J Econ Inequal (2016) 14:199–225
DOI 10.1007/s10888-016-9324-8

International income poverty measurement: which way now?

Stephan Klasen[1] · **Tatyana Krivobokova**[1] · **Friederike Greb**[2] · **Rahul Lahoti**[1] · **Syamsul Hidayat Pasaribu**[3] · **Manuel Wiesenfarth**[4]

Received: 16 February 2016 / Accepted: 22 February 2016 / Published online: 2 April 2016

Abstract We critically review conceptual and empirical issues surrounding the derivation of the international poverty line, expressed in PPP-adjusted dollars and linked to various rounds of the International Comparison Program (ICP). We find that there are some limitations in the current estimation of these lines, but show that statistically superior methods lead to lines that are relatively robust and confirm the $1.25 using 2005 PPPs and suggest $1.67–$1.71 using 2011 PPPs (or close to the $1.90 proposed by the World Bank if we follow the World Bank's approach of adjusting inflation rates in some countries); they also roughly confirm the current shape of the proposed 'weakly relative' poverty line. Using the new absolute line based on 2011 PPPs would lead to substantially lower poverty in our estimation. The extent of the decline depends on whether and how one treats China, India, and Indonesia differently from other countries in the 2005 and 2011 PPPs. More seriously, we note that the dependence on successive ICP rounds creates conceptual and empirical problems that have become worse over time so that we suggest that it would be best to consider alternatives to the current reliance on ICP rounds and the resulting PPPs. As a short-term solution we propose to fix the international poverty line in national currencies using either the 2005 or 2011 level; in the medium term, we argue for global poverty measurement based on internationally coordinated national poverty measurement.

Keywords Poverty · World Bank · Dollar-a-day · Weakly relative poverty

✉ Stephan Klasen
sklasen@uni-goettingen.de

[1] University of Göttingen, Göttingen, Germany

[2] Food and Agricultural Organization, Rome, Italy

[3] Bogor Agricultural University, Bogor, Indonesia

[4] German Cancer Research Center, Heidelberg, Germany

1 Introduction

Since 1990, the World Bank has been measuring poverty in the developing world using the so-called dollar-a-day indicator which attempts to track the share of individuals that have to live on less than an absolute minimum, defined by an international poverty line set in purchasing power parity adjusted dollars (World Bank 1990; Ravallion et al. 2009). The international poverty line has been derived based on the national poverty lines (in PPP-adjusted dollars) of a sample of poor developing countries. In 1990 it stood at $1.02 in 1985 PPP-adjusted dollars (Ravallion et al. 1991); in 2000 it was adjusted to $1.08 in 1993 PPP-adjusted dollars (World Bank 2000; Chen and Ravallion 2001); in 2008 it was adjusted to $1.25 in 2005 PPP-adjusted dollars (Ravallion et al. 2009); and, in 2015, it was adjusted one more time to $1.90 in 2011 PPP-adjusted dollars (Ferreira et al. 2015), extending work by Jolliffe and Prydz (2015) who suggested poverty lines ranging from $1.82–$1.92 in 2011 PPPs.

This international poverty measure has been highly influential in quantifying the extent of extreme absolute income poverty across the developing world and track progress in poverty reduction over time. It helped shape global efforts on poverty reduction. It was included as the first Millennium Development Goal, the World Bank used it to formulate its mission of a 'world free of poverty', and it has shaped academic and policy debates on poverty and policies to reduce global poverty.

Despite this success in shaping development policy, this approach of measuring poverty has not been without criticism (e.g. Reddy and Pogge 2010; Klasen 2013a, b). In fact, we argue in this paper that the problems associated with this particular approach of measuring global poverty have increased over time. They relate to the updates linked to successive ICP rounds, to the (changing) derivation of the line itself, to the missing link to national poverty measurement, and to the instability in poverty level estimates which are becoming increasingly problematic in a world where the complete eradication of absolute income poverty has now been agreed as one of the new sustainable development goals.

We will detail many of these issues below. First we will provide an overall assessment of the strengths and weaknesses of the international poverty line. Then we will focus in some detail on estimation issues related to the construction of the international poverty line. Using data from the 2005 as well as the 2011 PPPs, we will show that there are some statistical problems with the way the international poverty line has been derived so far and make proposals on how to improve on the derivation of both the absolute poverty line (the 'dollar-a day-line') as well as the 'weakly relative' version proposed by Ravallion and Chen (2011) and Chen and Ravallion (2013). Our estimates suggest an international poverty line of $1.67–$1.71 in 2011 PPPs and would lead to a considerable *reduction* in the level of global poverty, compared to previous estimates. These findings are sensitive to the inflation rates used in the sample of poor countries that form the basis of the international poverty line. In fact, if we follow the World Bank's approach to deviating from the CPI in some of the poor countries, we get to $1.88, close to the World Bank's proposed $1.90 poverty in 2011 PPP adjusted dollars. And the reduction of poverty depends to some degree on the treatment of rural and urban poverty lines in India, China, and Indonesia.

Beyond these statistical issues, we will then discuss alternatives to the current reliance of the international poverty line on PPP-rounds and on the process of "updating" the line with the release of each new round of PPP data. In particular we consider proposals to fix the poverty line now in national currencies (using either the 2005 or the 2011 PPP), or to base international poverty measurement on a consistent measurement of poverty using national poverty lines and national currencies as first proposed by Reddy and Pogge (2005, 2010),

Reddy et al. (2009) and also proposed in a modified version by Klasen (2009, 2013a, b). In fact, we will propose that fixing the poverty line in national currencies is a useful short-term solution while future work should focus on developing international poverty measurement that is based on consistently derived national poverty lines, where both absolute as well as weakly relative versions of such poverty measurement should be considered.

2 The World Bank's international poverty measure and its assumptions

Measuring poverty consistently in a single country is clearly a challenging task. Among the questions to be asked are the dimension (e.g. income, functionings, capabilities) in which poverty is to be measured, whether individuals or households are the unit of analysis, whether the poverty line should be invariant across space and time, whether and how one should account for different household size and composition, and whether one should consider just the incidence or also the depth and severity of poverty.[1] These are all complex questions that merit detailed conceptual discussions as well as high-quality comparable household survey data for its implementation. As shown, for example, by World Bank (2015) for the case of Sub-Saharan Africa, reliable and comparable household survey data continues to be a challenge.

For a poverty indicator that attempts to measure levels and trends in poverty in a comparable manner across all developing countries, matters are even more complicated as the inter-country comparability of poverty lines as well as of the underlying survey instruments will be critical additional issues to be concerned about. Data availability and comparability issues will necessarily involve simplifications and short-cuts. In fact, until 1990 it was not possible to generate such comparative poverty figures as the coverage of household surveys in developing countries was simply too sparse. In the 1990 World Development Report (World Bank 1990; Ravallion et al. 1991) the World Bank made a first attempt to measure poverty in a comparable way using an international poverty line and measuring poverty for the year 1985. While the poverty line itself was updated with each PPP-round, the overall approach for establishing the poverty lines has largely remained the same in these three versions which will be described below

Before turning to this point, it is useful to point out a number of implicit choices and simplifications that are inherent in this approach to the measurement of poverty. First, the focus is entirely on the income/expenditure dimension of poverty. Whether such income poverty is correlated with other forms of deprivation or a multidimensional view of poverty consistent with, for example, Sen's capability approach is not considered here (e.g. Sen 1985; Klasen 2000). While this is clearly a narrow view of poverty that can and should be complemented with other approaches to measuring poverty including multidimensional poverty measures (e.g. UNDP 2014; Alkire and Santos 2014), a focus on income is defensible in the context of the Millennium Development Goals (MDGs) where other forms of deprivation were captured in the other MDGs, and a hunger target was placed alongside the income poverty target in MDG1. Similar arguments can be made for the recently proposed Sustainable Development Goals.

[1] For a discussion, see, for example, Sen (1982), Ravallion (1994, 1998), Beegle et al. (2012), and Klasen (2000, 2007).

Second, the international poverty line is invariant in space and time[2] and thus constitutes an *absolute* poverty line that tries to capture the share of people who are in extreme poverty where basic physical survival and health is at risk. As a result, poverty measured in this way is found to be entirely absent in high-income countries, and very low in upper middle-income countries, even though these countries do report positive poverty rates based on broader conceptions of poverty. Interestingly, recently Ravallion and Chen (2011) and Chen and Ravallion (2013) proposed a *weakly relative* version of international poverty where, after a certain level of average incomes, the poverty line rises (under-proportionately) with mean incomes. Thus this is an issue that can be (and has been) addressed, but currently the focus remains on the absolute version of the poverty line. We will return to the issue of weakly relative poverty below (see also the paper by Ravallion in this special issue).

Third, poverty depth is not usually considered, for example in the target for MDG1, where a 50 % reduction in the incidence of poverty (measured using the $ a day indicator) was aimed for between 1990 and 2015. Considering the depth of poverty would indeed be preferable, but somewhat harder to communicate and also makes greater demands on the precision of the data.[3]

Fourth, all of these analyses are based on poverty measurement at the household level assuming equal distribution within its members. This is done in most applications of income poverty measurement (national or international) as it is impossible to assign consumption of all household resources to individual household members; in particular, it is impossible to assign consumption of household-specific public goods (e.g. housing, services, durable goods) to individual members. Of course, this might cause biases as some in non-poor households might be poor and vice versa. Moreover, this approach is therefore ill-suited to examine the differential in poverty by gender or age group as this would require some assessment of the intra-household distribution of income poverty, as males and females as well as different age groups live together in households and the equal distribution assumption would simply assume away most of the problem being studied.[4]

Fifth, figures are per capita figures and do not account for differences in household size and composition which is likely to affect the needs of households as well as their ability to economize on resources. This will have the consequence that poverty in regions with large households and many children (such as many countries in Sub-Saharan Africa) is overstated relative to regions where household sizes are smaller and there are fewer children (such as China or South-East Asia).[5]

Lastly, poverty measurement in this way is based entirely on household surveys. There are many detailed measurement questions such as the consistency of household surveys

[2]The poverty line is adjusted only for differences in prices across space and time. It is true that when the poverty line is updated (e.g. from $1.08 in 1993 PPPs to $1.25 in 2005 PPPs), poverty levels shifted in individual countries for a given year (see below). But each of those poverty lines is absolute in the sense that it does not depend on the economic conditions of a particular country or year.

[3]Most of the background papers by the World Bank team working on these numbers usually also prepare figures that consider the depth and severity of poverty. See, for example, Chen and Ravallion (2010). See also the paper by Ravallion in this special issue that proposes another way to examine how the poorest have fared.

[4]For a discussion, see Klasen (2007) and for an assessment of the bias this might cause, see Haddad and Kanbur (1990). Most multidimensional poverty measures also are based on household-level analyses (e.g. Alkire and Santos 2014), although individual multidimensional poverty measurement is possible in principle (e.g. Vijaya et al. 2014)

[5]In principle, this problem could be addressed by using equivalence scales although there is no consensus in the literature on which scales to use. See, for example, Deaton (1997) for a discussion.

between countries and over time (e.g. Beegle et al. 2012; World Bank 2015), as well as the consistency of income or consumption information in household surveys with the same information in national accounts. Using national accounts' means consumption instead of survey means would generally suggest lower rates of extreme poverty and faster poverty reduction.[6]

While these are all shortcomings of this approach and alternative approaches to some of these questions are clearly possible, most of these choices appear defensible in the context of global poverty measurement and the MDGs/SDGs, where there has been a need for a straightforward comparable poverty indicator that would particularly capture levels and trends in extreme income poverty across regions and over time.

Bearing these methodological choices in mind, the big remaining questions are how this international poverty line is actually derived and how it is then used to measure poverty in each developing country so that poverty levels and trends can then be aggregated and compared. This is described in detail in Ravallion et al. (2009) and in Ferreira et al. (2015). In essence, the international poverty line has been based on expressing available national poverty lines in international dollars using the respective PPP rounds (1985 PPPs for 1990, 1993 PPPs for 2000, 2005 PPPs for 2008, and 2011 PPPs for the 2015 derivation, respectively), plotting them against mean consumption also expressed in international prices (using the same PPP round), and then taking an average of the poverty lines of the poorest countries of the world as the international poverty line.

Using that line to measure poverty in different countries, the following subsequent three steps are undertaken. First, the international poverty line is turned into a poverty line in national currencies at the benchmark year using the PPP exchange rates from the particular ICP round (1985, 1993, 2005, 2011, respectively). Second, this poverty line is adjusted using national inflation rates to generate poverty lines in national currencies backwards and forward in time for all years since 1990 (or even since 1981).[7] Third, the share of the population living below this poverty line is then determined using national household income or expenditure surveys

It is important to emphasize that in all four rounds of calculation (1990, 2000, and 2008, and 2015), poverty rates were recalculated not only for the most recent years, but for *all* years since the beginning of measurement of poverty at the global level (where the first data point generally produced is 1981). Thus we have four sets of poverty estimates for 1981, one based on the 1985 ICP round published in 1990, one for the 1993 ICP round published in 2000, another one based on the 2005 ICP round published in 2008, and now one based on the 2011 ICP. The resulting numbers for the same year in a particular country are very different, sometimes dramatically so, and it is not obvious to say which estimate is the most accurate one, an issue that will be discussed in more detail below.

For example, as described in detail in Chen and Ravallion (2010) and mentioned in Klasen (2013b), the revisions associated with the move to $1.25 poverty line in 2005 prices changed the view on the level and distribution of global poverty in the world in a particularly drastic way, for example raising the poverty headcount for 1990, the starting year of MDG1, from 29 % using $1.08 in 1993 PPPs to 43 % using the $1.25 in 2005 PPPs. The level adjustments were particularly substantial in East Asia, followed by South Asia and Sub Saharan

[6]See Chen and Ravallion (2010) for a discussion of these issues at the global level, Bhalla (2004) for a discussion for the Indian case, and Szekely et al. (2004) for a discussion for Latin America.

[7]In Chen and Ravallion (2013), sometimes a reweighted CPI is used to deflate the poverty line where the share of food is increased in the weight to make the CPI more representative of the budget of the poor.

Africa, while they were much smaller elsewhere. The time trends in poverty between 1981 and 2005 were reported to be much more similar to before. Both are nicely summarized in the title of Chen and Ravallion (2010): "The developing world is much poorer than we thought, but no less successful in the fight against poverty."

The drastic revisions in 2008 have generated considerable debates and commentary with several authors questioning aspects of the revisions (e.g. Deaton 2010a, b; Ward 2009; Klasen 2009; Reddy 2008; Heston 2008). This debate was complicated by the fact that the revision undertaken by the World Bank (2008) included not one but two major changes. The first was to base the entire poverty analysis, including the international poverty line, on the new purchasing power parity estimates that had been produced in the 2005 round of the International Comparison Program (2005ICP), thereby discarding the previously used 1993 ICP. The 2005 ICP suggested that many developing countries, including particularly China, but also India and some African countries were much poorer than previously thought, related to the higher price levels identified in the ICP.

The second major change was that the new international poverty line of $1.25 was created using the same procedure but a different country sample from the one that had previously been used.[8] While many surmised that the changes in levels and regional distribution of poverty were largely driven by the changes in the ICP, Deaton (2010a, b) argued that this is unlikely to be the case. In particular, if the ICP simply lowered the average PPP-adjusted poverty line of the poor countries that make up the international poverty line (due to higher prices observed in these countries in the 2005 ICP) and reduced their consumption levels as well for the same reason, then this should not have any significant impact on measured poverty rates in the developing world. One way to test this assumption is to simply use the old sample of countries that made up the old international poverty line ($1.08) and calculate the new poverty line. Using the median of the national poverty lines of the 10 countries included in the $1.08 poverty line the updated poverty line at 2005 ICP would be $1.05 per capita per day (or $32.04 per month). This apparent decline from $1.08 to $1.05 in the value of the poverty line despite international inflation in the intervening years,[9] precisely reflects the fact that the ICP 2005 finds price levels to be much higher in poor countries (on average and relative to rich countries) than the 1993 ICP. At the $1.05 a day poverty line, the POVCAL database calculates that the number of poor people in 2005 would have been 979 million, only slightly higher than the 931 million found using the old $1.08 poverty line and the 1993 ICP.[10] Thus, indeed it appears to be the case that the change in the ICP has a minor impact on the global number of poor people, while the switch in the sample to generate the new poverty line (i.e. essentially from $1.05 to $1.25) accounts for the bulk of the change to be explained.[11] As a result, the question whether the new international poverty line is properly derived is a key question to examine.

While Deaton (2010a, b) expressed a range of criticisms and suggested some ad hoc adjustments we will take a different route. We basically examine whether the international

[8] This is discussed in detail in Ravallion et al. (2009) as well as Chen and Ravallion (2010)

[9] In fact, as calculated by Chen and Ravallion (2010), had one simply inflated the $1.08 poverty line using the US CPI, the international poverty line in 2005 would be $1.45.

[10] See http://go.worldbank.org/NT2A1XUWP0 accessed on March 23, 2011. After completing work on this paper, we noted that Deaton performed a similar calculation with similar results. See Deaton (2010b)

[11] This confirms the claim by Deaton (2010a, b) who arrived at this conclusion using a different approach. Of course, the changes in the ICP will have larger impacts on the regional distribution of poverty to the extent the changes in the PPP exchange rates differ between and within regions which they did to some extent. See Deaton (2010a, b).

poverty line produced using the 2005 PPPs is properly specified when the most suitable econometric and statistical methods are applied to the issue. As shown in the next section, this essentially boils down to the question how best to estimate a kinked regression line between (the log of) per capita consumption and the national poverty line (expressed in 2005 PPP$), allowing for a flat relationship for a range of low-income economies and an ascending portion covering richer economies, giving it the shape of a piece-wise linear curve.

3 Estimation issues

It is important to preface this section by emphasizing that we do not attempt to somehow generate some consistency between the poverty lines expressed in 1993, 2005, or 2011 PPPs. We thereby accept the (plausible) arguments advanced by Ravallion et al. (2009) that the data base used to generate the international poverty line in 2000 (using 1993 PPPs) was dated, unrepresentative, too small, and with insufficient official status. Indeed, they show that the older database included only 33 observations, largely from the 1980s, while the data base used for the 2008 exercise included 74 observations from 1988–2005; the latter also appear to originate from more official sources while quite a few of the older ones were based on academic studies where it was unclear to what extent these poverty lines were officially accepted. A consequence of accepting this line of argument is that the 'revisions' prepared by the World Bank (2008) were not so much 'revisions' and certainly cannot be considered an 'update': more properly, they are a completely new analysis starting essentially from scratch: a new poverty line is derived using a new sample of countries and new ICP data. The only link to previous estimates is that they are roughly based on the same empirical approach; and the second link is that, once the international poverty line has been derived for the benchmark year (now 2005, before 1993) and translated into local currency in that year, both approaches use *national* CPIs to inflate and deflate the poverty line backwards and forward in time and then use the household surveys of the respective years and the deflated poverty line to count the poor. As a result, it is, of course, not surprising that the trends in poverty have not changed a great deal. They have only changed to the extent that the location of the poverty line also affects the pace of poverty reduction. Since the density of people around the poverty line will differ depending on the location of the poverty line, this will affect poverty reduction, but the effect is typically empirically not substantial.[12]

Once it is accepted that the creation of the $1.25 poverty line was based on an entirely new analysis, trying to find consistency with the previous estimate is no longer the pertinent question. The key question is whether the methods to do it now from scratch are the best available and the results robust to different plausible methodological choices. This is what we focus on here.

In the assessment below, we will consider the revisions using the 2011 PPPs as an update in the sense that we will use the same sample of countries for the poverty lines that were used in 2008 and then re-estimate the line using the same procedures as followed in the 2008 exercise. As discussed below, this is different from the approach taken by the World Bank to generate the new $1.90 line.

The empirical starting point for the analysis is Fig. 1 which shows the relationship between per capita consumption from the national accounts to the poverty line in the sample

[12] See Bourguignon (2003) and Klasen and Misselhorn (2007) for a precise statement on this under the assumption of lognormal income distributions.

of 74 countries (2005 PPP, left panels) and 73 countries (2011 PPP, right panels).[13] The data are identical to the ones used by Ravallion et al. (RCS, 2009), which we then update using the new 2011 PPP exchange rates. We show three specifications, one where the poverty line (Z) is plotted against the (natural) log (ln) of mean consumption (C), one where Z is plotted against C, and a third where both are expressed in log forms. The Z–ln(C) chart is the one usually presented by Ravallion and co-authors (e.g. Ravallion and Chen 2011; Chen and Ravallion 2010, 2013; Ravallion et al. (henceforth RCS), 2009, see also Fig. 1 in Ravallion's paper in this issue). As can be seen, there clearly appears to be a range of low levels of (ln) per capita consumption where the relationship is flat, while the relationship turns clearly positive at higher levels of (ln) per capita consumption.[14] Since the first derivation of the international poverty line, the essence of the international poverty line has been to find an average of the flat portion of the lines. More specifically, this meant to take the approximate value of the poverty lines for the poorest countries (for the 1990 version), take the median (for the 2000 revision) or the mean (for the estimates relying on the 2008 and 2015 revisions) of the flat portion of the curve.[15]

The central questions to be addressed then are whether there indeed is a statistically significant kink in the curve, and where that kink is located. This then will generate the relevant reference group over which to calculate the average. RCS end up with a reference group of the poorest 15 countries which then delivers a mean $1.25 (and a median $1.27) international poverty line. They use two approaches to get there. The first is to estimate the following parametric regression equation

$$Z_i = Z^* I_i + f(C_i)\,(1 - I_i) + \varepsilon_i \tag{1}$$

where Z^* is the mean poverty line of the reference group (countries with $C_i \leq C^*$) and also known as the estimated international poverty line, I_i takes the value one if i is a member of the reference group and zero otherwise.

They then check whether the estimated curve is (roughly) continuous and whether the reference group is consistent so that the estimated per-capita consumption at the poverty line is below the maximum per capita consumption of the reference group countries, and find this to be the case. When estimating the above model, one only needs to check for one condition. If one does not impose continuity on (1), consistency is assured as the OLS estimate of the flat portion of the curve is simply the mean of the reference group. As that group was chosen ex ante, consistency is assured and one just needs to check for continuity which RCS do by visual inspection and find it to be (roughly) so.

They concede, however, that their approach of estimating (1) is statistically not valid as it treats "the regressor I as data since I is a function of C*, which depends on the parameters"

[13] We do not have update PPP estimates for Argentina and thus only have 73 observations in 2011.

[14] Jolliffe and Prydz (2015) do a related exercise and find that the relationship is not flat even for the poorest countries. But their analysis is based on per capita consumption figures translated into US-$ using the Atlas method (which relies on a moving average of market exchange rates). Thus they link per capita consumption using market exchange rates to 2011 PPP national poverty lines but find this relationship to be everywhere positive. It is very hard to interpret these findings as it is heavily affected by the relationship between market exchange rates and PPP exchange rates which can be quite heterogeneous between and within groups of countries of different income levels; mixing market exchange rates and PPP exchange rates this way seems problematic and leads to results that are hard to interpret.

[15] To keep with the more recent approach, we will stick to the mean.

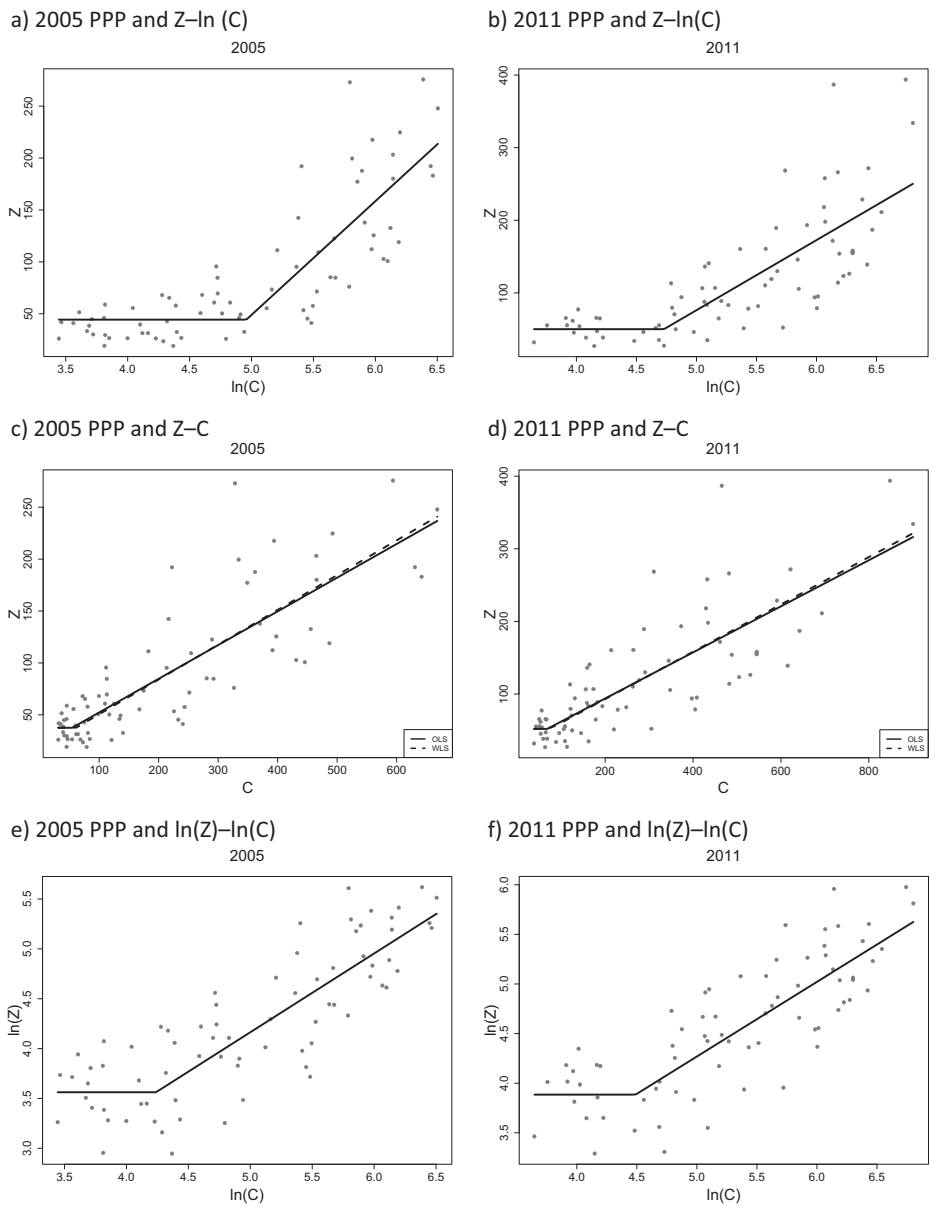

Fig. 1 Derivation of the International Poverty Line using 2005 and 2011 PPP. Note: In chart c) and d) we show two lines, one for an OLS (*solid line*) estimate and one for a WLS (*dashed line*) estimate (to address heteroscedasticity). For 2005, we always include 74 observations, and for 2011 73 (with Argentina missing as there are no data available)

(Ravallion et al. (2009): 175). To remedy this, they estimate a constrained piece-wise linear threshold model based on Hansen (2000) where they constrain the model to have a slope of

0 in the lower linear segment and that there must not be any discontinuity at the kink. Using this approach, the estimate for Z* is quite close ($1.23).

In his critique of the new global poverty numbers, Deaton (2010a, b) is largely concerned with trying to establish some consistency between the old and the new numbers and in the derivation of a new line proposes to weight the observations in Fig. 1 with the absolute number of poor people in the countries. As we are not treating RCS (2009) as an 'update' (as Deaton implicitly does), we are less concerned about the consistency between the estimates (although it is of course interesting to understand what drives the differences). As to the weighting of the poverty lines, while one may give higher weight to poverty numbers that have been derived with greater technical competence or have been based on a great deal of public discussion (as has been the case in India), it appears implausible to assume that the credibility or reliability of the poverty line is proportional to the poor people in the country, as proposed by Deaton (2010a). Also, this poverty line would then be influenced by countries in the ascending portion of the line which appears not right as in these countries apparently absolute poverty considerations have given way to more relative views of poverty, and it appears unclear why these countries should influence the global absolute poverty line (see discussion below).[16]

Thus, our approach is to more narrowly focus on whether the proposed two estimation methods discussed above are indeed the best to estimate the international poverty line. To this we now turn.

The first and rather important point of note is that both models estimated by RCS (2009) do not actually use the relationship in Fig. 1a where the national poverty lines are plotted against respective natural log (ln) of per capita consumption. Instead, both regressions use the per capita consumption (not its ln) as the regressor. They thus try to estimate the relationship in Fig. 1c. But the piece-wise linear relationship that drives the whole motivation for the international poverty line is actually not there in Fig. 1c for 2005 (and 1d for 2011). This is already apparent from visual inspection but can be tested as well. Using the Hansen model and assuming either homoscedasticity or heteroscedasticity, the p-values for the null hypothesis of no threshold (i.e. no kink), are 0.82 and 0.21, respectively. In both cases, one cannot reject the claim of a linear relationship between per capita consumption and the poverty line (i.e., no "flat" portion). In contrast, the p-value for the log-linear relationship in Fig. 1a is 0.0001, clearly rejecting the no threshold hypothesis and confirming that estimating a linear threshold model is clearly favored over a simple linear model. At the same time, the log-linear model suffers from other specification problems. Not only is heteroscedasticity a serious issue, but also the variables are not normally distributed which means that inference regarding the slope of the curve (and the presence of a kink) is not reliable. It turns out that from a statistical point of view, the log-log specification shown in Fig. 1e is statistically to be preferred as heteroscedasticity is much less serious, the variables are normally distributed, and there still is a significant kink (p value of 0.1). Using this model actually generates a reference group of 19 countries for the poverty line and a poverty line of $1.21, quite close to the one suggested by RCS (2009). So while there is a problem with the way they estimate the poverty line, addressing it would not drastically change the results.

For 2011, one way to provide an 'update' is to replicate the same method used in 2005, but stick to the same sample of 73 countries and just use the new 2011 PPPs for the

[16] On a closely related issue, see Ravallion and Chen (2011).

estimation of a new international poverty line in 2011 prices.[17] This is done in the right panels of Fig. 1. The specification tests again suggest that the Z–C relationship does not contain a statistically significant kink at the place indicated in the graph,[18] the Z–ln(C) relationship has a kink, but suffers from the same specification problems, and the ln Z–ln(C) graph shown in Fig. 1f) is the preferred specification and includes a statistically significant kink. The Z–C graphs yield a mean poverty line of about $1.71 and a reference group of 14 countries, while the preferred log–log specification yields a mean poverty line of $1.67, and a reference group of 15 countries, (or also $1.71 and a reference group of 14 countries if we remove three outliers).[19] The 14 countries in our preferred reference group are the same as they were in Ravallion et al. (2009) that lead to the $1.25 in 2005 prices except that our group does not include Nepal (and includes Burkina Faso when we do not drop the outliers and thus have 15 countries).

How does our analysis differ from Jolliffe and Prydz (2015) and the World Bank's new poverty numbers (see Ferreira et al. 2015)? Jolliffe and Prydz (2015) make two proposals. The first, also followed by the World Bank) is not to derive the poverty line afresh as we do here, but simply take the reference group of 15 countries from 2005 and calculate the mean of their poverty lines, using 2011 PPPs. A strict application of this procedure would yield a new international poverty line of $1.70 in 2011 prices, very similar to our proposal. This is not surprising since, as discussed above, our derived reference group is nearly identical to the reference group used by the World Bank (with just one country being different). But Jolliffe and Prydz (2015) and Ferreira et al. (2015) make a second change, which is to selectively adjust some of the inflation rates used to inflate the poverty line in 2011 national currency before translating it into international dollars. For three of these 15 countries they do not use the CPI (as they do for all other countries) but an inflation rate from POVCAL which tried to incorporate price changes faced by the poor more accurately. This way they get to $1.82. Further changes made to inflation rates in Ferreira et al. (2015) lead to poverty lines in 2011 PPPs that then average to $1.90 (rounded from $1.88) and these are now the new official World Bank numbers.[20] If one takes take out just one of these countries where this ad hoc and selective adjustments was made by Jolliffe and Prydz and Ferreira et al. (2015), i.e. Tajikistan where both find the national poverty line to be $3.18 in 2011 PPPs instead of $1.82 when using the CPI, the estimated global poverty line would drop from $1.88 to $1.78; in fact, if one took out all the price adjustments implemented in Ferreira et al. but used their procedure to estimate the global poverty line (taking the average of the 2005 reference group), one would get exactly to our estimate of $1.70. This demonstrates how sensitive the global poverty rate is to selective changes in inflation assumptions and that the difference between our estimates and those of the World Bank are entirely due to

[17] We also do the estimation on a sample that only includes the 73 observations that are common to both years which means we drop Argentina in the 2005 estimation; the resulting poverty line stays at $1.21 and the results regarding the lack of a kink in the C–Z plot remain.

[18] It finds a statistically significant kink at a threshold of 481$ a month (or 15.8$ a day), far above where it should be (which is around $90 per month or about $3 a day).

[19] The Z–ln(C) generates a poverty line of $1.46 using 39 countries in the reference group in 2005 and $1.64 including 19 countries in the reference group. Due to the specification problems discussed above, we do not place much confidence in these estimates. The three outliers are Hungary, Mauritius, and Uruguay.

[20] A further strong adjustment in the inflation rates was made for Ghana which leads to this change. A smaller change was also made in the case of Malawi.

these adjustments. Although Ferreira et al. (2015) provide some detailed discussion and motivation for these changes, it is not clear why similar arguments would not apply to the other countries, whether these particular adjustments are the best ones to be done for those countries, or whether there would be a better approach than these ad hoc adjustments.[21]

We believe that our general approach of re-doing the derivation of the poverty line is better than simply sticking to the old reference group; it is also in the spirit of previous adjustments where the reference group was always changed and derived endogenously. But we note that even their approach, without the ad hoc adjustment of the inflation rates made, would lead to $1.70, very close to our own estimate. And we also note, as shown above, that our reference group differs from the one now used by the World Bank only by one country. Though we believe it is conceptually superior, empirically it only has a minor impact.

Using these lines and the Global Consumption and Income Database (GCID, Jayadev et al. 2015), we then work out the headcount and the numbers of poor people for 2010 in Table 1 for the largest developing countries. Since the GCID works similarly to the World Bank's POVCAL database in the sense that it estimates Lorenz curves based on available information on quantiles of the distribution and uses survey means for their poverty assessment, one can then assess the impact this has on estimates of poverty using these international poverty lines.[22] An advantage of the GCID is that it uses a wider set of data sources than POVCAL, is particularly transparent about the sources of the data used and consistent about the way they were adjusted, and also uses a regression-based approach to make income and consumption surveys more comparable, a shortcoming of POVCAL also highlighted by Ferreira et al. (2015). Differences with results based on the use of POVCAL are generally slight with the exception of countries where income-based surveys are used in POVCAL (see below).

The table requires some careful interpretation. Column 1 (column 5) presents the headcounts (number of poor) using GCID and $1.25 using 2005 PPP, columns 2–3 (6–7) then use our preferred estimates for headcounts (number of poor) using $1.67 and $1.71 in 2011PPP, respectively. Columns (4) and (8) then reproduce the new official World Bank figures, based on Ferreira et al. (2015) and using POVCAL as the database.

For three countries, China, India, and Indonesia, we split up, following practice by the World Bank, the estimates in rural and urban areas. This is particularly important also to generate consistency with prior estimates by the World Bank and the estimates provided by Jolliffe and Prydz (2015) as well as the new World Bank poverty numbers. When using the 2005 PPP, the World Bank argued that the PPPs for China referred to urban areas only and an adjustment had to be made for rural areas where the price levels were thought to be substantially lower in PPP terms; as a result, poverty in rural China would be much lower than without this adjustment. Similarly, it was argued that the rural estimates were unrepresentative for India and also in Indonesia, another very large country, and that there should be an adjustment for differences between rural and urban PPPs. In each case, an adjustment was

[21] The second proposal by Jolliffe and Prydz (2015) and not followed by the World Bank, is to simply take the average of poverty lines of all 32 countries classified as low-income using the World Bank's 'Atlas method'. That would lead to a poverty line of $1.92 in 2011 prices. A problem with this approach is that the use of the Atlas method to classify countries is based on market exchange rates which yield very different results to PPPs. It is not the case that the 32 low income countries would also have the lowest per capita consumption when using PPP exchange rates. This reference group is then related to 2011 PPP poverty lines, which appears to be an odd mixture of concepts based on market exchange rates and PPPs.

[22] POVCAL increasingly resorts to calculating distributions directly using micro data. Empirically, this is more precise although rarely makes a significant difference, compared to using grouped data.

Table 1 Poverty rates and number of poor using 2005 and 2011 PPPs

Data source		(1) GCID	(2)	(3)	(4) POVCAL	(5) GCID	(6)	(7)	(8) POVCAL
Country	Year	Head count at $1.25 2005 PPP (%)	Head count at $1.67 2011 PPP (%)	Head count at $1.71 2011 PPP (%)	Head count World Bank $1.90 2011 PPP (%)	Number Poor $1.25 2005 PPP	Number Poor $1.67 2011 PPP	Number Poor $1.7 2011 PPP	Number poor WB $1.90 2011 PPP
Bangladesh	2010	43	28	29	43	65	42	44	65
Brazil	2010	0	0	0	6	0	0	0	12
China (ICP)	2010	17	17	18		227	227	241	
China (POVCAL)	2010	10	10	11	11	137	135	147	147
Rural (ICP)	2010	34	33	35		230	227	238	
Rural (POVCAL)	2010	18	18	19	21	122	120	129	143
Urban	2010	0	0	0	1	0	0	0	7
Egypt	2010	8	1	1	8	6	1	1	6
Ethiopia	2010	37	29	31	34	32	26	27	30
India (ICP)	2010	50	26	28		603	313	338	
India (POVCAL)	2010	33	15	17	31	395	181	205	379
Rural (ICP)	2010	62	34	36		515	283	300	
Rural (POVCAL)	2010	34	13	14	36	284	108	117	302
Urban (ICP)	2010	29	11	12		87	40	45	
Urban (POVCAL)	2010	33	15	16	20	108	56	60	76
Indonesia (ICP)	2010	22	13	14		53	31	34	
Indonesia (POVCAL)	2010	19	10	11	16	45	26	29	38
Rural (ICP)	2010	31	21	22		37	25	27	
Rural (POVCAL)	2010	18	10	11	20	21	12	13	24
Urban (ICP)	2010	13	7	7		15	8	8	
Urban (POVCAL)	2010	18	11	12	12	22	13	14	14
Mexico	2010	2	4	4	4	3	4	5	4
Nigeria	2010	61	46	48	53	97	73	77	83
Pakistan	2010	14	4	5	8	24	7	8	14
South Africa	2008	14	14	15	17	7	7	7	8
Tanzania	2010	49	46	48	47	22	21	22	21
Vietnam	2010	3	1	1	5	3	1	1	4
Total (ICP)						1143	754	803	
Total (POVCAL)						836	524	572	812

Note: Columns 1-3 and 5-8 are based on the data from the Global Consumption and Income Database (GCID). Columns (4) und columns (8) reproduce headcount and number of poor that are now the official World Bank figures, based on Ferreira et al. (2015); they are derived from a new version of POVCAL that now uses 2011 PPPs (and makes some other changes as discussed in the text). Note that the World Bank did not produce a 2011 PPP estimate for Bangladesh and Egypt; thus here the figures using the 2005 PPP are reproduced (see text). ICP refers to using the PPP exchange rates provided by the ICP. POVCAL in the rows refers to PPP exchange rates that were adjusted for urban/rural differentials in China, India, and Indonesia by the World Bank (see text). Note also that the figures for rural and urban poverty do not add up exactly to the figures for total poverty in India, China, and Indonesia. This is due to the fact that for the three estimates (rural, urban, national) a different distribution is fitted from the data and this leads to these discrepancies.
Source: Estimations based on Global Consumption and Income Database. For details see Jayadev et al. (2015)

made (in China, only the rural line was adjusted, while in India and Indonesia, both lines were).[23] This was then implemented in POVCAL and integrated in all the estimations of global poverty by the World Bank (e.g. Chen and Ravallion 2010). It served to substantially reduce estimated poverty in rural areas in the three countries, while increasing it in urban areas in India and Indonesia.

Since the 2011 ICP round better captured rural areas, Jolliffe and Prydz (2015) argue that such an adjustment is no longer necessary. In the new World Bank numbers, Ferreira et al. (2015) retain the adjustment, but use more recent data to make the adjustment which substantially reduces the impact of this adjustment.[24]

So in Table 1, we provide three sets of estimates for China, India, Indonesia, and the respective rural and urban areas in these countries. One is straight from the ICP, i.e. without the mentioned adjustment done by the World Bank using the 2005PPP. A second one uses the adjusted PPPs for urban and rural areas as they had been included in POVCAL for both periods (2005 and 2011). Jolliffe and Prydz (2015) proposed then to use the adjusted ones from POVCAL only for 2005 PPPs, and not for 2011 PPPs. That is, of course, simply a combination of the estimates of the two rows.[25] The third estimate are the World Bank numbers following Ferreira et al. (2015). They are also based on POVCAL, but the new version of POVCAL where the adjustment made for different poverty lines in rural and urban areas is much less important than before. A last point is worth noting before discussing the results: For 7 countries, the World Bank chose to retain the poverty line of $1.25 at 2005 prices as the 2011PPPs appeared to be implausibly different from the 2005PPPs. In Table 1, this concerns Bangladesh and Egypt. This is not unproblematic since it makes these poverty numbers less comparable to the other ones, and also affects global poverty numbers.

When comparing the $1.25 at 2005 prices with the $1.67–$1.71 at 2011 prices, two things are noteworthy. First, for all countries except China and South Africa, the poverty incidence and the number of poor people is lower using the $1.67 or $1.71 poverty line in 2011 PPPs, compared to $1.25 in 2005PPPs. In many countries this is substantially so (e.g. in Nigeria, Pakistan, and Bangladesh), suggesting that the developing world as a whole appears substantially less poor in 2011 PPPs than the 2005 PPPs had suggested. In South Africa and China, poverty estimates do not differ between 2005 PPPs and 2011 PPPs; in the case of China, this is only true if the adjustment for urban and rural areas is either applied to both years ('POVCAL') or to neither ('ICP'). Secondly, whether one makes the adjustments for urban and rural PPPs for the three largest countries, China, India, and Indonesia, really

[23] The adjustment was made in a way so that the ratio of poverty in rural and urban poverty line in PPP terms matched the ratio using national currencies.

[24] There is, in contrast to previous work by Ravallion on the matter, no thorough investigation of whether the PPPs in rural and urban areas seem reasonable in the three countries to back up this assumption. Also, since the adjustment in Indonesia was not based on perceived problems in the PPPs but on the desire to reflect regional differences in prices, it is not so clear that one should no longer do this in this case.

[25] Ferreira et al. (2015) make a further assumption when calculating the poverty numbers. For some countries (Bangladesh being the largest and, in terms of poverty numbers, the most important one) they are uncomfortable with the very large shift in price levels in the 2011PPPs, compared to the 2005PPPs and they stick for those countries to the $1.25 and 2005 prices. For details, see Ferreira et al. (2015).

matters for both levels of poverty and differentials between 2005 and 2011 PPPs. Not doing the adjustment leads to a poverty count using $1.25 of 1.14 billion for the countries included in Table 1, which drops to around 800 million using the 2011 PPPs; doing them in both years suggests a poverty count of 840 million using 2005 PPPs, and around 550 million using 2011 PPPs. And doing what Jolliffe and Prydz (2015) i.e. applying the adjustment for 2005 PPPs and not for 2011 PPPs, leads to a much smaller change in poverty, from 840 million using 2005 PPPs to 750–800 million using 2011 PPPs. Using the procedures of Ferreira et al. (2015) which, as discussed above, is based on a substantially higher poverty line for 2011, a much less drastic adjustment for urban-rural differences in China, India, and Indonesia, and a reliance on the 2005 figures for Bangladesh and Egypt, leads to the smallest change in poverty, from 836 million to 812 million in our set of countries. Note also that the use of POVCAL leads to much higher poverty in Brazil at 6 %, compared to 0 % when the GCID is used. This is entirely related to the fact that Brazil is the only country in Table 1 where the data in POVCAL are based on an income survey while the GCID uses the adjustment to make these data comparable to a consumption-based estimate.

A closer look at the three countries with urban and rural estimates shows the very high sensitivity of the rural-urban adjustment for poverty in these countries and, given the size of these countries, for global poverty counts. For example, rural poverty in China can be as high as 35 % when not using the adjustment and as low as 18 % when doing the adjustment. In rural India, the difference is even larger, ranging from 13 % when doing the adjustment to 62 % when not doing it. If this is empirically so important, it clearly deserves substantially more attention and requires further analysis to see whether this adjustment is justified in both years, whether it is appropriate to change the adjustment in the way it was done in Ferreira et al. (2015), whether it should be done in other countries as well, and how best to do the adjustment. Thus we are in a situation where one either finds very little change in poverty, if one uses the selective adjustments to inflation rates which lead to the $1.90 poverty line and changes the rural-urban adjustment in China, India, or Indonesia, or a substantial decline in poverty if one does not make these inflation adjustments and treats the rural-urban adjustments the same across the 2005 and 2011 rounds, a question also addressed in Martin Ravallion's contribution to this special issue. Since the poverty line is based on the same sample of countries, any observed declines must come from differences in the two PPP rounds that differentially affect the reference group and other developing countries, including changes to the rural-urban adjustment of the poverty lines.[26]

We have not studied in detail the accuracy and potential biases of the 2005 and the 2011 ICP rounds. Deaton and Aten (2014) have argued that the results of 2011 should be treated as more credible and they suggest that there were problems with linking the regional ICP exercises in the 2005 round which particularly led to the high prices (and high poverty) in Asia

[26]Ferreira et al. (2015) show that generating a country-specific poverty line that would keep poverty rates unchanged using the 2005 and 2011 rounds and that is calculated using all countries (not just the reference group) would also be around $1.90. This would suggest that there are no differences between the reference group and other countries. But this conclusion is only valid given the selective change in inflation rates to some countries in the reference group. Otherwise there is a substantial difference between the $1.70 we find and $1.90 this approach yields.

using the 2005 round.[27] Ravallion (this issue) has also examined this problem, suggesting that the 2005 round is to be preferred, compared to the 2011 round. More generally, these massive changes point to serious conceptual as well as empirical issues. On the conceptual side, it just reiterates that PPPs cannot directly be compared across rounds as they are only suitable from cross-sectional but not inter-temporal comparisons (see Klasen 2013a, b and Reddy and Pogge 2010). Thus it is possible that a significant share of the decline observed in Table 1 is due to this incomparability as global prices and structures of demand have shifted in ways that generates these changes. This could be investigated by linking the changes in prices and global demand to the changes observed in the PPP estimates, an exercise that is beyond the scope of this paper. The empirical issue is that despite serious efforts, better coverage, and arguably improving methods, even the latest ICP rounds cannot yet be considered as a very accurate assessment of PPPs across the developing world. The sheer complexity of the exercise is still militating against providing reliable results for many developing countries. Given these vagaries, it is doubtful whether one can rely on the successive PPP rounds to provide an accurate picture of the levels and distribution of global poverty, a discussion to which we return below.

4 Weakly relative poverty versus shared prosperity

As discussed above, one conceptual problem of the $ a day line is its absolute nature and focus on extreme poverty which makes this poverty line increasingly irrelevant for an increasing number of developing countries, and disregards that poverty can also have relative elements (e.g. Sen 1984). Of course, the first problem can be remedied by also considering higher absolute poverty lines (such as $2 a day) and this is regularly done in publications by the World Bank (and can be done by users in POVCAL). But for the second problem, relative poverty concerns cannot easily be addressed in this way.

In a series of papers (Ravallion and Chen 2011 and Chen and Ravallion 2013, as well as Ravallion's contribution to this special issue) have taken up this issue and argued for a concept of weakly relative poverty. Key to that concept is that they claim that there is a cost of social inclusion which is an important aspect of poverty and which rises with mean income/consumption. Figure 2 in Ravallion (this issue) shows that there is a schedule of the costs of social inclusion that has a positive y-axis intercept and then rises with a constant slope. Combining this with an absolute threshold, the 'weakly relative poverty' line is equal to the absolute poverty line below some threshold (which is the kink in the curves in Fig. 1), but above that threshold it is simply the schedule of the costs of social inclusion. As a result, above the kink, the elasticity of this weakly relative poverty line rises with mean consumption, but underproportionately so that the elasticity of the poverty line with mean income increases as incomes go up, but always stays below 1. This is in contrast to previous formulations by Atkinson and Bourguignon (2001) who posit a purely relative line (with an elasticity of the poverty line to mean income of 1) as indicated by the strongly relative line in Fig. 2 of Ravallion (this issue).

Empirically, this approach essentially boils down to estimating not just the location of the kink in Fig. 1 (to determine the reference group for the absolute poverty line) but to

[27] Ward (2009) also argued that the 2005 round might have overestimated prices in many poor countries by emphasizing too much the comparability of items in different countries, rather than their relevance in national consumption patterns.

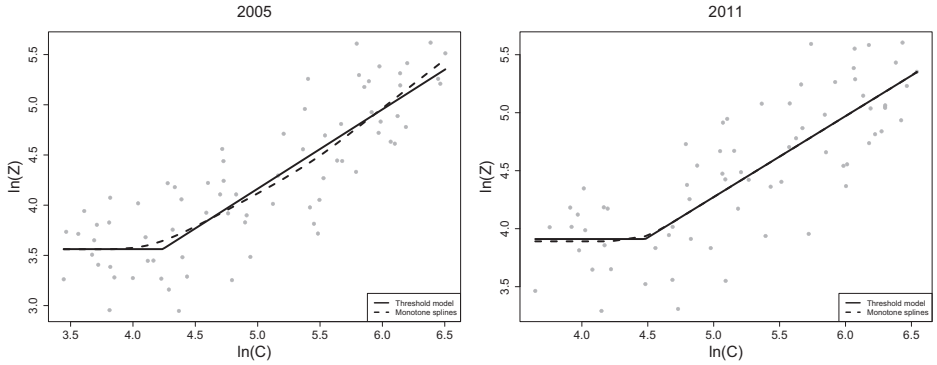

Fig. 2 Weakly relative poverty, piece-wise linear and using monotone splines

find the best fit for the entire curve, including particularly the rising portion. This can be done by using the same Hansen threshold model, but constraining the line before the kink to be flat, and to rise linearly above the kink. It turns out that the best fit for the entire curve is consistent with a curve where the elasticity of poverty to mean consumption is positive, increasing with mean consumption, but never approaches 1. In Ravallion and Chen (2011) these were estimated (presumably using the Z–C relationship shown in Fig. 1c although this is not explicitly stated) using the Hansen (2000) method, while in Chen and Ravallion (2013) they are derived by just considering the rising portion.

This approach leads, of course, to a drastically different impression of poverty levels and the pace of poverty reduction in the developing world (Chen and Ravallion 2013). For example, 'weakly relative poverty' is much higher in Latin America than absolute poverty (46 % versus 6 % in 2008) as Latin America is much richer, which raises their 'weakly relative' poverty line far above $1.25 (to $5.93 in 2008). In fact, 'weakly relative' poverty is much higher there than in East Asia, while the reverse is true for absolute poverty. High mean incomes and high inequality lead to drastically high poverty rates in Latin America. Second, 'weakly relative' poverty reduction is noticeably smaller than absolute poverty reduction. Between 1990 and 2008, weakly relative poverty fell only from 56 % to 47 % while absolute poverty fell from 43 % to 22 % (Chen and Ravallion 2013). This is not surprising as rising incomes lead to a rise in the 'weakly relative' poverty line, thereby making progress in poverty reduction harder.

Within the limitations of the overall approach of generating poverty lines using PPP-adjusted national poverty lines (see discussion above and below), this particular formulation of weakly relative poverty has a few interesting and desirable features. It recognizes that poverty, at least when measured in the income space, is partly relative without moving to a purely relative formulation.[28] It thereby recognizes the empirical reality that poverty lines are higher in richer countries and tend to be adjusted upwards (but underproportionately) in real terms as countries grow richer (Chen and Ravallion 2013). And it also ensures that such a 'weakly relative' international poverty line is relevant for all developing countries. In fact, it could easily be extended to rich countries as well and thus ensure, in the spirit of the

[28] In this sense it can be seen as consistent with Sen's statement that poverty should be seen as absolute in the space of capabilities, but relative in the space of resources, if one recognizes that not all capabilities are purely relative (e.g. the capability to be adequately nourished is unlikely to rise proportionately with mean consumption levels).

universality of the new Sustainable Development Goals (SDGs), that one could adopt goals and targets that are globally relevant and not just focus on (poor) developing countries.

This way of analyzing 'weakly relative' poverty compares favorably with the recently proposed 'shared prosperity' goal by the World Bank, which tracks the growth of average incomes of the poorest 40 % and compares this to mean growth rates (Basu 2013), and seeks to enhance the mean growth rate of the bottom 40 %. But this 'shared prosperity' approach is a rather ad hoc and discontinuous way of considering a particular poor segment of the income distribution with no direct link to poverty reduction at all. High growth of the poorest 40 % may coincide with high or low poverty reduction, depending on whether the poverty headcount is above or below 40 % and which groups among the poorest 40 % are growing particularly rapidly. Secondly, this approach of using the mean growth rate of the poorest 40 % is biased towards the fortunes of the richer segments of that group (i.e. the fourth decile) as their growth will affect mean growth much more than the growth of the poorest people.[29] 'Weakly relative' poverty is a much more straight-forward way to include a concern for inequality reduction and thus shared prosperity that has a direct link to poverty reduction than the ad hoc goal proposed by the World Bank.

At the same time, both the conceptual as well as the empirical derivations are open to question and could be further developed. At the conceptual level, it is not clear that this approach needs to mix an absolute threshold below a certain level of consumption, and a weakly relative one above that. In particular, the justification for the absolute poverty below the threshold is unclear as there are evidently rising costs of social inclusion already below the threshold so that one may wonder what justifies that the slope of the poverty line is flat there.

Instead of positing a fixed cost of social inclusion one could just as easily argue that, whatever the income, there is a fixed cost of survival that is absolute. On top of that comes the cost of social inclusion that is relative and rises with mean consumption. To be non-poor means that consumption is high enough to cover the fixed costs of bare survival plus the costs of social inclusion that depend on mean consumption.

Empirically, this would then imply a 'weakly relative' poverty schedule that has no flat portion but a smoothly rising curve that is made up of the fixed costs of survival and the variable costs of social inclusion that rise continuously with mean incomes. This might also fit the data better, particularly if one gives up the restriction that the function must be piecewise linear (and flat below the threshold), and allows it to be estimated using splines.[30] The results are shown in Fig. 2 below for 2005 (left panel) and 2011 (right panel), where we compare monotone splines with a piecewise linear formulation. In 2005, using a continuous function estimated via splines makes a bit of difference, particularly in the area close to the threshold and also above it. In 2011, the difference between the spline estimate and

[29] For a discussion of these issues in the context of distribution-weighted growth rates, see Klasen (1994). One way to solve this problem would be to use the mean of growth rates of the poorest 40 percentiles, as done in growth incidence curves and related measures of pro-poor growth (see Ravallion and Chen 2003).

[30] Monotone regression splines allow to fit a function with a given constraint, for example concave, convex, or monotonically increasing. With this approach we fitted the data by a fully flexible function, constrained to be monotonically increasing. To compare the fit one can compare the mean of squared residuals which was found to be lower for our monotone spline model, compared to the threshold model, although the different in shape is rather slight. See Meyer (2008) for a discussion of monotone splines.

the piecewise linear is smaller.[31] To conclude this discussion, we believe that the idea of a 'weakly relative' poverty line is quite interesting and offers a range of advantages, but can arguably be better represented by a continuous function that increases in the level of average prosperity.

5 The international poverty line: an assessment

In the discussion so far, we have pointed to a number of problems and issues related to the implicit assumptions and the derivation of the international poverty line. The most serious problem we found concerns the massive differences in poverty levels that arise from changes in the PPP benchmark years. This was already an issue when the benchmark year was changed from 1985 to 1993 (see Reddy and Pogge 2010) and the poverty line switched from $1.02 in 1985 prices to $1.08 in 1993 prices. But the problem got much more severe with the switch to the 2005 benchmark year and the $1.25 poverty line. Here particularly the changes in the sample to estimate the poverty line generated a massive change in the global poverty incidence. The change in the PPPs also led to significant shifts in the regional distribution of poverty. While many made convincing arguments that the 2005 PPP was substantially better than the previous ICP rounds (e.g. Chen and Ravallion 2010), the publication of the 2011 PPPs which are yet again vastly different, not only questions some of these apparent improvements (e.g. Deaton and Aten 2014) but more generally questions the ability to derive reliable and consistent PPP estimates for all countries of the world that are suitable for poverty analysis.

While the numbers presented by the World Bank suggest smaller changes to poverty rates in the world and in most regions using the 2011 PPPs, we have shown above that this result derives from adjustments to inflation in some countries as well as changes in the treatment of the rural-urban differentials in three countries. Different ways to address these issues would lead to sizable changes in the number and distribution of poverty.

There are three further problems with the reliance on the PPP rounds that suggest that the problems of using them are becoming increasingly apparent and actually increase with time. The first relates to the weak linkage of international poverty measurement with national poverty measurement. An increasing number of countries have developed their own national poverty lines and track poverty in their countries using these lines; indeed the World Bank is generally using these national poverty lines also in their advisory and policy work in individual countries (Ravallion 2010). The dramatic mismatch caused by the gap between the generally reasonably consistent trends in national poverty measurement and the highly erratic levels of poverty associated with the different ICP rounds only generate policy confusion. What should China make of the question that its poverty rate using 1993$ was 10 % in 2005, or 16 % using the 2005 international poverty line? What information does Table 1 contain for Indian policy-makers that suggest that poverty in 2010, using the international poverty line, is 15 percentage points lower than previously thought?

In addition to these jumps that have no relation to consistent national poverty measurement using national currencies, there is even a problem of mismatch for those countries whose poverty line was actually included in the reference group of countries that generate

[31] Using those curves, the splines, the estimated elasticities are also increasing with higher mean consumption which is consistent with the arguments made by Ravallion and Chen (2011).

the international poverty line. This is basically a question about the variance of the poverty lines in the reference groups. While Chen and Ravallion (2013) readily acknowledge that the national poverty lines in the reference groups are not identical and have some variance, they do not discuss the implications of this. This is done in Dotter (2013) which shows that the seemingly small spread of data points around the flat portion of the line in Fig. 1 actually has huge implications. One particularly striking example is the difference between Tanzania and Tajikistan, two countries that are in the reference group for the 2005 $1.25 poverty line and have similar mean per capita expenditures (of about $45 a month). In Tanzania, the national poverty line is far below $1.25 (at $0.64, the lowest outlier in the flat portion of the curve in the left-hand panels of Fig. 1). In national currency, the poverty rate stands at 53 %, while according to the $1.25 a day line, it is 89 %. Conversely, in Tajikistan, the national poverty line is substantially higher (at $1.96, the highest outlier in the reference group in the left-hand panel). As a result, the national poverty headcount is 77 %, while using the $1.25 poverty line, it is only 44 %. These are the most extreme examples, but differences in the headcount using national and the international poverty line in the countries included in the reference group are more than 10 percentage points for the majority of countries. Thus even for countries whose national poverty lines have helped to form the international poverty line, the difference between the national and international lines are large

A second problem relates directly to the practice, used until today, to recalculate all poverty rates back to 1981, always using the newest PPP estimates available. This is done by the World Bank to avoid having to address the inconsistencies that are inherent (as seen above) in the different PPP rounds. It also ensures, as discussed above, that *trends* in poverty reduction are hardly affected by the switches in PPP rounds over time (while levels shift a lot), since the recalculation involves using the same national CPIs back to 1981 used throughout. While this approach has important advantages, it creates a different problem. This practice assumes that the latest PPP round always gives the best impression of PPPs also for years that are increasingly far back in the past, i.e. that the ICP done in 2011 represents the best estimate of relative purchasing powers in 1990 or even 1981. As the structure of the world economy, world demand, and prices have shifted dramatically over the past few decades, this is an increasingly untenable assumption. It generates a seeming consistency of poverty trends that is artificial and simply unlikely to reflect PPPs in past decades even if it were the case that the 2005 or 2011 ICP is an accurate reflection of today's PPPs.

Lastly, the change from the MDGs to the SDGs poses a further problem for international poverty measurement linked to the conceptual and empirical vagaries of successive ICP rounds. As discussed above, the change in the level of poverty associated with the switch in the ICP rounds affected only in a minor way poverty trends, and thus progress towards the MDG of *halving* world poverty. But the new SDGs call for the *elimination* of absolute extreme poverty and the World Bank has similarly set itself the goal of reducing absolute extreme poverty to below 3 % by 2030. These fixed level end-goals only make sense if we know what the current level is. And if we now find out, as some figures in Table 1 suggest, that poverty is substantially lower using the 2011 PPPs than using the 2005 PPPs, we are making progress in poverty elimination by simply switching between PPP rounds![32] And who knows, maybe the next ICP round will reveal that the poverty problem is more severe after all. Clearly, monitoring these goals with fixed level targets does not make sense.

[32]This is one of the reasons why Ferreira et al. (2015) explicitly state as a goal to reduce the change in poverty levels using 2005 and 2011 PPPs, and their adjustments to the data made sure that the change was indeed relatively small.

As a result of this increasing number of problems with the current international poverty line, it is high time to consider possible alternatives to global poverty monitoring to which we now turn.

6 A quick fix and a longer-term alternative

Clearly, a central problem of the current international poverty line is its reliance on successive ICP rounds and their associated conceptual and empirical problems and their massive empirical inconsistencies. The quick fix would be to translate the international poverty line into national currencies, fix it in national currencies, and merely update it for changes in inflation in the country (possibly using an inflation rate that particularly matches the consumption patterns of the poor).[33] When a new PPP round becomes available, this would then have no further influence on global poverty measurement as the level of the poverty line would continue to be based on the inflation-adjusted national poverty line that, at some point in the past, had been linked to the international poverty line. Concretely, if one has doubts about the 2011 PPP (as Ravallion does), one could disregard the 2011 PPP round and merely adjust the national poverty lines that were consistent with $1.25 PPP-adjusted in 2005 using national inflation rates. This would allow consistent monitoring of global poverty, also towards a level-end goal, and countries would no longer be surprised with sudden jumps in the level of poverty associated with a new PPP estimate. Of course, this proposal is merely a fix, not a real solution, as its accuracy depends entirely on the quality and relevance of the ICP round for which the fixing in national currencies was done. Moreover, it is unclear whether one should fix it using the 2005 ICP or the 2011 ICP; those who believe that the 2011 round is superior (including Deaton and Aten 2014, and Ferreira et al. 2015) might find it preferable to fix it in 2011$. Which approach is to be preferred depends on the relative biases and problems with these two rounds which are discussed in other contributions to this special issue.

The longer-term solution to this problem would be to find ways to develop internationally consistent national poverty lines in national currencies for global poverty monitoring (Klasen 2013a, b). The approach, which has been suggested by Reddy and Pogge (2005, 2010) and Reddy (2008) and applied as an example in Reddy et al. (2009) consists of creating *national* poverty lines using a procedure that is internationally consistent so that poverty measured in this consistent way could be aggregated across countries. Reddy et al. (2009) have a particularly ambitious way to implement this, which is to first define a basket of basic functionings/capabilities deemed necessary for the poor across the world, and then investigate its monetary costs in different settings.

While this approach is a very ambitious program that would require a detailed conceptual process of defining basic functionings/capabilties, deriving appropriate weights, and then costing them across the globe, there is a cruder method available that builds on existing ways to set national poverty lines. In fact, the most common way to generate national poverty lines in developing countries is to link them in some form to a nutritional requirement. There are principally two approaches (see Ravallion 1994): The food-energy-intake method and the cost of basic needs method. Briefly, the former asks what incomes are empirically

[33] Of course, there are other fixes available, such as keeping the reference group constant as in Jolliffe and Prydz (2015), ensuring that global poverty numbers match, or others. For a discussion of various options, see Jolliffe and Prydz (2015).

needed to allow households to have a specified number of calories per capita (or adult equivalent). This is done by running a regression of caloric intake on incomes (or expenditures) to identify the required expenditures to meet a certain caloric norm. India's poverty line adopts this approach and is based on the incomes that in 1973/74 were sufficient to purchase an adequate diet in rural and urban areas (see Subramanian 2005; Reddy 2007). These poverty lines can then be updated over time by either some consumer prices index (ideally using a basket that reflects purchasing habits of the poor), as done in India, or the exercise can be simply repeated in each (survey) year, as apparently done in Bangladesh where a new poverty line is generated using the expenditure-food intake relationship (Wodon 1997).

The Cost of Basic Needs (CBN) Method, now used predominantly by many developing countries as well as the World Bank, is closely related but proceeds somewhat differently. It first chooses a reference group of probably poor people (e.g. the bottom third of the income distribution), examines the level and type of food expenditures to generate a food basket that determines the shares of food types in that basket. The (food) poverty line is then the amount of food expenditures needed so that this basket will provide a pre-defined caloric content (i.e. the food expenditures in each group are proportionately scaled up or down across the entire basket until they deliver this caloric norm). Allowance for non-food items is then made by either taking the average non-food share of those households whose food expenditure equals the food poverty line (upper limit) or whose total expenditure equals the food poverty line (lower limit).[34] Updating of the poverty line can be done in three ways, either by simply using a consumer price index (or one relevant for the poor), or by using the specific prices for the items in the food basket (and either keeping the non-food share fixed or using a new survey to allow it to vary), or by redoing the entire exercise using a new household survey. Most often, the second method is used, i.e. updating the prices of the food basket and (most often) keeping the non-food share fixed.

Using these nationally-set poverty lines and poverty rates derived from either of these methods, one would examine levels and trends in poverty, country by country, and then simply add up the number of poor people across countries, without reference to an international poverty line. To the extent that these approaches are indeed fully comparable across countries (and time) and measure how many people have insufficient incomes to consume enough food, one would this way generate a global poverty estimate of the poor. This estimate would obviate the rather complex conceptual and empirical problems inherent in the current PPP-based international poverty lines. There would also be other benefits, including their direct link to national poverty measurement which, as discussed above, is a huge problem with the current international poverty line. Such an approach would also guarantee a better and more consistent way to address complex data issues such as ways to inflate the poverty line over time, study poverty by regions and urban/rural areas and examining its determinants.

This approach is, in principle, rather straight-forward, feasible on the basis of available household survey data, and is already used in many developing countries to analyze poverty nationally. In their empirical illustration, Reddy et al. (2009) produce estimates for three countries (Vietnam, Nicaragua, and Tanzania) and a much older study by Altimir (1979) used this method to produce comparable estimates of income poverty in a large number of Latin America countries. The poverty lines generated in this way are being regularly updated

[34] Reddy et al. (2009) in their proposal for comparable poverty lines using such an approach rely on this method in their illustrative analysis, while readily acknowledging this is only a crude approximation of their much more ambitious proposal.

for inflation and are still used today for measuring levels and trends in income poverty in Latin America (ECLAC 2014).

Unfortunately, there are several serious conceptual and empirical issues that have to be taken care of. First of all, consistency across space and time will require to select one of the two approaches outlined above and to make uniform choices when actually implementing them (e.g. concerning updating, the reference group for the food basket, etc.).

With enough international coordination, achieving consistency is principle is possible. But there are serious problems with each of the two approaches mentioned. The problems with the food-energy intake method are nicely illustrated by Wodon (1997) in Bangladesh. In urban areas, much higher expenditures are apparently required to achieve the caloric norm than in rural areas. Does this merely reflect higher prices in urban areas? Or greater need or preferences for non-food items? To the extent it is tastes, should that be reflected in a poverty line? Updating can create further problems as the comparison between India and Bangladesh illustrates. As shown by Wodon, redoing the food-energy intake method leads to a *falling* poverty line between 1985 and 1989 as the amount of income needed to reach the caloric norm has fallen. Wodon convincingly shows that this is related to the fact that falling incomes lead to a substitution to cheaper calories and thus the falling poverty line is actually a result of households *reacting* to *higher* poverty. Conversely, not updating the food-energy intake poverty line can also lead to serious problems as well, as the Indian case demonstrates. The poverty line developed in 1983 (and confirmed in 1993) was sufficient to purchase 2400 calories per adult in 1973/74. By 1999/2000, (rural) people at the poverty line were only purchasing less than 1900 calories (see Patnaik 2004; Subramanian 2005; Reddy 2007), suggesting that, in some sense, the Indian poverty line is at a level where households are no longer adequately nourished. This would generate a case for updating which would lead to a much higher poverty line in India today, and consequently much higher poverty levels (and much less poverty reduction in recent decades).

The CBN method has also serious shortcomings. First, it is not obvious who is supposed to be the reference group for the poverty food basket in a country (those close to the poverty line or all below it?) More importantly for international comparisons of poverty lines there is the question of whether these food baskets (as well as the non-food requirements at the poverty line) should be determined separately for each country, or established internationally. In their illustration, Reddy et al. (2009) determine them separately for each country but this might go against the idea of developing an absolute standard that is comparable across countries.[35] In richer countries, the presumed poor will likely consume more expensive calories and have higher non-food needs than in poorer countries; as a result deriving the poverty line for each country contains an element of a relative poverty line, driven by prevailing consumption patterns.[36] Conversely, if one chose a common food basket, it is unclear whether this could adequately account for specificities of climate, food availability, specific needs, etc.

[35] In contrast, Altimir (1979) used the average budget shares of the entire population but this is unlikely to reflect the budget shares of the poor.

[36] Of course, there might be a good justification for doing so. As Reddy et al. (2009) want to create a capability-based poverty line based on the capability 'adequate nourishment', fulfilling that capability might indeed require more resources in a richer country than in a poorer one, making it still 'absolute' in the space of capabilities while relative in the space of resources (see also Sen 1984 on that); in this sense one would come closer to the weakly relative poverty line suggested by Ravallion and Chen (2011) in the income space.

Moreover, updating presents similar problems which are not apparent in Reddy (2008) as well as Altimir (1979) which both examine a cross-section of countries.[37] If one simply updates using prices from the food basket, the problem identified in India would still largely hold. The reason the people at the poverty line are in 2000 consuming less than 1900 calories is only to a small extent due to the fact that cereal prices rose faster than the price index used for updating the poverty line (Subramanian 2005; Reddy 2007). It is more related to the fact that households apparently switched their consumption habits, turning to more expensive calories and more non-food items. Conversely, redoing the poverty line with each new survey puts into question the inter-temporal comparability of the poverty estimates which each time are based on a different basket of goods. In particular it is unclear whether the drivers of the changed baskets are income effects (positive or negative) which might make this again somewhat of a relative (rather than absolute) poverty standard. As far as international comparisons are concerned, it is possible that some countries would frequently update their poverty line, while others would do it more rarely (as surveys are done more infrequently). Which survey estimates should be compared is then not clear. A benchmark year approach, as done in the ICP, might be one way to deal with this.

There are also a host of empirical issues to consider. They include problems of comparability of questionnaires of household surveys, different extent of measurement error in food expenditures that would affect the construction of national poverty lines, the increasing (and internationally highly variable) difference between mean consumption in household surveys and consumption as reported in the national accounts. Also here, the devil is in the detail as has been shown in Deaton and Kozel (2005) with reference to India. Also, Beegle et al. (2012) experimented with different ways of generating food consumption data from households (including short and long lists of items, diary and recall methods) and find that they yield dramatically different results. Measurement errors and the incomparability of survey instruments (and survey implementation) across countries and time are the most serious empirical drawbacks of moving to such an approach to measuring global poverty. As shown by World Bank (2015), this has been a particular challenge in Africa where household surveys have been particularly inconsistent over time and across countries so that comparable poverty data are particularly hard to come by. Devarajan (2013) argues that political meddling with data gathering as well as different and changing donor tastes for types of surveys and data have contributed to these problems. On the other hand, Altimir (1979) shows for the Latin American case that many of these issues can be addressed when the underlying surveys are roughly comparable.

It is clear that implementing such an approach would require a totally different set-up of poverty analysis than the one currently in place. In particular, it would either require extensive international coordination and standardization of poverty measurement approaches as well as survey methods, which is currently largely absent, or would require an international agency, such as the World Bank (or maybe the regional UN commissions), to support all these household surveys and build up comparable national poverty lines for as many countries as possible. Both paths are not entirely infeasible. The first route has been chosen in the creation of the System of National Accounts where all countries of the world agreed

[37] The continued use today of the (inflation-adjusted) poverty lines generated by this method by the Economic Commission of Latin America has also avoided the updating problem by just relying on one cross-sectional analysis for the creation of these poverty lines (ECLAC 2014). Thus no updating occurred and it is totally unclear whether the updated poverty lines used today would suffice to cover the nutritional needs of Latin American populations, or whether the same problem as in India applies. To investigate, one would need a new assessment using new consumption surveys and adjust the poverty lines accordingly.

to specific rules for the calculation of national income, GDP, and other aggregate statistics. The size of the effort was and remains huge, and something rather similar might be needed to implement internationally coordinated poverty measurement. As far as the second route is concerned, the World Bank has already gone down quite far in its work on global poverty as well as its work on national poverty and its construction of the Income Distribution for Development (I2D2) database which is a database of household surveys using, to the extent possible, consistent methods, variables, and means of analysis; and earlier ECLAC also played that role as shown by Altimir (1979). But currently the work at the World Bank on national poverty is highly decentralized and the critical conceptual and empirical issues discussed previously have not been addressed.

In short, it would not appear to be entirely infeasible to try out such an alternative approach. If implemented successfully, such an approach would obviate the need for the periodic drastic revisions of poverty levels and would also present a more accurate picture of poverty trends over time. To be sure, the conclusion on poverty trends would, as discussed above, likely not be substantially different from those based on the current method favoured by the World Bank, but they would be based on a better foundation and give us a better grounding on comparative poverty levels. And it would give us more guidance on whether we are indeed eradicating poverty by 2030 (or not).

Acknowledgments Funding from the German Ministry of Economic Development and Cooperation and from the German Research Foundation as part of the institutional strategy of the so-called Excellence Initiative is gratefully acknowledged. We would like to thank Francisco Ferreira, Martin Ravallion, Shaohua Chen, Sanjay Reddy, Jacques Silber, Nora Lustig, and participants at workshops and conferences in Marseilles, Berlin, and Göttingen for helpful comments on earlier versions of this paper.

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