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Estimating international poverty lines from comparable national thresholds

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Abstract The World Bank's international poverty line (IPL) of $1.90/day at 2011 PPPs is based on a collection of national poverty lines provided in Ravallion et al. (World Bank Econ. Rev. **23**(2), 163–184, 2009), originally used to set the IPL of $1.25/day at 2005 PPPs. This paper proposes an approach for estimating a more recent, complete and comparable collection of national poverty thresholds from reported national poverty rates, and then presents a set of IPLs based on this new database of national poverty lines. In contrast to the lines used to estimate the $1.90 IPL, this approach produces national poverty lines that are (1) consistent with national poverty rates, (2) expressed in common units, and (3) provide greater support to the estimated IPL. These national poverty lines are used to estimate an extreme IPL, and three higher IPLs that are more relevant to higher-income countries. We provide evidence of the robustness and relevance of the $1.90 IPL as a measure of extreme poverty for low-income countries.

Keywords Global poverty · Poverty lines · International comparisons · Adult-equivalence

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1 Introduction

The share of people living in extreme poverty, as assessed by the international poverty line (IPL) estimated by the World Bank, has become one of the most prominent indicators for assessing progress in global economic development. It has been a central indicator for the Millennium Development Goals and is now an important indicator among the Sustainable Development Goals. The most recent World Bank IPL of $1.90 per day described by Ferreira et al. (2016) in this issue is the simple average of national poverty lines from the 15 poorest countries from a sample of 74 national poverty lines constructed by Ravallion et al. (2009).[1]

The 15-country approach based on the RCS data has been critiqued for several reasons. One criticism of this approach is that 15 national poverty lines provide weak support for the IPL and results in a line that is sensitive to small changes in the underlying data (Deaton 2010; Reddy and Pogge 2008; Klasen et al. 2016). Deaton (2010) provides an example where changes in the composition of the 15-country reference group can result in changing the poverty status of millions of people. He further notes that the 15 countries represent only about 11 % of the total number of poor people in 2005.[2] In this paper, we offer two additional issues of concern for the current approach of basing the poverty estimate on 15 countries from RCS – the age of the lines and incomparability of the lines (resulting in a conceptually incoherent average value for the IPL). A second strand of criticism of the IPL itself is less linked to the methodology and more linked to the suggestion that the threshold is too miserly for all countries, but in particular for many developing countries of the world (e.g. Pritchett 2006).

This paper aims to address these critiques by proposing both a new dataset of national poverty lines and then an approach for estimating a new set of IPLs that addresses the issue of the official line as being too frugal or irrelevant. The next section elaborates on the critiques of the current 15-country approach, and then describes how we estimate a new set of national poverty lines that has greater temporal and spatial coverage, and are more comparable than the RCS sample. The subsequent section first follows an approach similar to RCS for finding the set of countries that use extreme, absolute poverty thresholds, argues that the data do not support this approach, and then offers an alternative method for setting a poverty line relevant for the poorest countries. A key finding discussed in the concluding section is that the new set of national poverty lines proposed in this paper provide evidence in support of the robustness and relevance of the $1.90 IPL as a measure of extreme poverty. The paper also offers supplemental poverty lines that may be more relevant for higher income countries.

2 A new dataset on national poverty lines

Ever since the dollar-a-day poverty line was first introduced in 1990 (World Bank 1990), the guiding concept for how to estimate the IPL has been to collect a set of national poverty lines and then to base the IPL on a *typical* value of a sub-sample of the *lowest* of these

[1] The national poverty lines, expressed in local currency units, are inflated based on national temporal deflators and converted into US dollars based on the 2011 Purchasing Power Parity (PPP) conversion factors. See Ferreira et al. (2016) for a more detailed discussion of the details of the $1.90 line, and see Jolliffe et al. (2014) for more details on the history of the IPL along with some of the measurement challenges.

[2] We estimate this to be about 13 % in 2011 based on the official $1.90-line estimates.

national poverty lines. The details have differed with each revision, where sometimes *typical* would mean average, median or mode; and the selection of the sub-sample of poverty lines has sometimes been based on the lowest of poverty lines and in other cases, the sub-sample has been selected based on the poorest countries (as assessed by measures of per capita consumption from national accounts).

In the case of the original dollar-a-day line, Ravallion et al. (1991) compiled a data base of 33 national poverty lines and suggested that six of the lower lines were near a common value – one US dollar when using the 1985 Purchasing Power Parity (PPP) conversion factors. The same database of 33 national poverty lines was used by Chen and Ravallion (2001) to update the dollar-a-day line based on the 1993 PPP conversion factors, although this time the median value of the ten lowest lines became the revised IPL.

For the next revision of the IPL, Ravallion et al. (2009) compiled a new sample of 74 national poverty lines, typically drawing these lines from World Bank reports or from national government poverty reports. To select the sub-sample of national poverty lines from the 74 lines, they fitted various parametric regressions of national poverty lines on a measure of average national household consumption. Unsurprisingly, over most of the range, the fitted line indicated that richer countries have higher national poverty lines. They argue though that this positive relationship did not hold for the poorest 15 of the 74 countries. For these 15 poorest countries, they observed essentially no correlation between the value of the national poverty line and the average wealth of the country.[3] RCS interpreted this flat part of the fitted line as reflecting a threshold of absolute minimum needs because they argued that among the poorest 15 countries, lower average national household consumption did not result in lower lines.[4] The average value of the national poverty lines for these 15 countries was $1.25 in 2005 PPP terms and this became the IPL used by the World Bank in its poverty updates from 2008 to 2014, and by the United Nations in tracking the MDG of halving extreme poverty by 2015. The latest update to the IPL, takes the simple average of these same national poverty lines, but now the average rounds to $1.90 when updated to 2011 values (through 2011 PPP conversion factors and national deflators, as explained in Jolliffe and Prydz (2015) and Ferreira et al. (2016)).

An important element of the criticism of this approach is linked to the sensitivity of the estimates to the method for selecting the sub-sample of national poverty lines which serves as the reference group for the international line. Deaton (2010) provides an example where the growth in India's national income meant that it graduated out of the low-income countries used to identify the sub-sample of poor countries, but its graduation out of this sub-sample had the effect of increasing the value of the IPL (because the national poverty line in India was relatively low) and thereby increasing the number of poor people in India as assessed by the global poverty headcount. Economic growth for India led to an increase in estimated poverty in India.

Another concern, not discussed in the literature, is that the average poverty line estimated from these 15 countries is quite sensitive to the quality of the inflation data for these countries. The approach used for setting the IPL in PPP terms requires inflating the value of the national poverty lines to the reference year of the International Comparison Program. The current $1.90 line is set in 2011 PPP terms, so this means that each of the 15 national lines

[3]More specifically, they use the Hansen (2000) threshold estimator to identify a break between a flat part and an upward sloping part from a regression of national poverty lines on the log of per capita consumption.

[4]This idea of viewing poverty lines from the poorest of countries as reflecting minimum absolute needs was also articulated in RDV (Ravallion et al. 1991) and World Bank (1990).

used by Ferreira et al. (2016) need to be updated from the reference period of the national poverty line (typically the period of survey fieldwork) to 2011 values. On average, the 15 national poverty lines date from 1997, requiring 14 years of inflation data; with Mali having the oldest line from 1988–89 and requiring 22 years of CPI data to update it to a 2011 value. Given that many of these 15 countries have limited capacity for the production of national statistics, and some have experienced very high levels of inflation, a reasonable concern is that even small errors in CPI data, when compounded over decades, can have potentially large effects on the estimated value of the IPL.[5]

One might assume that national CPI data are used to update the values of the national poverty lines from the time of fieldwork to 2011, but this is not the case for three of the 15 countries. Ferreira et al. (2016) note that in the case of Ghana, Malawi, and Tajikistan, there were significant concerns about the CPI data, and for this reason, household survey data are instead used to construct a temporal deflator (typically from unit values). While the decision to doubt the quality of the CPI as a measure of inflation for the poor may be justified, it is important to recognize that it has a nontrivial effect on the global count of poor people. For example, if using national CPI reported in World Development Indicators (WDI) instead of alternative measures of inflation for Ghana, Malawi and Tajikistan when converting the RCS lines from 2005 to 2011 PPPs, the IPL would drop by 20 cents, which would result in more than 200 million people being reclassified as not poor.[6]

Basing the IPL on more recent national lines would reduce the demands placed on inflation data and reduce this sensitivity. While this discussion of inflation is linked to the 15 countries that support the IPL, the need for inflation data holds for all countries in the global poverty count. Household survey data values need to be updated from the time of survey field work to the reference year for the global poverty count. For seven of the 133 countries in the global poverty count, concerns about the quality of CPI data results in the use of alternate temporal deflators. It just happens that the 15-country sub-sample that is used for the IPL disproportionately come from countries where CPI data are a concern. An implication of this is that increasing the sub-sample of countries for the estimation of the IPL, as our approach allows, will also reduce the sensitivity of the estimated line to this particular concern.

Another concern, not yet noted in the global poverty literature, with any IPL estimated from the set of national poverty lines in RCS, is linked to the heterogeneity in methods used in constructing and reporting national poverty lines. National poverty lines are expressed in many different ways. Some countries report a single national line, others report urban and rural lines, some report regional lines, others report the lines by household typology (to account for household economies of scale and/or differential needs of adults from children). When there are multiple lines, RCS note that they estimate the national poverty line for each country as an average (in most cases, weighted by consumption shares; in other cases, unweighted; and in one case, population weighted) of the official reported lines. It is important to note though, that the average was not constructed to ensure that the poverty rate derived from using the estimated national poverty line would equal the official, reported poverty rate (which was based upon the multiple lines). Indeed, none of the consumption-share-weighted or simple-average lines will result in an estimated national poverty line that

[5]Gimenez and Jolliffe (2014) document significant discrepancies in Bangladesh between the official CPI and alternative measures of inflation.

[6]A poverty line of $1.70, which was an early estimate of the updated IPL by Jolliffe and Prydz (2015), produces a global headcount for 2012 of 692 million, compared to 897 million for the $1.90.

corresponds to the official national poverty rate. In other words, many of the estimated national poverty lines used in RCS which have been drawn from country reports, will not produce national poverty estimates that match the official poverty rates provided in these reports. We view this inconsistency between the estimated national poverty line and the reported national poverty rate to be an undesirable attribute of the approach followed by RCS.

There is also a lack of comparability across the RCS national poverty lines used to estimate both the $1.90 and $1.25 lines. Some of the lines define a minimum-needs threshold for adults, and some define a minimum-needs threshold for the average person. One third of the 15 poverty lines used to define the IPL are expressed in terms of adult-equivalents,[7] while the remaining ten lines are expressed in terms of the average person. Given the demographic composition of these 10 countries at the time when the lines were defined, the average person means an adolescent. van den Boom et al. (2015) note that per-capita based food poverty lines are on average seven tenths the value of the corresponding adult-equivalent version of this line.[8] An adult-equivalent poverty line represents the same needs as a per capita poverty line, but these needs are expressed in different units. In the same way that it does not make sense to take an average of lines expressed in different currencies without first converting them to a common currency, it similarly does not make sense to take an average of lines expressed in terms of different reference people.[9] To bolster this point, the World Bank's online tool for counting the poor, PovcalNet,[10] provides all consumption and income data in *per capita* terms and expresses the IPL in *per capita* terms. For setting IPLs, it is therefore also desirable that the national poverty lines on which it is based are expressed in per capita terms.

We propose an approach for constructing a set of national poverty lines that addresses in significant ways each of the concerns discussed above. The approach yields a significantly larger set of national poverty lines, with greater temporal and country coverage. The approach also yields national poverty lines that are all expressed in per-capita units and that result in poverty estimates that match the official poverty estimates. Our approach is based on estimating implicit national poverty lines by combining national poverty headcounts from national sources, reported in the World Bank's databases, with corresponding consumption and income distributions from PovcalNet used for international poverty estimates.[11]

By directly inferring the national poverty line from the poverty rate, we ensure that our estimated national poverty line directly corresponds to the reported national poverty rate when used with the PovcalNet version of the survey data.[12] Further, because the consumption and income distributions we use are all expressed in per capita PPP terms, the estimated

[7] These five countries are Uganda, Tanzania, Sierra Leone, Rwanda, and Ghana.

[8] They also refer to James and Schofield (1990) manual for nutritionists.

[9] It is again the case that the adult-equivalent national poverty lines used in RCS will not produce national poverty estimates that match official estimates when applied to the data in PovcalNet. This is because PovcalNet archives consumption and income measures in per capita (not adult equivalent) terms.

[10] PovcalNet is perhaps the most commonly used data tool for estimating global poverty counts. It is an online tool, maintained by the World Bank, which allows analysts to specify parameter values such as the global poverty line, and then estimate the number of poor people in the world based on their assumptions. For more details, see: http://iresearch.worldbank.org/PovcalNet/index.htm.

[11] For the purposes of our analysis, we use a set of fitted distributions, similar to those used in Jolliffe and Prydz (2015), and described in their annex.

[12] Another useful attribute of this approach is that it allows us to identify the national average poverty line even in those countries where no national line exists, but only regional lines or lines for household types.

national poverty lines are all expressed in comparable per capita PPP dollars. Following this approach allows us to substantially increase the set of countries for which we have national poverty thresholds (thereby allowing for increased support for the estimated IPL) and also produces a series of poverty lines that are closer to the ICP reference year (thereby reducing the sensitivity of the estimate to errors and updates in inflation data).

Specifically, we implement our approach using 1,376 income and consumption distributions from 154 countries and territories available in PovcalNet. For 1,158 of these distributions, PovcalNet uses microdata when estimating poverty and inequality, and reports 100 points from the corresponding Lorenz curve (percentiles and percentile shares) for each distribution in the online detailed output. For the remaining 218 of the distributions, grouped data is used for the estimation, and in these cases, only 20 (or sometimes fewer) points of the Lorenz curve are available in the detailed output. For each publicly available Lorenz curve, we generate synthetic distributions with 1000 points, using the ungroup command included in the DASP Stata Package (Abdelkrim and Duclos 2007). We apply the adjustment proposed by Shorrocks and Wan (2008), which ensures that the fitted distribution matches the observed shares in the grouped data. This approach and adjustment produces synthetic distributions with a high degree of precision, particularly in the cases where PovcalNet reports Lorenz curves with percentiles. In Appendix 1, we provide an assessment of the precision of our method, which suggest that the errors are small with a mean absolute error of 1.0 % of the value of the poverty line, and a standard deviation of 1.1 %.[13]

The vast majority of national poverty headcounts we use to estimate the implicit national lines come from the World Bank's series of poverty headcount ratios at national poverty lines, available in its Poverty and Inequality Database.[14] This data set contains 800 poverty rates at national poverty lines. Of these, we are able to match 699 observations from 107 countries with surveys available in PovcalNet. The World Bank's series of national poverty headcounts does not include estimates for most high income countries. We therefore supplement the sample with national poverty estimates from OECD based on relative poverty lines.[15] For the U.S., one of few rich countries using absolute poverty lines, we include official national poverty headcounts.[16] For Canada, we use the nationally reported prevalence of *low-income status*.[17] We end up deriving 864 'implicit' national poverty lines for 129

[13]The method of fitting distributions on the most granular data available in PovcalNet taken by this paper is in contrast to the fitted distributions using decile shares, as was done by Jolliffe and Prydz (2015).

[14]The series is called *Poverty headcount ratio at national poverty lines (% of population), including non-comparable values (SI.POV.NAHC.NC)*. We use a version downloaded on November 12, 2015. The national poverty headcount ratio is the percentage of the population living below the national poverty threshold. The source for this data is the World Bank's Global Poverty Working Group. Data are compiled from official government sources or are computed by World Bank staff using national poverty lines. Since China only defines a rural poverty line, for 2005 and the following years we use the rural poverty headcount rate. We treat the resulting poverty line as our implicit national line since the rural consumption vector for China in PovcalNet has been spatially adjusted to national price levels. The data are available at http://databank.worldbank.org/data/views/variableselection/selectvariables.aspx?source=Poverty-and-Inequality-Database.

[15]The OECD poverty rates are estimated after taxes and transfers, using a relative poverty line set at 60 % of median income drawn from the (PVT6A) series, accessed June 12, 2015. These are explicitly relative poverty lines and comparable to the Eurostat lines used by Ravallion (2010) for rich countries. We include OECD poverty rates for Australia, Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Luxembourg, Mexico, Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey and United Kingdom.

[16]U.S. estimates are from U.S. Bureau of the Census, Current Population Survey.

[17]Canada does not measure poverty, but rather refers to the prevalence of low-income status. The source for the low-income estimates is Statistics Canada, CANSIM table 202-0802 and Catalogue no. 75-202-X.

countries which correspond to officially reported national poverty rates when applied to the PovcalNet per capita welfare measure. This is more than a tenfold increase over the number of observations used by RCS.

Figure 1 (panel a) plots the distribution of these 864 implicit national poverty lines from our method, all of which are expressed in per capita PPP terms and uniquely correspond to the reported poverty headcounts. On this figure, we also overlay a weighted density function of the lines, where each country has an equal weight. The majority of national poverty lines, and the majority of countries, are bunched together at relatively low values. Thirty-seven percent of all the poverty lines are less than \$3/day and 52 % are less than \$5/day. Panel B of this figure zooms in on the distribution of poverty lines that are less than \$5/day and reveals that there is a significant mass of national poverty lines right around \$1.90, the poverty line chosen by the World Bank to monitor extreme poverty. This is the first piece of evidence that, despite the documented concerns, the official \$1.90 appears to be robust to potential CPI issues and seems quite relevant for a large number of poor countries.

3 International poverty lines drawn from the range of national lines

For most countries, national poverty lines are increasing with national per capita consumption (and income); that is to say, richer (poorer) countries have higher (lower) definitions of what poverty means. RDV (1991) and RCS (2009) present evidence that this relationship largely does not exist for countries at very low levels of mean consumption, and this was the basis for identifying the 15 countries which have been used to estimate both the

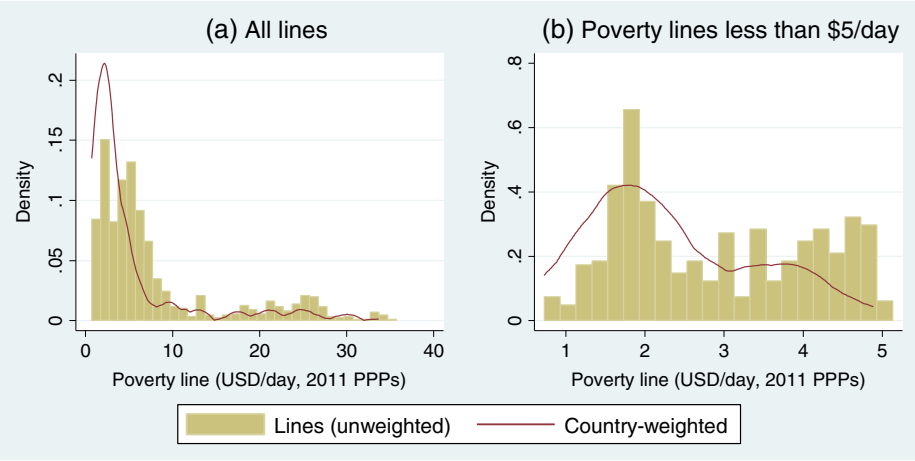

Fig. 1 Distribution of estimated national poverty lines. *Note*: The sample consists of 864 national poverty lines which we obtain from our method of matching national headcount rates with internationally comparable distributions in PovcalNet. Panel **a** shows the full range of lines, while panel **b** zooms in on the distribution of poverty lines with value less than \$5/day . In the histogram, each poverty line is equally weighted; in the density function, each country is equally weighted. For a country that has only one poverty line in the sample, this line receives a weight of one. For a country that has 10 poverty lines in the sample, each line receives a weight of 1/10. *Source:* Authors' calculations based on poverty headcount ratio at national poverty lines (% of population), including noncomparable values (SI.POV.NAHC.NC), available at databank.worldbank.org/data/views/variableselection/selectvariables.aspx?source=Poverty-and-Inequality-Database and OECD relative poverty lines

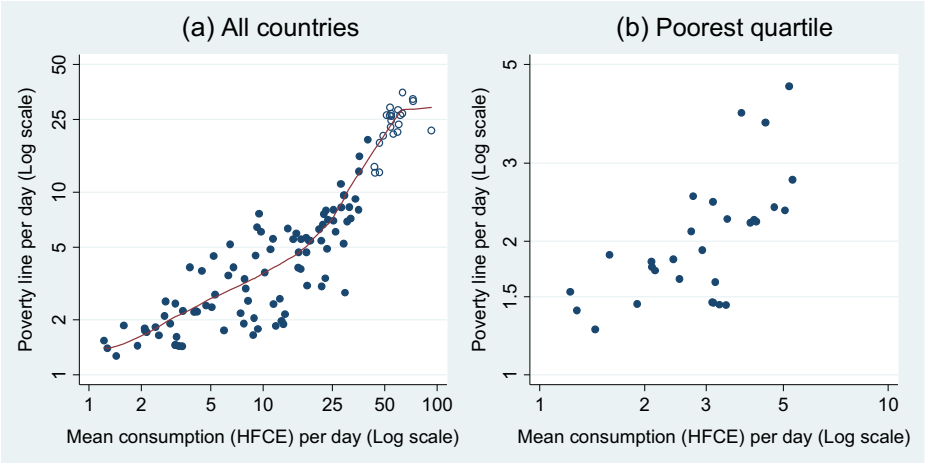

Fig. 2 Economic gradient in poverty lines – even among poorest countries. *Note*: In panel **a** relative OECD and rich country lines are indicated with hollow markers. Panel **b** zooms in on the 29 poorest countries (bottom quartile group)

$1.25 and $1.90 IPLs. Our initial interest in constructing the national poverty lines was to re-assess this relationship between national poverty lines and mean consumption based on the 2011 PPP conversion factors and a more recent and complete sample of national lines. Our expectation was that we would identify a different set of countries than found by RCS for which there is no significant correlation at low levels of consumption, and we would then use the new set of countries as the reference group for estimating an IPL. We follow RDV and RCS in using household final consumption expenditure (HFCE) per capita from the national accounts as the key measure of economic welfare of each country.[18] For our analysis, we use a sample of our estimated national poverty lines from 115 countries, where we use the closest line to the PPP reference year of 2011. The full set of lines is available in Appendix 2.[19]

Panel a of Fig. 2 plots the log of the poverty lines for these 115 countries on the log of HFCE at 2011 PPPs for private consumption and shows that there continues to be a strong, positive economic gradient in national poverty lines. Panel B focuses this plot on the poverty lines from the poorest quartile of countries, as assessed by HFCE. In contrast to RDV and RCS, this plot appears to indicate a strong positive gradient in the national lines for even the poorest of countries. In order to examine this more carefully, we regress the national lines on HFCE using a variety of specifications to assess whether the apparent finding in Fig. 2 is robust.

We report (see, Table 1) estimates from two general specifications of models – one that regresses logs on logs, and the other that regresses levels on levels. For each of these, we

[18]We use HFCE data available from the World Development Indicators and the ICP (series code NE.CON.PRVT.PP.KD in the World Bank's public databases). The series is available in constant 2011 PPPs, and we convert it to per capita amounts using WDI population figures for the same year and country (series name SP.POP.TOTL).

[19]We drop 14 countries from our full sample in this analysis. Three countries in our sample with national poverty lines use imputed PPPs rather than benchmark PPPs and we therefore choose to exclude them, while the remainder (11) are missing data for HFCE at 2011 PPPs.

Table 1 National poverty lines regressed on mean consumption

Sample	(1) 2011 lines	(2) 2011 lines (Poorest 4th)	(3) All lines [weighted]	(4) Without OECD lines [weighted]
Panel A. Log-log model				
Log (HFCE)	0.76***	0.51***	0.79***	0.59***
	(21.74)	(5.13)	(36.06)	(25.69)
Constant	−0.32***	0.15	−0.41***	−0.06
	(−3.38)	(1.68)	(−6.12)	(−1.05)
R-squared	0.78	0.43	0.79	0.62
N	115	29	796	635
Panel B. Linear-linear model				
HFCE	0.39***	0.44***	0.40***	0.27***
	(14.22)	(4.18)	(44.87)	(22.30)
Constant	−0.47	0.74**	−0.36*	0.98***
	(−1.02)	(2.80)	(−2.31)	(7.45)
R-squared	0.86	0.44	0.89	0.67
N	115	29	796	635

Note: Panel (A) is a log-log specification of national poverty lines regressed on HFCE (Household final consumption expenditure), and (B) is the levels on levels specification. Column (1) constrains the sample to the poverty line closest to 2011 for each country, giving a total of 115 lines. Column (2) uses poverty lines from the bottom quartile group only. Column (3) lists the estimates from the full sample of 796 national poverty lines from a weighted regression. The weight for each observation (i.e. poverty line) is 1/Ni, where Ni is the number of poverty lines we observe for country i. Column (4) is similar to Column (3), but excludes explicit relative lines from OECD countries. The absolute value of t-statistics, based on robust standard errors, are in parentheses

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

examine four models. The first model is an unweighted OLS regression based on the sample of 115 lines in panel a of Fig. 2, while the second model is the same except that it is restricted to the poorest fourth of countries in panel B. Model 3 is a weighted regression of 796 poverty lines (all for which we have HFCE and 2011 PPP conversion factors), where the weights are set to ensure each of the 115 countries is equally weighted. If country i has N_i poverty lines in the sample, then each of country i's lines are weighted by $1/N_i$. This model allows us to examine if the results qualitatively change when we change from considering recent lines (those closest to the 2011 reference year for each country) to considering in addition a much larger set of older lines. The last column repeats model 3, but drops relative poverty lines from OECD countries.[20]

For all models over both the log-log and level-level specifications, the data indicate that there is a positive and statistically significant relationship between national poverty lines

[20]We consider a model where OECD poverty lines are dropped because it is not obvious that a harmonized definition across several countries of relative poverty is relevant within each country in the same way that a national poverty line is. This is similar to a point noted in Ravallion (2010) in questioning the national relevance of explicitly relative Eurostat poverty lines.

and national income (as measured by HFCE). For both the log-log and level-level specifications, the slope coefficients for the unweighted, all-lines model are statistically the same as the coefficients from the weighted regressions. Similarly, across both specifications, the model that excludes the OECD relative poverty lines exhibits a decline in the magnitude of the slope coefficient. This suggests that these high-income countries where the national poverty line is parametrically linked to (median) income (except for the US and Canada), do positively influence the slope coefficient. As further evidence of this, the fitted lowess (locally weighted scatterplot smoothing) regression line in Fig. 2 indicates a steepening of the slope over the range of rich countries, and the cluster of hollow markers indicating OECD countries are influencing this.

The findings from Model 2, which is where the regressions are restricted to the 29 poverty lines from the poorest fourth of countries, are perhaps the most important findings for this analysis. Here again we find evidence that is in contrast to RDV and RCS. The regression coefficients indicate that there is a positive and statistically significant economic gradient in the national poverty lines of the poorest of countries. It is important to recognize that the sample of lines on which this regression is based are much more recent than those in RCS and RDV, so this finding could simply reflect the fact that now countries have grown past the identified threshold in RCS, below which there appeared to be no relationship.[21]

Regardless of the relative magnitude of the slope coefficients, both specifications indicate that poverty lines are increasing over the entire range of national consumption. This positive economic gradient across all levels of consumption is also robust to alternative measures of economic development, including household survey mean and, importantly, constant GNI per capita at Atlas exchange rates. Ravallion (2016) raises the concern that the positive slope we find when regressing national poverty lines on mean per capita consumption, even among poor countries, is caused by measurement error induced by our methodology for estimating implicit poverty lines. This concern would be valid if there is evidence, or reason to believe, the error in the estimated national poverty line is positively correlated with measurement error in HFCE, and if the measurement error is sufficiently large. However, our assessment suggests that our method-induced measurement error is minimal and that there is little reason to believe that measurement errors should be correlated. Indeed, one reason why we use HFCE is to reduce the potential for correlated errors. A more thorough discussion of this issue is described in Appendix 1.

With no evidence that there exists a set of very poor countries for which increases in mean consumption do not also coincide with increases in national poverty lines, we are not able to follow the approach of RCS for estimation of an IPL. Given that we have no data-driven basis on which to select national poverty lines from our sample of 864 lines, we examine a series of lines derived from differing sub-samples of the set of poverty lines. Our first selection criterion is to use the line for each country that is closest to the 2011 PPP reference period. This gives us the sample of 115 lines displayed in Fig. 2. One motivation for this selection is to base the IPL on lines that are reflective of current social norms. The lines that underpin the official $1.90/day are nearly 20 years old on average. Just as we expect national lines to be higher for richer countries, so too do we expect poverty lines to increase in value as countries grow. Another motivation for this selection, the one that is more linked to the focus of this paper, is that the 15 national lines that underpin the $1.90 estimate need on average 14 years of national CPI data. In contrast, the sample of 115 poverty lines closest

[21] Klasen et al. (2016) find that the flat segment observed by RCS holds at 2011 PPPs, using the original RCS sample.

Table 2 International poverty lines: median and mean national lines, by group

A. Country quartile groups	Median	Mean	B. Income Classifications	Median	Mean
Lowest 25 % (29)	1.86	2.11	Low Income (33)	1.91	2.23
25–50 % (29)	3.34	3.65	Lower Middle (32)	3.21	3.87
50–75 % (29)	5.62	6.17	Upper middle (32)	5.48	5.61
Highest 25 % (28)	22.20	21.45	High Income (29)	21.70	21.19

Note: Countries are grouped based on per capita HFCE quartile in panel A and categorized based on World Bank official income classification, which uses per capita GNI, in panel B. Number of countries in each group in parentheses

to 2011 require on average just over one year of CPI data. More than half the lines are from 2011 and require no CPI, while fewer than 15 % of the lines require more than 2 years of CPI data.

From this sample of 115 national poverty lines, we consider two very different ways to select a reference set of national poverty lines upon which to base the estimated IPL. The first approach cuts the sample of national lines into quartile groups based on HFCE. Given that we have no income threshold to define countries whose poverty lines reflect absolute extreme poverty, we view the bottom quartile group as being a reference group for the poorest countries of the world, similar to the interpretation of the 15 poorest countries supporting the $1.90/day line. However, these 29 countries (representing about 25 % of the population of poor people in 2005) approximately double the coverage of the poor relative to the 15-country approach. This doubling of the number of countries and of the coverage of poor people, in part addresses one of the critiques levied by Deaton (2010) questioning the support of the World Bank's IPL. Panel A of Table 2 lists both the mean and median of the national poverty lines within each quartile. For the poorest 25 % of countries, the median of their national poverty lines is $1.86 and the mean is $2.11. Given that our focus is on enhancing the robustness of the estimated IPL to the sort of shifts in the composition of countries described by Deaton (2010), and potential outliers caused by measurement errors in poverty lines or CPI, our preferred estimates are medians for each sub-sample.

The other approach we consider for selecting a reference set of national poverty lines upon which to estimate the IPL, is to use the World Bank's income classification scheme. The World Bank income classifications separate countries into four categories based on per capita gross national income (GNI). These categories are low-income, lower-middle, upper-middle, and high-income countries. To sort and rank countries, GNI at local currencies are converted into a common currency using exchange rates averaged over a three-year time period (i.e. the Atlas method). The classification scheme was established in 1989, and is updated on an annual basis to adjust for international inflation.[22] The cut-off points for the classification are somewhat arbitrary, as with many typologies, but the classifications are

[22] As of 1 July 2014, low-income economies are defined as those with a GNI per capita, calculated using the World Bank Atlas method, of $1,045 or less in 2013; middle-income economies are those with a GNI per capita of more than $1,045 but less than $12,746; high-income economies are those with a GNI per capita of $12,746 or more. Lower-middle-income and upper-middle-income economies are separated at a GNI per capita of $4,125. For more details, see datahelpdesk.worldbank.org/knowledgebase/articles/378833-how-are-the-income-group-thresholds-determined

well established and quite widely used in policy discussions within and outside of the World Bank.[23]

Taking the median values of national poverty lines within each of the four income classifications results in values that are quite close to the medians from the quartile subsamples of the distribution of national poverty lines. Comparing panels A and B in Table 2 reveals that the median values of national poverty lines within each quartile group matches (with a difference of less than 5 % for all cases) the median value for the corresponding income-classification category. In particular, the median poverty line observed over the set of low-income countries is $1.91, which is within five cents of the median value from the bottom quartile group of poverty lines and similarly within a cent of the World Bank $1.90 IPL. As a check on the stability of this straight-forward approach over time, we estimate the median LIC lines using 2005 PPP conversion factors and find that the median poverty line is $1.21 in 2005.[24] That this procedure results in an estimate that is close in value to the previous $1.25 IPL is a desirable attribute both in terms of avoiding major revisions to historical global poverty headcounts denominated in 2005 PPPs, and in terms of ensuring conceptual comparability with the previous IPL.

4 Concluding comments

This paper offers two main contributions to the literature on measuring global poverty. The first is that we offer an improved database of national poverty lines. This database is not only much larger in terms of country and temporal coverage, but it also based on a methodological approach that allows for easy updating and creates a set of lines that have greater comparability than the set offered in RCS. Most importantly, the approach proposed in this paper for estimating national poverty lines has the desirable attribute that when the estimated national poverty lines are applied to the consumption or income vector from PovcalNet, the resulting poverty headcount will match the poverty headcount for that country (as reported in the WDI).

The other main contribution of this paper is to show that the World Bank's IPL of $1.90 for extreme poverty corresponds very closely with alternative methods for estimating the IPL. In particular, we show that the median national poverty line of the poorest 25 % of countries (as defined by per capita HFCE) in our sample of lines is $1.86 almost identical in value to the estimate of $1.88 reported in Ferreira et al. (2016), which both round to $1.90. Similarly, we show that the median value of our estimated national poverty lines from all low-income countries (as defined by per capita GNI) is equal to $1.91. Despite using different measures for sorting countries, following different approaches for selecting the reference sample, and using much more recent poverty lines, both estimates result in an IPL that directly corresponds to the World Bank definition of extreme poverty. We interpret this as evidence of the robustness of the $1.90 estimate to variations in how one selects the reference set of poverty lines and some of the measurement issues linked to its estimation. We also interpret the findings as providing evidence of the relevance of $1.90 line for the poorest of countries.

[23] As one example, the classifications are part of the widely used WDI database. See Fantom and Serajuddin (2016) for more details on the classifications and on their use.

[24] The median value of the bottom quartile group of poverty lines is $1.20 in 2005 PPP values.

While it is well recognized that the IPL for measuring extreme poverty does result in a line that is too miserly for middle-income countries, and largely irrelevant for high-income countries, this paper offers lines to supplement the extreme line for better-off countries. In particular, when we examine median values of lines for countries that are grouped into income categories, these values largely mirror the values obtained when sub-sampling the national lines into quartiles. For example, the median national poverty line for the fourth of the population below the median but above the 25th percentile rounds to \$3.30. The corresponding value for lower-middle income countries is \$3.20. Similarly, when examining countries above the median but below the 75th percentile, their median line rounds to \$5.60, while the corresponding line for upper-middle income countries is \$5.50.[25]

While this convergence of median lines from the income classification system and quartiles of the distribution of national poverty lines is lacking in a conceptual foundation, it is nonetheless a useful and simple result to show that these values both match a common definition of economic wellbeing of countries and the empirical density of poverty lines, reflecting in principle social norms of each country. The advantage of simplicity may be particularly important for estimating an IPL which should be attentive to the need for clearly communicating how the lines are estimated in order to build up public consensus around these values which ultimately are measures of social norms.

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[25]The median value for the highest quartile group is \$22.20. While the U.S. is in this quartile group, the value of its line is less than this. The U.S. is a country that has a grid of 61 lines for different types of families (DeNavas-Walt et al. 2012). As one example though, a single-adult family with two children has an annual poverty threshold in 2011 of \$18,123 (or roughly \$16.55 per person per day).

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