether the conventions adopted earlier remain reasonable, or there is a good cause for their review.

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This paper presents the results of such an exercise, in which we evaluate summaries of the poverty gap for the 26 countries represented in the European Union's Survey of Income and Living Conditions (EU-SILC) in 2007. We show that the established definition of the mean poverty gap is highly problematic, because it aligns the countries according to their mean equivalised household income. That itself might not amount to a contradiction in general, but the finding that the western and northern European countries have, without an exception, higher levels of mean poverty gap than all the east European countries is counterintuitive and not credible. The source of this problem is the definition of the mean poverty gap. We propose two alternatives that are more in line with the general idea of the poverty gap and do not have the glaring deficiency of the established definition. For background and related discussion, see Atkinson *et al.* (2002, Section 6.2) and Saalvedra, Nolan and Smeeding (2009, Part 3).

Reduction of poverty and inequality is an uncontroversial goal of the members of the European Union, and collection of data for reliable analysis of the progress made in this endeavour is an important element of the related informational infrastructure. Closely connected to it is the effort to promote certain national and regional indicators (summaries) for use in all reporting, research and discourse; Atkinson *et al.* (2002). The EU-SILC database is a principal source of information about all aspects of monetary poverty and deprivation in the participating countries — the members of EU, except for Malta, and Iceland and Norway from outside EU. Harmonisation of the survey protocols is a great strength of EU-SILC, which facilitates comparable national summaries of household income.

With the increasing attention to poverty and social exclusion, the poverty rate, defined as the percentage of citizens (or residents) of a country or region who are classified as poor, is likely to become a media headline figure with a status similar to the unemployment rate. Although easy to interpret, the poverty rate has the weakness that it relies on a dichotomous classification (poor or not poor) and disregards the extent and concentration of poverty. The poverty gap, which summarises the shortfall of the income of households with respect to a specified threshold (standard), takes the extent of poverty into account, but its interpretation is less straightforward.

Many papers have explored these and related measures of poverty and inequality across countries and have studied changes and rates of transition from and to poverty or analysed the effect of welfare policies on poverty measures. For example, Maquet-Engsted and Stanton (2009) explain how income summaries are used in the European Strategy for Social Inclusion; Camaida and Goudswaard (2009) analyse how effective the national welfare policies and their systems of social transfers are in alleviating poverty in the EU countries. Several other studies compare the national distributions of household income in the countries that joined EU recently; Förster (2005) and Lelkes and Zólyomi (2008). Longford and Nicomedo (2009) conduct a set of sensitivity analyses of definitions and measures commonly used to summarise poverty and assess how suitable they are for the EU countries.

The next section gives details of the definition of the poverty gap, with an extension in which the poverty gap is represented by a curve, that is, as a function of the percentage involved in the definition of the poverty threshold. Section 3 evaluates the poverty gap curves for the countries in EU-SILC and discusses the contradiction found. An alternative definition we propose can be described as the original definition applied on the logarithmic (log) scale. Some complications that arise with the interpretation of this mean log-poverty gap are discussed. Section 4 studies the poverty gap curves for the regions of Spain. Section 5 gives details of the estimators used in the preceding sections, which incorporate the sampling weights.

In the analysis, we use the cross-sectional component of EU-SILC from 2007, in which the income of the households is recorded for year 2006. More populous countries tend to have larger sample sizes in EU-SILC, but there are several notable exceptions. For example, the sample for

Italy in the cross-sectional component of the Survey in 2007 comprises 52800 individuals in 21000 households, much more than for Germany (31700 and 14150, respectively) or any other country. Cyprus, Iceland and Luxembourg have the smallest sample sizes in EU-SILC (fewer than 4000 households), but the samples for Portugal and Latvia are only slightly greater (4300 and 4500 households, respectively). See Longford and Nicodemo (2009) for details.

2. POVERTY GAP. Essential prerequisites for defining the poverty gap of a household are the household's total income, its equivalisation, and the poverty threshold. The household's total income is defined as the total of the incomes of the members of the household. A household may have some income that is not associated with any of its members; such income is added to the total. The income of an individual is defined as the total of his or her income as an employee, self-employed, unemployed, pensioner, landlord or investor, income from one-off sales and contracts, such as a severance payment, presents received, lottery winnings, and the like, with the understanding that some of these components may not apply. As a convention, the total income is calculated for a calendar or tax year and, if recorded in another currency, converted to Euro at the average rate for the year. Over shorter periods, some households have substantial fluctuations in the income that do not affect their poverty status directly. They may be seasonal or related to some administrative and accounting procedures.

In a household, one adult individual is associated with unit weight and every other adult (above the age of 14 years) with weight 0.5. Each child (up to and including the age of 14) is associated with weight 0.3. The total of these weights is the equivalised household size (*eHS*). For example, a household with two adults and two children has *eHS* equal to  $1.0 + 0.5 + 2*0.3 = 2.1$ . The equivalised household income (*eHI*) is defined as the ratio of the household's total income and *eHS*. For example, if the total income of a household comprising two adults and two children (*eHS* = 2.1) is 42000 Euro, then  $eHI = 42000/2.1 = 20000$  Euro. The poverty threshold (*PT*) for a country is defined as 60% of the median *eHI*. The poverty rate, the principal summary of poverty in a country, is defined as the percentage of individuals who are members of households with *eHI* smaller than *PT*. The poverty rate is easy to interpret; rates (percentages) are used as scales for other key economic phenomena, such as unemployment, inflation, wage increases, and change of productivity. However, the division of individuals to poor and not poor is too simplistic. It ignores the extent of poverty of those who are classified as poor, and maybe also the proximity to poverty of those whose *eHI* exceeds *PT*. only by a narrow margin.

The mean poverty gap is intended to address this weakness. The poverty gap of a member of a household with *eHI* in excess of *PT* is equal to zero. For a member of a household with *eHI* smaller than *PT*, his or her poverty gap is equal to  $PT - eHI$ . A country's mean poverty gap is defined as the average poverty gap of its residents. Note that the median poverty gap is zero, because the definition of *PT* implies that fewer than half of the residents of a country are classified as poor.

For illustration, suppose a very small country comprises 20 households, three of them in poverty, with respective poverty gaps of 100, 200 and 300 monetary units. Suppose these households have two, three and one member, respectively, and the remaining 17 households have 44 members in total, so that the population of the country is 50 (in 20 households). Then the mean poverty gap is equal to

$$(2*100 + 3*200 + 300) / 50 = 22$$

This figure can be interpreted as follows. If the income in this country were to be supplemented for those who are classified as poor, so that they would reach the *PT*, the expenditure of 22 monetary

units per capita would be required. Of course, the *PT* may be altered by such an income supplement, so this interpretation has to be carefully qualified. Also, the calculation in our example ignores the equivalisation of the household sizes.

We may question several aspects of the definition of the poverty gap, such as the weight assigned to a child or an adult other than the first in a household, or why 60% of the median income (and why the median) is chosen as the threshold. See Longford and Nicodemo (2009) for an in-depth study of this issue, generically referred to as sensitivity analysis (Saltelli et al., 2004). Here we explore only one factor, the percentage at which *PT* is set. In the definition of the poverty gap, we alter the percentage that specifies the *PT*. Given ample computing resources, we can evaluate the mean poverty gap on a fine grid of these percentages in a range that contains 60%. For a lower threshold percentage, we have fewer individuals classified as poor, and a smaller or unchanged poverty gap for everybody, so the mean poverty gap cannot be greater. However, a country may have a higher poverty gap than another with respect to one threshold, and the comparison may be reversed for another threshold. If (many) such cases occur, with percentages not too far from the established value of 60%, the setting of the threshold has to be considered carefully and all inferential statements qualified by this percentage.

3. POVERTY GAP ON THE LINEAR AND LOG SCALES. Figure 1 displays the national mean poverty gap curves as functions of the threshold percentage. We say that these curves are defined on the linear scale, to distinguish them from the poverty gap curves defined later in this section. Note however, that the vertical axis in the diagram is on the log scale, so as to improve the resolution of the plot. The linear poverty gap curves are constructed from the mean poverty gaps evaluated for the percentages 40, 40.5, ..., 80.

If these curves were parallel or they intersected in very few cases and at acute angles, it would not be important how the threshold (percentage) is set. However, several pairs of curves intersect very close to the conventional 60% threshold, so the countries would rank differently if the thresholds of, say, 55% or 65% were adopted instead of 60%. The curves for Cyprus, Czech Republic, Finland, Luxembourg and Slovenia rise much more steeply than for the other countries, so their mean poverty gaps are relatively small for lower percentages. In contrast, the curves for Norway and the Netherlands are nearly linear (on the log scale) and they rise at rates slower than others. The mean poverty gaps of these two countries are relatively large for lower threshold percentages, although Norway has the highest mean poverty gap throughout the range of threshold percentages.

Notwithstanding these ambiguities in the assessment of the poverty gap, none of the countries appear at one extreme for the lowest thresholds and at the other extreme for the highest. In fact, throughout the range, the countries generally regarded as the most prosperous in Europe (in 2007), the Scandinavian countries and the established members of EU, have higher mean poverty gaps than any of the 'new' members of EU from eastern Europe. The finding that national average income is so closely associated with *any* aspect of poverty is not credible and calls into question the (established) definition of the mean poverty gap.

This paradox is explained by the vast discrepancy of the levels of income and the related levels of *PT* in the countries. As an extreme example, consider a household in Norway with *eHI* of 15000 Euro, about 9000 Euro short of Norway's *PT* of 24 00 Euro. In 2007, this *eHI* was well in excess of the *PT* of any of the east European countries. For instance, the national median income in Slovakia was around 4800 Euro, and its *PT* around 2900 Euro. Thus, with the established definition of the poverty gap, we equate the extent of poverty associated with *eHI* of 15 000 Euro in Norway with negative *eHI* (a loss) of about 6100 Euro in Slovakia. This is clearly not appropriate, and in the light of this example, the distortion in the comparisons in Figure 1 is not surprising.

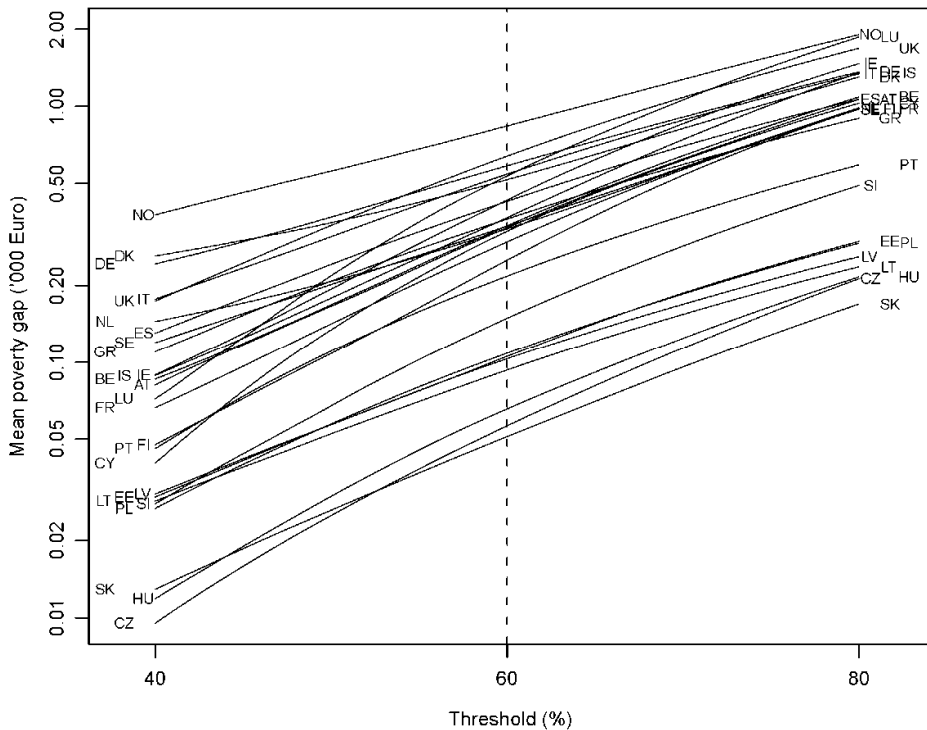


Figure 1. The national mean poverty gaps. The countries are listed in the Appendix

It may be more appropriate to equate the extent of poverty on the percentage scale. That is, the shortfall of 9000 Euro in Norway amounts to  $100 \cdot 9000 / 24000 = 37.5\%$ , and in Slovakia it would correspond to the shortfall of  $2900 \cdot 0.375 = 1090$  Euro, that is, *eHI* equal to 1810 Euro. The advantage of this percentage scale (the relative poverty gap, denoted by  $100r$ ) is that zero income corresponds to the relative poverty gap of 100% in every country, irrespective its *PT*. This motivates the definition of the mean relative poverty gap as the average of these percentages, or of fractions  $r = (PT - eHI) / PT = 1 - eHI / PT$ .

The log-transformation is frequently applied to variables in monetary units, such as income, prices and valuations, because linear models for such outcome variables are much more palatable than on the original scale. Following this practice, we consider the log-poverty gap, equal to the difference of the  $\log - PT$  and  $\log - eHI$ , truncated at zero:

$$[\log (PT) - \log (eHI)]_+ = \log (1 - r) \tag{1}$$

where the truncation  $[\ ]_+$  is defined as equal to zero for negative arguments, and to the argument itself otherwise. This definition fails for zero and negative values of *eHI*, for which the logarithm is not defined. We replace such values of *eHI* by a token quantity, such as 1 Euro. Then the log-poverty gap has an upper bound, and the influence of any one individual on a summary of the log-poverty gaps is limited.

The mean log-poverty gap is defined as the average of the log-poverty gaps over the individuals of the country. Equation (1) implies that the mean relative poverty gap and the mean log-poverty gap differ, in effect, only by the scales on which the averaging is applied. The relative poverty gap is summarised by its average  $\bar{r} = (r_1 + \dots + r_n) / n$  and the log-poverty gap by

$$\bar{l} = -\frac{1}{n} \sum_{i=1}^n \log(1 - r_i) = -\log \left\{ \sqrt[n]{\prod_{i=1}^n (1 - r_i)} \right\} \quad (2)$$

Note that individuals who are classified as not poor do not contribute to either summary because  $r = \log(1 - r) = 0$  for them. Subject to an approximation, the two summaries can be related as follows. For positive  $r$ ,  $-\log(1 - r) - r > 0$ . When  $r$  is small (and  $r \geq 0$ ),  $r = \log(1 - r) = 0$ , with equality when  $r = 0$ . Therefore, the left-hand side of (2) exceeds  $\bar{r}$ , but only by a narrow margin when the vast majority of the positive values of  $r_i$  are small.

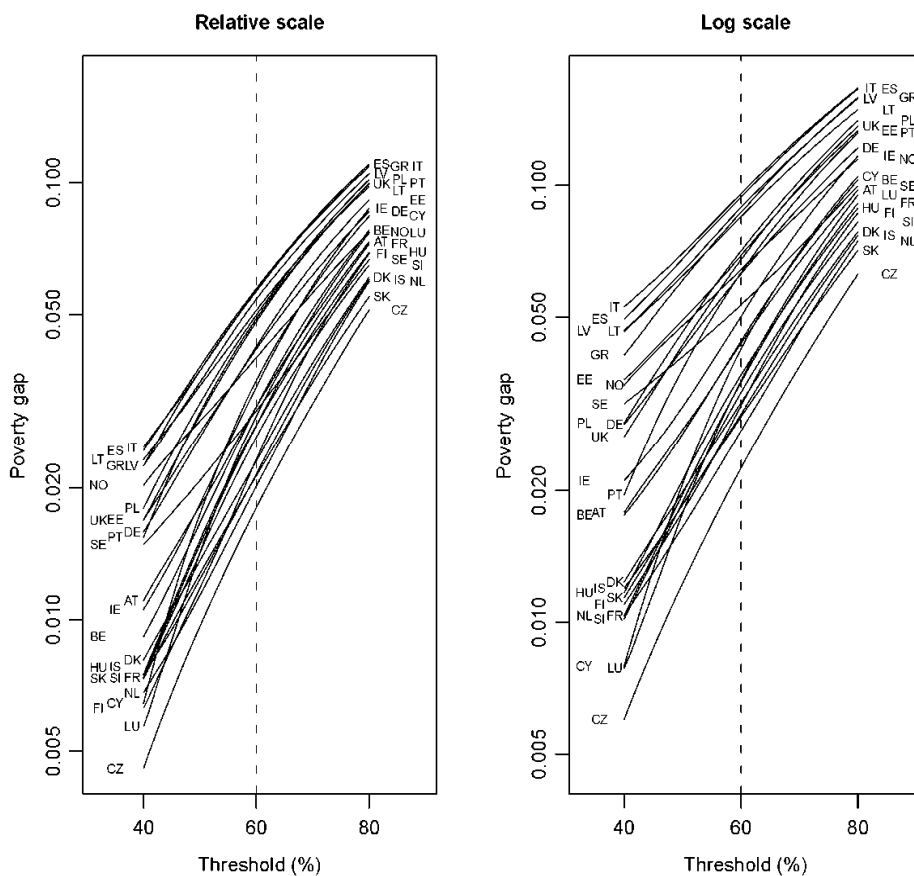


Figure 2. The national mean relative and log-poverty gaps.  
The countries are listed in the Appendix

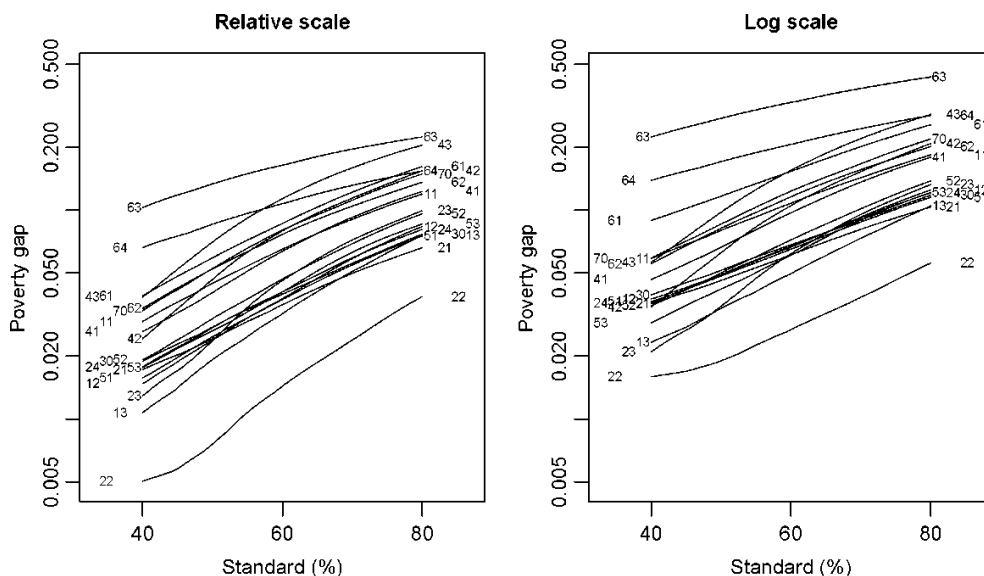
Figure 2 displays the curves of the mean relative poverty gaps and the mean log-poverty gaps of the countries for the threshold percentages in the range 40–80%. The two panels have the same vertical scale, to facilitate their comparison. As in Figure 1, log scaling is used for the vertical axes in both panels. The diagram confirms that the values of the mean log-poverty gap are greater than the values of the mean relative poverty gap, and that all the curves are increasing functions of the threshold percentage. The countries have very similar (relative) positions in the two panels: Czech Republic has the lowest poverty gap on both scales and for all thresholds, followed by Slovakia for higher thresholds and Luxembourg for lower thresholds. At the other extreme, Greece, Italy, Latvia and Spain have the highest values on both scales and nearly the entire range of thresholds.

The curves in both panels are far from parallel, so the choice of the threshold percentage is important. In both panels, the curve for Sweden is nearly linear (on the log scale) and ascends at the slowest rate. Sweden's mean log-poverty gap is the eighth highest at the 40% threshold, but only the fifteenth highest at the 80% threshold. The curves for Norway have similar features. The curves for Portugal and Luxembourg ascend at the fastest rate.

4. POVERTY GAP IN THE REGIONS. Unlike in different countries, the poverty gap in the regions of a country is defined with respect to the same (national) *PT*. The basis of this convention is questionable. If we adopt a separate threshold for each region, based on its own distribution of income, then we face a setting similar to the comparison of summaries of the poverty gap in the countries; therefore we focus on the setting with a common *PT*. Only two countries have many regions (areas at NUTS2 level) recorded in EU-SILC: Spain (17 autonomous communities and two autonomous cities — Ceuta and Melilla on the north African coast) and France (22 regions; the four other overseas regions are not represented in EU-SILC). We study in detail the summaries of the poverty gap in Spain.

Let the poverty gap of an individual  $i$  in region  $j$  be  $g_{ij}$ , and the common *PT* be  $T$ . Then the mean poverty gap in region  $j$  is  $\bar{g}_j = (g_{1j} + \dots + g_{n_jj}) / n_j$ , where  $n_j$  is the population size of region  $j$ . The relative poverty gap is  $\bar{r}_j = \bar{g}_j / T$ , so the mean linear and relative poverty gaps are for the purpose of a comparison equivalent, because they differ only by the common (multiplicative) factor  $1/T$ ; for a pair of distinct regions  $j_1 \neq j_2$ ,  $\bar{g}_{j_1} / \bar{g}_{j_2} = \bar{r}_{j_1} / \bar{r}_{j_2}$ . The reciprocal exponential of the mean log-poverty gap,  $\exp(-\bar{l}_j)$ , is the geometric average of its complements  $1 - g_{ij} / T$ . The geometric average is smaller than or equal to the arithmetic average, so  $\exp(-\bar{l}_j)$  is smaller than or equal to  $1 - \bar{r}_j$ . Since  $\exp(-\bar{l}_j) > 1 - \bar{r}_j$  whenever  $l_j > 0$ ,  $l_j$  is always greater than  $\bar{r}_j$ . But the difference is small when  $\bar{l}_j$  is small, because then  $\exp(-\bar{l}_j) = 1 - \bar{l}_j$  and the arithmetic and geometric averages differ only slightly.

The relative and log-poverty gap curves for the 19 regions of Spain are plotted in Figure 3. The sets of curves in the two panels differ insubstantially. Regions 22 (Navarra) and 63 (Ceuta) stand out as having, respectively, the lowest and highest average poverty gap on both scales. The ranks of other regions differ across the scales only slightly. For example, region 64 (Melilla) has the second highest mean log-poverty gap for nearly the entire range 40–80%, but region 43 (Extremadura) has the second highest mean relative poverty gap in the range 60–80%. Similarly, the curves for regions 13 (Cantabria) and 23 (La Rioja) intersect on the log scale, but not on the relative scale, although the curve for La Rioja increases steeply on both scales, as it does for regions 42 (Castilla-La Mancha) and 43 (Extremadura). Similar observations can be made on the mean poverty gap curves for the 22 regions of France; details are omitted.



**Figure 3. The mean relative and log-poverty gap curves for the regions of Spain.**  
*The regions are listed in the Appendix*

5. ESTIMATION WITH SAMPLING WEIGHTS. The summaries of the poverty gap defined in the previous section have two versions: as population quantities, which one could evaluate only if the population of the country concerned were enumerated, and their sample versions, which can be evaluated on the sample and serve as the estimates of the former. The subjects in the EU-SILC cross-sectional survey for 2007 are associated with sampling weights which should be incorporated in any analysis to reflect the unequal probabilities of inclusion in the survey. We evaluate the (weighted) sample version of the median by the following procedure.

The subjects are set in the ascending order of their *eHI*; let the sampling weights that correspond to this order be  $\omega^{(1)}, \omega^{(2)}, \dots, \omega^{(n)}$ , and their cumulative totals  $\omega^{(1)}_+ = \omega^{(1)}$ ,  $\omega^{(2)}_+ = \omega^{(1)} + \omega^{(2)}$ , ...,  $\omega^{(n)}_+ = \omega^{(n-1)} + \omega^{(n)}$ , so that their overall total is  $\omega^{(n)}_+ = \omega^{(n)}$ . The (weighted) sample median is defined as the value of *eHI* that corresponds to subject (*k*) for which which  $\omega^{(k-1)} < \frac{1}{2} \omega_+ < \omega^{(k)}$ . If there is no such *k*, because  $\omega^{(k)} = \frac{1}{2} \omega_+$  for some *k*, then the sample median is set to  $\frac{1}{2}(y^{(k-1)} + y^{(k)})$ , where  $y^{(h)}$  is the *h*th smallest value of *eHI* (*h*th in the ordered list). Given large samples for all countries, and a multitude of unique values of the weights, this provision is never called upon, and devising alternatives which take into account the sampling weights  $\omega^{(k-1)}$  and  $\omega^{(k)}$  is not necessary.

The sampling weights are used in all estimators. For example, the population mean of a variable (recorded or constructed) is estimated by  $(\omega_1 y_1 + \omega_2 y_2 + \dots + \omega_n y_n) / \omega_+$ , where  $y_h$  is the value of the summarised variable for subject *h*, and  $\omega_h$  the corresponding sampling weight.

6. CONCLUSION. We identified a problem in the established way of summarising the poverty gap in a country by its (weighted) sample mean, and proposed two related alternatives which resolve it. The mean relative and log-poverty gaps yield similar conclusions (relative locations and ranks) for the countries in EU-SILC. We regard the mean log-poverty gap as easier to interpret because it is the mean



poverty gap on the log scale, and the log transformation is commonly applied to variables in monetary units.

However, the key attribute of a definition related to the poverty gap is its face validity, the faithful reflection of the extent of poverty in the country (or region). Establishing it for the summaries we defined is beyond the scope of this paper, although we have provided strong evidence that the mean poverty gap patently lacks such validity for international comparisons.

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## Appendix

We list here the variables from the EU-SILC database, which are used in the analysis described in this paper.

HB030	Household identification
PB030	Personal identification
HY020	Total household disposable income
HY010	Total household gross income, used when HY020 is not recorded
DB090	Household cross-sectional weight
RB080	Person's year of birth

In Figures 1 and 2, we use the following abbreviations for the country names:

AT	Austria	ES	Spain	IT	Italy	PL	Poland
BE	Belgium	FI	Finland	LT	Lithuania	PT	Portugal
CY	Cyprus	FR	France	LU	Luxembourg	SE	Sweden
CZ	Czech Republic	GR	Greece	LV	Latvia	SI	Slovenia
DE	Germany	HU	Hungary	NL	the Netherlands	SK	Slovakia

DK	Denmark	IE	Ireland	NO	Norway	UK	United Kingdom
EE	Estonia	IS	Iceland				

In Figure 3, we use the following codes for the regions (autonomous communities or cities) of Spain:

11	Galicia	23	La Rioja	43	Extremadura	62	Murcia
12	Asturias	24	Aragon	51	Catalunya	63	Ceuta
13	Cantabria	30	Madrid	52	Valencia	64	Melilla
21	Pais Vasco	41	Castilla y Leon	53	Balears	70	Canarias
22	Navarra	42	Castilla-La Mancha	61	Andalucia		

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*ЛОНГФОРД Н., НИКОДЕМО К.*

### ДЕЯКІ АЛЬТЕРНАТИВИ ВИЗНАЧЕННЯ ГЛИБИНИ БІДНОСТІ ДЛЯ МІЖНАРОДНИХ ПОРІВНЯНЬ

Глибина бідності, визначена як середній дефіцит еквівалентного доходу домогосподарств країни відповідно до встановленої межі бідності, використовується як важливий показник бідності у монетарному її вимірі. У статті показано, що таке визначення глибини бідності є не дуже зручним для здійснення міжнародних порівнянь, і запропоновано альтернативні підходи, в яких використано логарифмічну трансформацію доходу. Наведено результати практичного застосування методів з використанням мікроданих обстеження EU-SILC за 2007 рік.

**Ключові слова:** еквівалентний дохід домогосподарства; база даних обстеження EU-SILC; глибина бідності; вибіркові ваги.

*ЛОНГФОРД Н., НИКОДЕМО К.*

### НЕКОТОРЫЕ АЛЬТЕРНАТИВЫ ОПРЕДЕЛЕНИЯ ГЛУБИНЫ БЕДНОСТИ ДЛЯ МЕЖДУНАРОДНЫХ СРАВНЕНИЙ

Глубина бедности, которая определена как средний дефицит эквивалентного дохода домохозяйств страны в соответствии с установленной чертой бедности, используется как важный показатель бедности при монетарном ее измерении. В статье показано, что такое определение глубины бедности не является достаточно удобным при международных сравнениях, и предложено альтернативные подходы, в которых использовано логарифмическую трансформацию дохода. Представлены результаты практического применения методов с использованием микроданных обследования EU-SILC за 2007 год.

**Ключевые слова:** эквивалентный доход домохозяйства, база данных обследования EU-SILC; глубина бедности; выборочные веса. JEL: I32 – Измерение и анализ бедности; C83 – методы обследования; выборочные методы.

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