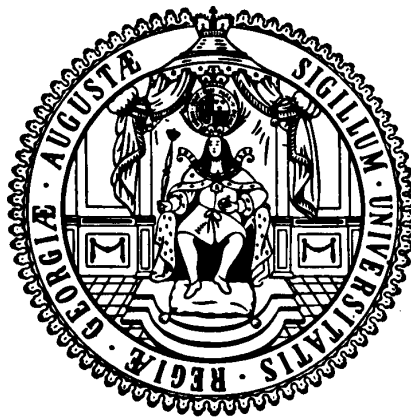# Courant Research Centre
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International Income Poverty Measurement:
Which way now?

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Abstract

In this paper, 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 of Prices (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 2005PPPs and suggest $1.67-1.71 using 2011PPPs; they also roughly confirm the current shape of the proposed 'weakly relative' poverty line. Using the new absolute line using 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 the conceptual and empirical problems associated with the link to successive ICP rounds creates problems that have gotten 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 quick fix 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

JEL Codes: I32

*University of Göttingen, Göttingen, Germany **Food and Agricultural Organization, Rome, Italy, ***Bogor Agricultural University, Bogor, Indonesia ****German Cancer Research Center, Heidelberg, Germany. Corresponding author: Stephan Klasen, sklasen@gwdg.de

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, Chen, and Sangraula, 2009). The international poverty line has been derived by averaging the 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, Datt, and van de Walle, 1991), in 2000 it was adjusted to $1.08 in 1993 PPP-adjusted dollars (World Bank, 2000; Chen and Ravallion, 2001), and in 2008 it was again adjusted to $1.25 in 2005 PPP-adjusted dollars (Ravallion, Chen, and Sangraula, 2009). Now the World Bank is working on adjusting its estimated poverty line using 2011 PPP-adjusted dollars. One paper from the World Bank is suggesting a new poverty line of $1.82 in 2011PPPs but this is not yet the official position of the World Bank (Jolliffe and Prydz, 2015).

This international poverty measure has been highly successful 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 PPP 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 is being contemplated as a new international development goals for coming decades.

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 how to improve on the derivation for both the absolute poverty line (the 'dollar-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 would lead to a considerable *reduction* in the level of global poverty, compared to previous estimates.

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 consistent measurement of poverty using national poverty lines and national currencies as first proposed by Reddy and Pogge (2005, 2010), Reddy, Visaria and Asari, (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 fix 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 version of such poverty measurement should be considered.

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, Datt, and van de Walle, 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 methods for establishing the poverty lines have 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 are captured in the other MDGs, and a hunger target is placed alongside the income poverty target in MDG1. Similar arguments can be made for the recently proposed Sustainable Development Goals.

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

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

[2] The poverty line is adjusted only for differences in prices across space and time.

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 (underproportionately) 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 completely assign access all household resources to individual household 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 intrahousehold 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 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 mean consumption instead of survey means would generally suggest lower

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[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.

rates of extreme poverty and faster poverty reduction (Chen and Ravallion (2010) and Bhalla (2004) for a discussion).

While these are all short-comings 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 where there was a need for a straight-forward 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, Chen, and Sangraula (2009) and will be summarized here. We first turn to the construction of the international poverty line. In all three versions presented by the World Bank (1990, 2000, and 2008), the starting point was always the national poverty lines of a large sample of developing countries, expressed in their national currencies. In order to render them comparable, the results of the so-called International Price Comparison Project (ICP) were used to turn these national poverty lines into international prices (expressed in international $). The ICP rounds, which take place every 3-10 years, compare prices of a large basket of goods and services in many different countries to generate exchange rates that appropriately reflect purchasing power differences between countries (see below and contribution by Ward in this volume). These so-called purchasing power parity (PPP) exchange rates are used for the translation of national poverty lines into international $ in the hope that this approach will adequately reflect purchasing power differences and thus make these poverty lines comparable. For the 1990 exercise the 1985 ICP was used; for the 2000 revision, the 1993 ICP was used, and since 2008, the poverty estimates are based on the 2005 ICP; the results for the 2011 ICP are also available and allow an assessment of a new poverty line which we will discuss below.

In a second step, the poverty lines are plotted against (the log of) per capita consumption and it is regularly found that among low income countries, the poverty lines, when expressed in international $, are very similar. The average of these poverty lines then is used as the international poverty line, which turned out to be $1.02 in 1985 prices in the 1990 World Development Report, $1.08 in 1993 prices in the 2000/01 World Development Report, and $1.25 in 2005 prices in the recent revision.[6]

To measure poverty in different countries using these international poverty lines, the following three steps are then 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

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[6] While this procedure has been followed at this level of generality in all three revisions, the details have differed, including whether the mean or the median of poverty lines were used, or whether the consumption/capita was taken from the surveys or from national accounts. These choices matter somewhat, but do not have a large quantitative impact on the resulting poverty lines. For a discussion, see Ravallion, Chen, and Sangraula (2009), Reddy and Pogge (2010), and Chen and Ravallion (2013).

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 each three rounds of calculation (1990, 2000, and 2008), 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 three 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, and another one based on the 2005 ICP round published in 2008. The resulting numbers for the same year 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.

As described in detail in Chen and Ravallion (2010) and shown in Table 1, 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. The global headcount rate of poverty in 1990 increased from 29% using $1.08 (1993 ICP) to 43% using $1.25 (2005 ICP); similarly the rate of poverty was revised upwards in 2005 by some 7 percentage points. The difference implies that some 400 million more people (1.37 billion instead of 930 million) were now declared to be absolutely poor, compared to before. The level adjustments were, as shown below, particularly substantial in East Asia, followed by South Asia and Sub Saharan 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.' While these figures also substantially changed the target for MDG1 (halving global poverty now meant moving from 43% to 21.5% using the $1.25 poverty line, instead of moving from 29% to 14.5% using the $1.08 poverty line), the similar trend observed using both lines did not cause serious problems for measuring progress towards MDG1.

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[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.

Table 1: Share of population suffering from extreme poverty, 1993 and 2005 ICP Rounds

Region	1990		1996		2002		2005	
Poverty line	1.25 (2005)	1.08 (1993)	1.25 (2005)	1.08 (1993)	1.25 (2005)	1.08 (1993)	1.25 (2005)	1.08 (1993)
East Asia and Pacific	56.0	29.8	37.1	16.1	29.6	12.3	17.9	9.1
Of which China	60.2	33.0	36.4	17.4	28.4	13.8	15.9	9.9
Eastern Europe and Central Asia	1.5	0.5	4.5	4.4	5.6	1.3	5.0	0.9
Latin America and Caribbean	10.7	10.2	11.5	8.9	10.1	9.1	8.2	8.6
Middle East and North Africa	5.4	2.3	5.3	1.7	4.7	1.7	4.6	1.5
South Asia	51.1	43.0	46.9	36.1	43.8	33.6	40.3	30.8
Of which India	51.3	44.3	46.6	39.9	43.9	36.0	41.6	34.3
Sub-Saharan Africa	54.9	46.7	57.5	47.7	52.7	42.6	50.4	41.1
Total	**41.6**	**28.7**	**34.8**	**22.7**	**31.0**	**20.1**	**25.7**	**18.1**
Total excluding China	35.2	27.1	34.2	24.5	31.9	22.2	28.7	20.7

Note: The first column refers to the share of the population below the new poverty line of $1.25 a day, the second one to the old poverty line. The differences in the figures are, to a very small degree, also due to changes in survey data; also note that the $1.08 figures in the 2005 column refer to 2004. Sources: Klasen (2013), based on Chen and Ravallion (2010), Chen and Ravallion (2007).

The drastic revisions in 2008 have generated considerable debates and commentary with several authors questioning aspects of the revisions (e.g. Deaton, 2010, Ward, 2009; Klasen, 2009; Reddy, 2008; Heston, 2008). This debate was complicated by the fact that the revision undertaken by the World Bank in 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 of Prices Project (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 (2010) argued that this is unlikely to be the case. In particular, if the ICP simply made the average PPP-adjusted poverty line of the poor countries that make up the international poverty line lower than before (due to higher prices observed in these countries in the 2005ICP) 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 (Bangladesh, China, India, Indonesia, Nepal, Pakistan, Tanzania, Thailand, Tunisia, and Zambia, see Chen and Ravallion, 2001)[9], the updated poverty line at 2005ICP would be $1.05 per capita per day (or $32.04 per month). Note that this apparent decline from $1.08 to $1.05 in the value of the poverty line despite international inflation in the intervening years[10], precisely reflects the fact that the ICP2005 finds price levels to be much higher in poor countries (on average and relative to rich countries) than the 1993ICP. 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 1993ICP.[11] 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.[12] As a result, the question whether the new international poverty line is properly derived is a key question to examine.

Deaton (2010) already expressed a range of criticisms and suggested some ad hoc adjustments which we will discuss below. We will take a different route here though. We basically examine whether the international 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 2005PPP$), 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.

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[8] This is discussed in detail in Ravallion, Chen, and Sangraula (2009) as well as Chen and Ravallion (2010)

[9] To create the median, we take the average of the two middle observations: Indonesia ($32,63 a month) and Bangladesh ($31.46 a month).

[10] 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.

[11] 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)

[12] This confirms the claim by Deaton (2010) 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).

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.[13] We thereby accept the (plausible) arguments advanced by Ravallion, Chen, and Sangraula (RCS, 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 22 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 in 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 (see below); 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.[14]

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.

Regarding the 2011 PPPs, we do not know at this stage how the World Bank is proceeding to generate a new line and a new estimate. 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[15] and then re-estimate the line using the same procedures as followed in the 2008 exercise.

The empirical starting point for the analysis is Figure 1 which shows the relationship between per capita consumption from the national accounts to the poverty line in the sample of 74 countries

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[13] For reasons explained, for example, in Reddy and Pogge (2010), it is not possible to generate inter-temporally consistent PPP-adjusted estimates of incomes or poverty. Each ICP produces PPP exchange rates valid for the benchmark year. Linking them with previous years using old ICP rounds (as was done using the Penn World Tables) or national inflation rates (as done in the World Bank poverty work) has different conceptual advantages and disadvantages. We also do not want to contribute here to the debate whether using the ICP rounds to derive an international poverty line and then calculate global absolute poverty numbers is conceptually a good idea. See Klasen (2009) for a discussion of these issues and possible alternatives.

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

[15] In fact, due to the unavailability of 2011PPP data for two countries, we will estimate the poverty line based on 70 countries for the 2011.

(2005PPP, left panels) and 73 countries (2011PPP, right panels).[16] The data are identical to the ones used by Ravallion, Chen and Sangraula (RCS, 2009), which we then update using the new 2011PPP exchange rates. We show three specifications, one where the poverty line (Z) is related to the log of mean consumption (C), one where Z and C are related, and the third where both are expressed in log forms.   The Z- log (C) chart is the one usually presented by Ravallion and co-authors (e.g. Ravallion and Chen, 2011; Chen and Ravallion, 2010, 2013; Ravallion, Chen, and Sangraula, 2009, see also Figure 1 in Ravallion's paper in this issue). As can be seen, there clearly appears to be a range of low levels of (log) per capita consumption where the relationship is flat, while the relationship turns clearly positive at higher levels of (log) per capita consumption. Since the first derivation of the international poverty line, the essence of the international poverty line has been to take an average (mean or median) of the flat portion of the curve.[17]

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

$$Z_i = Z^* I_i + f(C_i)(1 - I_i) + \varepsilon_i \qquad (1)$$

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.

Figure 1: Derivation of the International Poverty Line using 2005 and 2011PPP
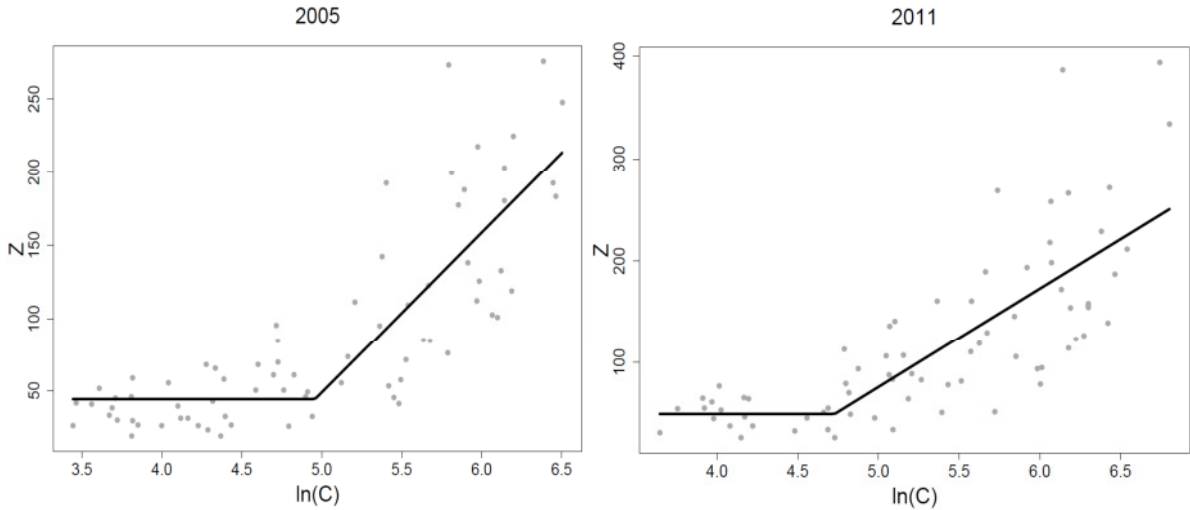
a) 2005PPP and Z - ln (C)   b) 2011PPP and Z - ln(C)

[16] We do not have updated PPP estimates for Argentina and thus only have 73 observations in 2011.
[17] In Chen and Ravallion (2001) using the old 1993ICP, the median of the countries along the flat portion was used. In Ravallion, Chen, and Sangraula (2009), the mean is used (although the median is also mentioned and does not differ much). To keep with the more recent approach, we will stick to the mean.
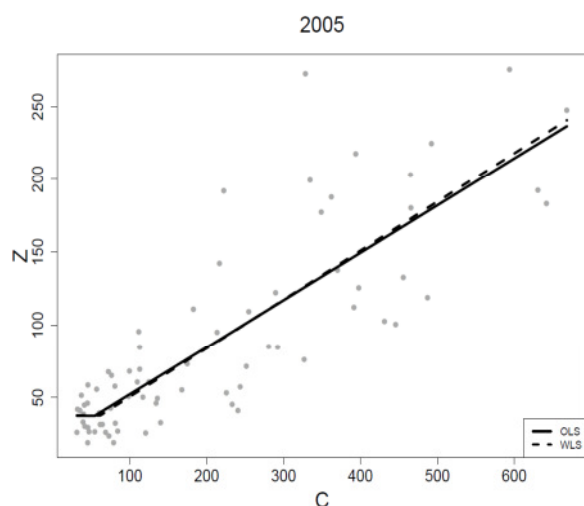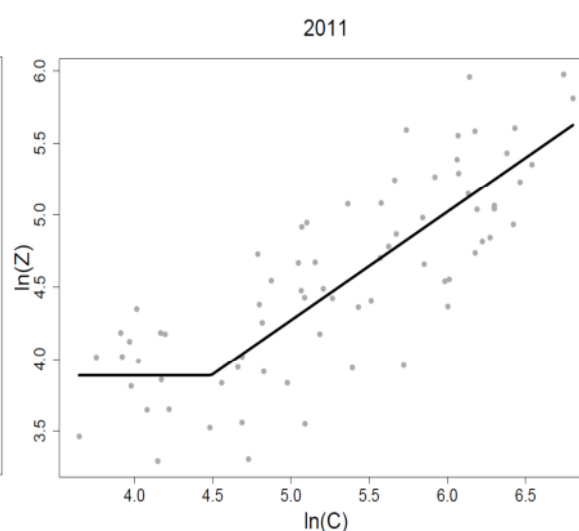
c) 2005PPP and Z - C
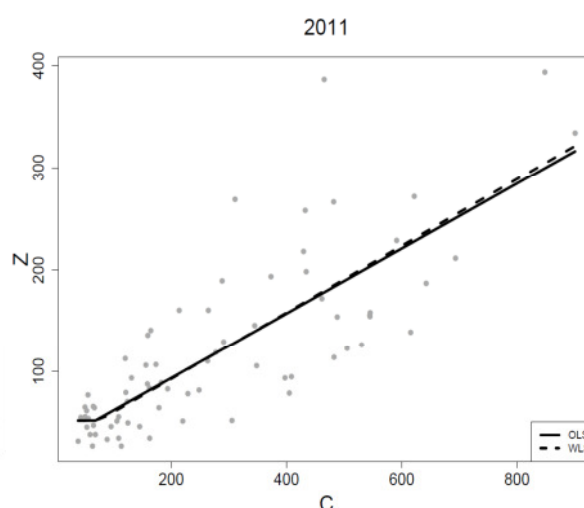
d) 2011PPP and Z - C

e) 2005 PPP and ln(Z) - ln(C)
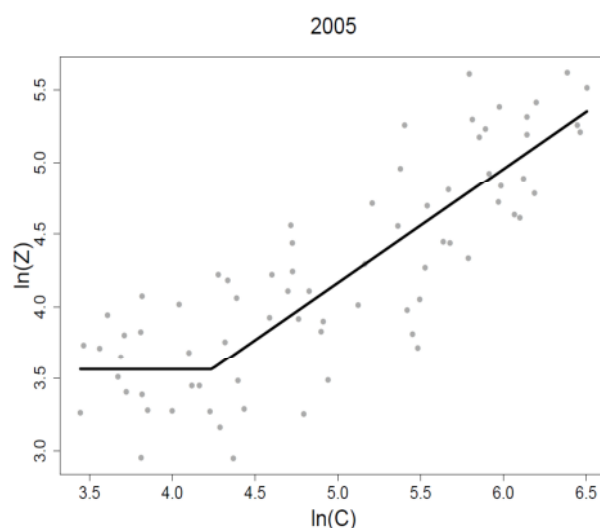
f) 2011 PPP and ln (Z) and ln (C)

Note: In chart c) and d) we show two lines, one for an OLS estimate and one for a WLS estimate (to address heteroscedasticity). For 2005, we always include 74 observations, and for 2011 73 (with Argentina missing as there is no data available)

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." (Ravallion, Chen,

and Sangraula (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. He carefully investigates to what extent the change could be due to changes in the ICP and estimates that this might have boosted global poverty count by some 100 million poor people. The rest is due to the re-estimation of the poverty line using the new sample. Here Deaton criticizes that several populous fast-growing countries including China, India, Indonesia, and Bangladesh are no longer part of the new reference group. As some of them, notably India and China, have rather low poverty lines, their removal from the reference groups contributed to increasing the global poverty line and, paradoxically, leading to higher measured poverty rates using this global line in India and China. He then proposes that a better procedure would be to calculate the international poverty line using all 74 observations, but weighed by the number of poor people in each country. This would, of course, mean that the international poverty line thus derived would be heavily driven by the poverty lines of the population giants India and China and many other data points would be largely irrelevant. This would then generate a poverty line of $0.92 in 2005PPP$ and a global poverty count of 874 million, actually lower than the last count using the old $1.08 line of 931 million.

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 standard of the poverty line is proportional to the poor people in the country. 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).[18]

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 actually estimated by RCS (2009) do not actually use the relationship in Figure 1a where the national poverty lines are plotted against respective *log* of per capita consumption. Instead, both regressions use the just per capita consumption (not the log thereof) as the regressor. They thus try to estimate the relationship in Figure 1c.

But the piece-wise linear relationship that drives the whole motivation for the international poverty line is actually not there in Figure 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-value 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 simply linear relationship between

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

per capita consumption and the poverty line. In contrast, the p-value for the log-linear relationship in Figure 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. In fact, it turns out that from a statistical point of view, the log-log specification shown in Figure 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 countries and just use the new 2011PPPs for the estimation of a new international poverty line in 2011 prices.[19] This is done in the right panels of Figure 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,[20] the Z-log C relationship has a kink, but suffers from the same specification problems, and the log Z- log C graph shown in 1 f) is the preferred specification and includes a statistically significant kink. The Z-C graphs yield a poverty line of about 1.71 and a reference group of 14 countries, while the preferred log-log specification yields a poverty line of $1.67, and a reference group of 15 countries, (or also 1.71 and a reference group of 14 countries is we remove three outliers.[21]

Using these lines and the Global Consumption and Income Database (Jayadev, Lahoti, and Reddy, 2015), which 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.   This is done in Table 2 below for a sample including most of the populous developing countries. 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). When using the 2005PPP, 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. Similarly, it was argued that the rural estimates were unrepresentative for India and also in Indonesia, a very large country, they wanted to adjust for differences in rural and urban PPPs. In each case, an adjustment was made (in

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[19] This is actually not what Jolliffe and Prydz (2015) do. They simply take the same 15 countries that formed the reference group in 2005 and calculate the average of the poverty lines. We also do the estimation on sample that only includes the 73 observations that are common to both countries 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.

[20] 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)

[21] The Z-log 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.

China, only the rural line was adjusted, while in India and Indonesia, both lines were)[22] This was then implemented in PovCal and entered all estimations of global poverty by the World Bank (e.g. Chen and Ravallion, 2010). Since the 2011PPPs included rural areas, Jolliffe and Prydz (2015) argue that such an adjustment is no longer necessary.[23]So in Table 2, 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 included in PovCal for both periods (2005 and 2011). And a third one does what Jolliffe and Prydz (2015) propose: used the adjusted ones from PovCal only for 2005 PPPs, and not for 2011 PPPs (called JP below). That is, of course, simply a combination of the estimates of the previous rows.

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 suggested. In South Africa and China, poverty estimates do not differ between 2005PPPs and 2011PPPs; 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 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, which drops to around 800 million using the 2011 PPPs; doing them in all three years suggests a poverty count of 840 mission using 2005PPPs, and around 550 million using 2011PPPs. And doing what Jolliffe and Prydz (2015) propose, i.e. applying the adjustment for 2005PPPs and not for 2011PPPs, leads to the least change in poverty, from 840 million using 2005PPPs to 750-800 million using 2011PPPs. Following that procedure would also suggest that poverty using 2011PPPs is much higher in China than the 2005PPPs suggested, is only slightly lower in India than 2005PPPs suggested, while the difference between the two estimates is not so large for Indonesia. Thus while all estimates suggest that global poverty is lower using the 2011PPPs, how much our impression of the level and distribution of world poverty changes when switching to the 2011PPPs depends to a very great extent on whether and how to adjust for differentials in PPPs between urban and rural areas in China and India. 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 should be done in other countries as well, and how best to do the adjustment.

Apart from this important issue of whether and how to make adjustments in India, China, and Indonesia, note that our analysis differs from the estimates produced by the World Bank in Jolliffe and Prydz (2015) in two other important respects. First, they actually do not derive the poverty line afresh as we do here, but simply take the reference group from 2005 and take the average of their poverty lines, using 2011 PPPs. If they just follow this procedure, they would end up with a new

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[22] 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.

[23] 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 were based on the desire to reflect regional differences in prices, it is not so clear that one should no longer do this in this case.

international poverty line of $1.70 in 2011 prices. But they make a second change, which is to change 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 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. If one takes take out just one of these three countries where this ad hoc and very selective adjustments was made, i.e. Tajikistan where Jolliffe and Prydz find the national poverty line to be $3.18 in 2011 PPPs instead of $1.82 when using the WDI CPI, one would be back to a poverty line of $1.72. We think that our 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, would lead to $1.70, very close to our own estimate.

What explains this substantial reduction in poverty using the 2011 PPPs, esp. if one treats the adjustment in the three countries consistently over time? This is an issue also tackled by Ravallion in his contribution to this special issue. In contrast to the massive changes associated with the move from $1.08 in 1993 prices to $1.25 in 2005 prices, there is no change in the sample which drove those changes. Thus the change must come entirely from the use of the new PPPs. This is only possible, however, if the changes in the PPPs between 2005 and 2011 are different for those who are included in the reference group, compared to other countries containing a substantial number of poor people that are not included in the reference group. And this is indeed what has happened. While the poverty rates in countries that are part of the reference group, on average, do not differ much when using 2005 and 2011 PPPs, the changes in the PPPs are much more substantial in the countries just above the reference group, particularly the large and populous South and South-East Asian countries of India, Pakistan, Bangladesh, Indonesia, and Vietnam.

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 using the 2005 round.[24] Ravallion has also examined the issue and comments on them in this forum (see accompanying paper). More generally, these massive changes point to a serious conceptual as well as an empirical issue. 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, 2013 and Reddy and Pogge, 2010). Thus it is possible that a significant share of the differences observed in Table 2 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 leads beyond the scope of this paper. The empirical issue is that despite best efforts, better coverage, and arguably improving methods, even the latest ICP rounds cannot still be considered 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

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

rely on the successive PPP rounds to provide an accurate picture of the levels of global poverty, a discussion to which we return below.

Table 2: Poverty Rates and Number of Poor using 2005 and 2011 PPPs

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

Note: ICP refers to using the PPP exchange rates provided by the ICP. Povcal refers to PPP exchange rates that were adjusted for urban/rural differentials in China, India, and Indonesia by the World Bank (see text). JP refers to the proposal by Jolliffe and Prydz to use adjusted PPPs from Povcal for 2005PPPs and ICP PPPs for 2011PPPs. For Brazil, GCIP estimates a headcount ratio for 2010 of 0% for poverty line of $1.25 2005 PPP, but Povcalnet's estimate is of 4.72%. This difference is because Povcalnet uses income surveys to estimate poverty but GCIP converts the distribution to equivalent consumption estimates. 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, Lahoti, and Reddy (2015).

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 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. This is shown in Figure 2 as the line with slope k. But there is also a fixed cost of social inclusion which has to be borne even if consumption is 0 which is α in Figure 2. As shown in Figure 2, there is therefore a schedule of the costs of social inclusion that have a positive Y-intercept and then rises with a constant slope. They then combine this approach with the absolute poverty line and argue that their 'weakly relative poverty' line is equal to the absolute poverty line below some threshold (which is the kink in the curves in Figures 1 and 2), 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) above a certain threshold (see strongly relative line in Figure 2).

Empirically, this approach essentially boils down to estimating not just the location of the kink in Figure 1 (to determine the reference group for the absolute poverty line) but to 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 empirical poverty lines set by countries are consistent with this formulation of 'weakly relative poverty', i.e. that the best fit for the entire curve is consistent with a curve where the elasticity of poverty to mean is positive, increasing with mean consumption, but never approach 1. In Ravallion and Chen (2011) these were estimated (presumably using the Z-C relationship shown in Figure 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 the drastically high poverty rates. 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 in 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.

Figure 2: Justification for a weakly relative poverty line
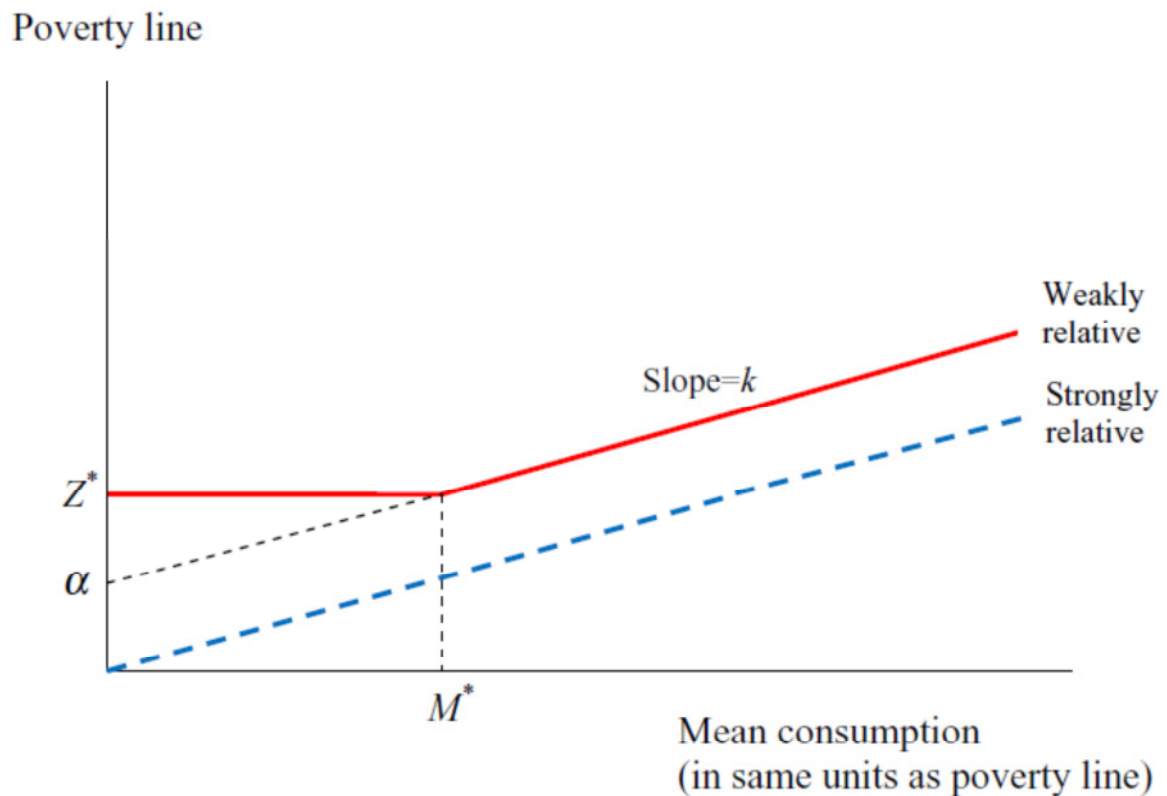
Source: Chen and Ravallion (2013).

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.[25] It thereby

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[25] 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

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 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.

In fact, this approach to analyze '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 approach is a rather ad hoc and discontinuous way to consider a particular poorer 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.[26] '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 clearly there are rising costs of social inclusion already below the threshold and what then justifies that the slope of the poverty line is flat there?

One could just as easily argue that everywhere there is a fixed cost of survival that is absolute. Thus instead of arguing that there is a fixed cost of social inclusion, the α in Figure 2 just becomes the fixed costs of survival. On top of that come 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 piece-wise linear (and flat below the threshold), and allows it to be estimated using splines.[27] The results are shown in Figure 3 below for

relative (e.g. the capability to be adequately nourished is unlikely to rise proportionately with mean consumption levels).

[26] 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).

[27] Monotone regression splines allow to fit a function with a given constraint, for example concave, convey, or monotonically increasing. With this approach we fitted the data by a fully flexible function, constraines to be monotonically increasing. To compare the fit one can compare the mean of squared residuals which was found

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 some difference above it. in 2011, the difference between the spline estimate and the piecewise linear is smaller.[28]

To conclude this discussion, we believe that the idea of a 'weakly relative' poverty line is quite interesting and offers a range of advantages. As discussed, we would propose to see this as a continuous concept with a fixed cost of survival plus a variable cost of social inclusion which would be best estimated using a continuous function. Empirically, the difference in resulting weakly relative poverty lines, compared to a piecewise linear estimate, would be moderate in 2005 and small in 2011.

Figure 3: Weakly relative poverty, piece-wise linear and using monotone splines
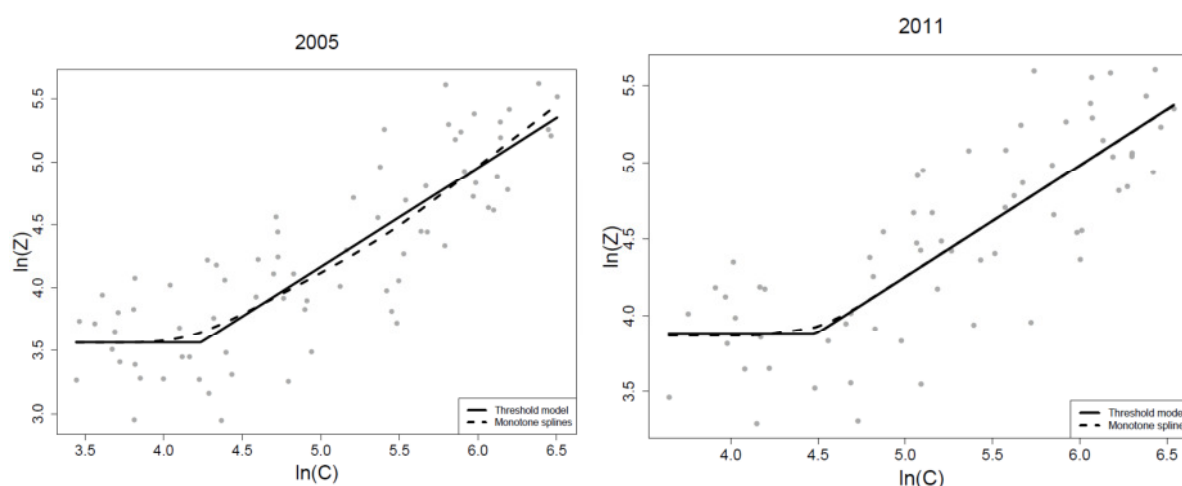
The International Poverty Line: An Assessment

In the discussion so far, we have pointed to a number of problems and issues related to the international poverty line. We first noted the many implicit assumptions made using this line (absolute, income dimension only, household-based assessment, no depth considered, no equivalence scales). One of these shortcomings, the focus on absolute extreme poverty can be remedied, as the discussion on 'weakly relative' poverty. Also, the focus on incidence can also easily be addressed by considered a wider array of poverty measures, such as the FGT poverty indicators that include the poverty gap ratio and the severity index. But the most severe problem associated with the international poverty line is its rather weak and unstable empirical base. In the previous two sections, we highlighted several estimation problems although we found that ways to address them in a statistically satisfactory way would not lead to dramatically different poverty lines; but our update of the international income poverty line of $1.66-1.71 in 2011PPPs is somewhat lower than the proposed line of $1.82 by Jolliffe and Prydz (2015) which used a simpler method and made some ad hoc adjustments.

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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.

[28] 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 much more serious problem we found above is, however, the massive differences in poverty levels that arise from changes in the PPP benchmark years. This was already a problem 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 2011PPPs which are yet again vastly different, question some of these apparent improvements (e.g. Deaton and Aten, 2014) but question more generally the ability to derive reliable and consistent PPP estimates for all countries of the world that are suitable for poverty analysis.[29] The results of the ad hoc adjustments made for urban-rural differences in China, India, and Indonesia also show that rather minor technical issues can have substantial impacts on levels and regional distribution of measured world income poverty.

Given these massive discrepancies that have happened with each ICP round, we have to fear that future rounds will generate similarly massive inconsistencies about the levels and regional distribution of global poverty, when measured using the PPPs of the various rounds.

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 using these lines to track poverty in their countries; 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 generally reasonably consistent trends in national poverty measurement with 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, as shown in Table 1? What information does Table 2 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 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 Figure 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

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[29] Not only are the challenges of the fieldwork, and the reliability of the numbers emanating from it, huge, but there are also difficult conceptual issues that may make it very difficult

of the curve in the left-hand panels of Figure 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 so large that a serious disconnect exists between national and international poverty measurement.

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 these are important advantages of this approach, they create 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 a 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 Table 2 suggests, 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! 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.

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. These are considered in the next section of this paper.

A quick fix and a longer-term alternative

Clearly, a central problem of the current international poverty line is its reliance on successive PPP rounds and their associated conceptual and empirical problems and their massive empirical inconsistencies. Consequently, a solution must find a way to link international poverty measurement to national poverty measurement in national currencies and continue to track global poverty by

tracking the sum of national poverty across the developing world. In order to do that, there are two options available in principle, a quick fix, and a longer-term alternative.

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).[30] When a new PPP round became 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, 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 round. Of course, this proposal is merely a fix, not a real solution, as its accuracy depends entirely on the quality and relevance of the PPP 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. This depends on the relative biases and problems with these two rounds which are discussed in other parts of this forum.

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, Visaria, and Atali (2009) consists of creating *national* poverty lines using a procedure that is internationally consistent so that then poverty measured in this consistent way could be aggregated across countries. Reddy, Visaria and Asali (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 global, 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 for a nutritional requirement. There are principally two common ways suggested in the literature to this (see Ravallion, 1994): The food-energy-intake method and the cost of basic needs method. Briefly, the former asks the question what incomes are empirically 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 is essentially based on 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 Subramanian2005, 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 simply the exercise can be redone in each (survey) year, as apparently

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

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).[31] 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 (while most often) keeping the non-food share fixed.

Using these nationally-set poverty lines and poverty rates using 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 all 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. They would also yield other benefits, including their direct link to national poverty measurement which, as discussed above, is a huge problem with the current international poverty line. It would also allow 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, examining its determinants.

This approach is, in principle, rather straight-forward, possible with available household survey data, and this method is being used in many developing countries already to analyze poverty nationally.

Unfortunately, there are several serious conceptual and empirical issues that would need to be tackled. First of all, consistency across space and time will require that one consistently uses one of the two approaches outlined above and also uses consistent choices when actually implementing them (e.g. on updating, on the reference group for the food basket, etc.).

With enough international coordination, achieving consistency in principle is possible. But it is not obvious on what approach this international poverty measurement should converge on. There are serious problems with each of the approaches taken. 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

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[31]   Reddy, Visaria and Asali (2008) 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.

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; this reaction should scarcely be seen as representing falling 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).

But also the CBN method has serious questions and short-comings. 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?), which will affect results. More importantly for international comparisons of poverty lines is the question 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, Visaria, and Asali (2009) determine them separately for each country but this might go against the idea of developing an absolute standard that is comparable across countries. 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.[32] 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.

Moreover, updating presents similar problems. 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 only 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 household 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. For international comparisons, the problem will naturally arise that some countries would then frequently update their poverty line, while other do it more rarely (as surveys are done more infrequently) and it is not always clear then which survey estimates should be compared. 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 are the most important ones. Also here, the devil is in the detail as has been shown in Deaton and Kozel (2005) who survey the great debates on poverty in India where these

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[32] Of course, there might be a good justification for doing so. As Reddy, Visaria, and Asali (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 a weakly relative poverty line suggested by Ravallion and Chen (2010) in the income space.

issues are the centre of the debate. Also, Beegle et al. (2012) experiment with different ways to generate food consumption data from households (including short and long lists of items, diary and recall methods) and find that they yield dramatically different results, pointing to the need for strict quality control as well as consistency across countries. In particular, the issue of measurement error and 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 and there 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.

Clearly, this alternative approach of using consistent national poverty lines to measure poverty at the global level would also, at least initially, generate a host of serious conceptual and empirical issues. As a first step, it would be important to investigate the feasibility of this approach in much more detail. Also, it is clear that implementation of such an approach would require a totally different set-up of poverty analysis than is currently in place. In particular, it would either require extensive international coordination and standardization on poverty measurement approaches, which is currently largely absent, or would require an international agency, such as the World Bank, to take 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 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. And the second route 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. But currently its work on national poverty is highly decentralized and the critical conceptual and empirical issues discussed above 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).

Conclusions

In this paper, we have reviewed a range of conceptual and empirical issues associated with the currently used PPP-based international poverty line. We first show that the current approaches to deriving the absolute poverty line (and a weakly relative version) require some adjustment in terms of estimation, but our own results generate quite consistently a $1.25 poverty line using 2005PPPs and an international poverty line of $1.66-1.71 using 2011 PPPs. We have argued that this approach, while useful to promote important debates on global poverty and goal-setting in the past, suffers from accumulating conceptual and empirical problems so that we suggest that it is time to look for alternatives. A short term fix would be to fix the international poverty line (either the 2005 or 2011 version) in national currencies and use that to track global poverty for the coming decades, without making recourse to successive ICP rounds. But a longer-term solution would be to develop

internationally consistent national poverty lines and track global poverty this way. While this requires considerable effort of harmonization and coordination, it would offer substantial benefits, avoid the erratic jumps associated with each new PPP round, and link national and international poverty measurement and debates. The feasibility of this approach would, in our view, be the next urgent step to address in this important research and policy agenda.

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