



Purchasing power parities and the Dollar-A-Day approach: An unstable relationship[☆]

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ABSTRACT

We show that the Dollar-A-Day methodology in global poverty measurement provides inconsistent International Poverty Line (iPL) solutions when a complete set of consistency criteria in the iPL definition is used. This article illustrates that minor fluctuations in purchasing power parity exchange rates can yield inconsistent iPLs. We find a rate of inconsistency of 46.1% and we conclude that this is a worrisome attribute of the method.

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1. Introduction

The Dollar-A-Day (DAD) global poverty measurement approach can be traced in its latest version in [Ferreira et al. \(2015\)](#). The main aspect of the method is the derivation of an international poverty line (iPL) that is applied to every country for any year, and is expressed in PPP international dollars.

Purchasing Power Parity (PPP) exchange rates are instrumental in the traditional global poverty measurement utilized by the World Bank and the United Nations for monitoring global poverty within the Millennium and the Sustainable Development Goals agenda. Their main function is to convert local currencies into an international common denomination that would express the purchasing capacity of each household independent of local currency denominations.

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2. Materials and methods

[Ravallion et al. \(2009\)](#) (hereafter RCS) revised in 2005 PPP terms the definition of the iPL previously followed by [Ravallion et al. \(1991\)](#) and [Chen and Ravallion \(2001\)](#). Their estimation of the iPL included two steps: (i) selecting a reference group of countries, and (ii) taking the average of the national poverty lines from the countries in that reference group.

When [Ferreira et al. \(2015\)](#) adjusted the iPL to the 2011 PPP exchange rates they did not follow the method introduced by their colleagues at the World Bank in [Ravallion et al. \(2009\)](#). Instead they kept the same countries in the reference group of [Ravallion et al. \(2009\)](#), thereby making their iPL to depend both in 2005 and 2011 PPPs.

2.1. The Dollar-A-Day

To define the iPL [Ravallion et al. \(2009\)](#) use the following equation:

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

Z_i is the poverty line of country i , Z^* is the average of the reference group's National Poverty Lines (NPLs), I_i takes the value of one when country i belongs to the reference group and zero otherwise, and $f(C_i)$ is a function of consumption per capita per month C_i . The function $f(C_i)$ is fitted as a linear function of C_i corresponding to non-reference group countries. The estimated

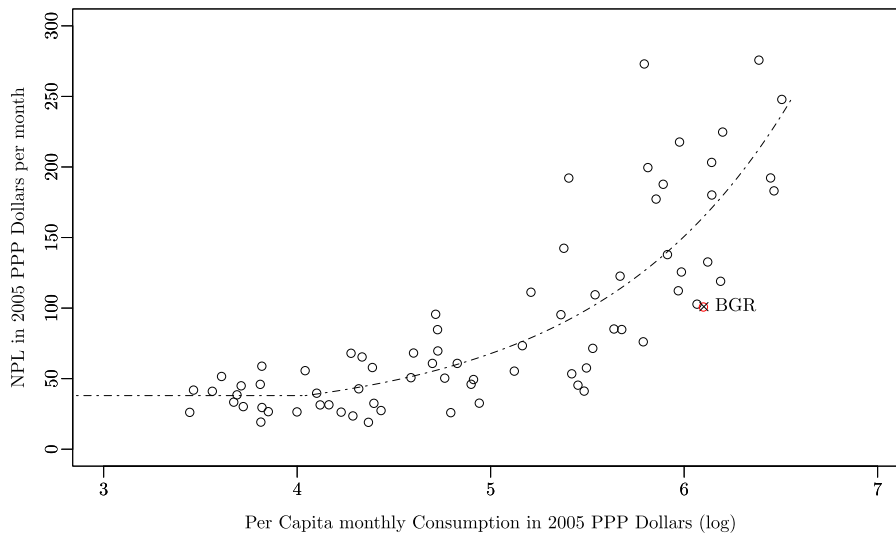


Fig. 1. The elbow fitting of the National Poverty Lines as a function of log consumption per capita for the 74 countries in the RCS data set, using the PovcalNet PPP exchange rates. PPP rates for Bulgaria (BGR) are specially marked (discussed in the results section).

Table 1

Elbow fitting original. Numerical results for the elbow fitting of the Ravallion et al. (2009) data set for the first 30 countries. All monetary values in 2011 PPP dollars per month, except iPL that is given in per day values. (b) and (c) correspond to the criteria (b) and (c) described in the text; 1 corresponds to fulfilling the criterion and 0 for not. See main text for the explanation of the criteria. See main text for the explanation of the criteria.

	ISO3	Cons.	C*	iPL	beta0	beta1	(b)	(c)	DAD
1	MWI	31.34		26.110					0.86
2	MLI	31.96	39.311	34.000	21.403	0.320	1	0	1.12
3	ETH	35.22	47.387	36.347	21.128	0.321	1	0	1.19
4	SLE	36.94	60.853	40.145	20.500	0.323	1	0	1.32
5	NER	39.34	56.657	38.786	20.495	0.323	1	0	1.28
6	UGA	40.01	56.994	38.740	20.313	0.323	1	0	1.27
7	GMB	40.88	60.812	39.623	19.895	0.324	1	0	1.30
8	RWA	41.33	56.858	38.441	20.014	0.324	1	0	1.26
9	GNB	45.12	60.576	39.277	19.575	0.325	1	0	1.29
10	TZA	45.26	52.797	37.269	20.180	0.324	1	0	1.23
11	TJK	45.49	61.433	39.229	19.187	0.326	1	0	1.29
12	MOZ	45.52	58.454	38.422	19.381	0.326	1	0	1.26
13	TCD	47.04	54.711	37.512	19.742	0.325	1	0	1.23
14	NPL	54.55	50.939	36.721	20.240	0.324	0	1	1.21
15	GHA	56.90	56.935	37.983	19.448	0.326	1	1	1.25
16	ZMB	60.40	57.336	38.089	19.420	0.326	0	1	1.25
17	NGA	61.49	55.062	37.695	19.821	0.325	0	1	1.24
18	BGD	64.34	52.722	37.348	20.297	0.323	0	1	1.23
19	BFA	68.54	48.587	36.765	21.155	0.321	0	1	1.21
20	COG	72.13	56.908	38.327	19.861	0.324	0	1	1.26
21	BEN	72.82	51.683	37.624	20.999	0.322	0	1	1.24
22	KHM	75.06	52.037	37.859	21.138	0.321	0	1	1.24
23	YEM	76.37	59.018	39.055	19.914	0.324	0	1	1.28
24	SEN	78.92	51.825	38.222	21.630	0.320	0	1	1.26
25	MNG	80.55	56.201	39.008	20.918	0.322	0	1	1.28
26	VNM	81.18	52.599	38.758	21.961	0.319	0	1	1.27
27	IND	84.24	46.794	38.338	23.578	0.315	0	1	1.26
28	PAK	98.31	47.353	38.778	23.875	0.315	0	1	1.27
29	MRT	99.63	53.449	39.791	22.838	0.317	0	1	1.31
30	KGZ	109.85	56.361	40.492	22.582	0.318	0	1	1.33

version of Eq. (1), as it appears in RCS and shown in Fig. 1, is as follows¹:

$$Z_i = 37.983I_i + (19.388 + 0.326C_i)(1 - I_i) + \hat{\varepsilon}_i \tag{2}$$

(12.55) (2.99) (11.15)

$$R^2 = 0.890, \quad n = 74.$$

¹ T-ratios in parenthesis based on robust standard errors.

Ravallion et al. (2009) split the set of 74 countries in their data, in order to separate the absolute poverty from relative poverty components, and thus they fit an elbow function. In this setup, the critical issue is where the consumption per capita threshold is located (shown in Fig. 1) which would provide a consistent solution according to the following criteria: (a) the continuity criterion that requires $Z^* = f(C^*)$ at the threshold, and (b) the consistency criterion requiring $C_i < C^*$ for all countries i in the reference group.

$f(C)$ and Z^* are estimated directly from the data so they are used to determine the threshold level by actually enforcing the aforementioned continuity criterion (a). Table 1 shows the detailed results of this investigation at various threshold levels within the original (Ravallion et al., 2009) set of countries. Ravallion et al. (2009) find that \$60 is a consistent solution and includes 15 countries in the reference group.

Importantly, in the above discussion one consistency criterion is omitted, and must be added to the two above. It stems from the trivial observation that for a threshold to be consistent it should in addition hold that:

$$(c) \text{ for any country } j \text{ not in the reference group } C_j > C^*.$$

Intuitively, the need for this criterion is similar to the need behind criterion (b), as criterion (c) is the complimentary of (b). Criterion (b) is required to assure that the fitted line in the non-reference group will not have a gradient that makes its fitted line intersect with the fitted horizontal line of the reference group below the C^* consumption level (see also the lognormal Fig. 1 for an overview). Likewise, criterion (c) is required to guarantee that the intersection of these lines will not happen at a location above the consumption level of any country *not* belonging to the reference group. Only when taken together the three criteria above guarantee that the gradient of the second fitted line of the elbow is such that their intersection will happen within the consumption per capita area between reference and non-reference countries.

2.2. Microsimulations

Our approach for teasing out the frequency with which the solutions to the choice of threshold provided by the Ravallion

Table 2

Elbow fitting amended. Numerical results for the elbow fitting of the Ravallion et al. (2009) data set for the first 30 countries, with the slight modification of Bulgaria's (BGR) PPP rate (see text for details). All monetary values in 2011 PPP dollars per month, except iPL that is given in per day values. (b) and (c) correspond to the criteria (b) and (c) described in the text; 1 corresponds to fulfilling the criterion and 0 for not.

	ISO3	Cons.	C*	iPL	beta0	beta1	(b)	(c)	DAD
1	MWI	31.34		26.110					0.86
2	MLI	31.96	39.283	34.000	21.416	0.320	1	0	1.12
3	ETH	35.22	47.360	36.347	21.141	0.321	1	0	1.19
4	SLE	36.94	60.830	40.145	20.514	0.323	1	0	1.32
5	NER	39.34	56.632	38.786	20.509	0.323	1	0	1.28
6	UGA	40.01	56.968	38.740	20.328	0.323	1	0	1.27
7	GMB	40.88	60.786	39.623	19.910	0.324	1	0	1.30
8	RWA	41.33	56.830	38.441	20.029	0.324	1	0	1.26
9	GNB	45.12	60.548	39.277	19.591	0.325	1	0	1.29
10	TZA	45.26	52.766	37.269	20.196	0.324	1	0	1.23
11	TJK	45.49	61.404	39.229	19.204	0.326	1	0	1.29
12	MOZ	45.52	58.422	38.422	19.398	0.326	1	0	1.26
13	TCD	47.04	54.676	37.512	19.759	0.325	1	0	1.23
14	NPL	54.55	50.901	36.721	20.258	0.323	0	1	1.21
15	GHA	56.90	56.899	37.983	19.466	0.325	0	1	1.25
16	ZMB	60.40	57.298	38.089	19.439	0.325	0	1	1.25
17	NGA	61.49	55.021	37.695	19.841	0.324	0	1	1.24
18	BGD	64.34	52.679	37.348	20.317	0.323	0	1	1.23
19	BFA	68.54	48.541	36.765	21.176	0.321	0	1	1.21
20	COG	72.13	56.863	38.327	19.883	0.324	0	1	1.26
21	BEN	72.82	51.634	37.624	21.021	0.322	0	1	1.24
22	KHM	75.06	51.986	37.859	21.161	0.321	0	1	1.24
23	YEM	76.37	58.967	39.055	19.938	0.324	0	1	1.28
24	SEN	78.92	51.769	38.222	21.654	0.320	0	1	1.26
25	MNG	80.55	56.144	39.008	20.944	0.322	0	1	1.28
26	VNM	81.18	52.538	38.758	21.988	0.319	0	1	1.27
27	IND	84.24	46.726	38.338	23.605	0.315	0	1	1.26
28	PAK	98.31	47.283	38.778	23.904	0.315	0	1	1.27
29	MRT	99.63	53.378	39.791	22.868	0.317	0	1	1.31
30	KGZ	109.85	56.288	40.492	22.613	0.318	0	1	1.33

et al. (2009) methodology turn out to be inconsistent uses a Monte-Carlo microsimulation (Bailer-Jones, 2017; Chib, 2001). The core idea in this approach is that the PPP exchange rates corresponding to the 74 NPLs used in Fig. 1 are being sampled following a log-normal distribution following Rao et al. (2010), as implemented in Moatsos and Lazopoulos (2021).²

2.3. Data

The PPP error terms that we use here are coming from Rao et al. (2015), which cover both 2005 and 2011 ICP rounds for 181 countries. The PPP error terms they provide relate to the consumption GDP component, and therefore is a better match with the concept of the household final consumption PPP compared to the error terms provided by the other sources which relate to GDP as a whole (Deaton and Dupriez, 2011; Deaton, 2012). In addition, on average they are less than half the estimates made by Deaton (2012), and have an average standard deviation of 5.7% for 2005. This makes our implementation a rather conservative one.³

3. Results

Fig. 1 shows the elbow fit using the PPP rates of PovcalNet, and provides identical conclusions as in RCS, suggesting a 1.9\$/a-day as the result of a consistent reference group selection (shown in Table 1). It further considers the case of a small deviation from

² All analysis has been conducted with R open source statistical computing software (R Core Team, 2018).

³ Deaton (2012), for example, estimates for China and India give a relative standard error of 15%, a value similar to most other countries in his estimates.

those PPP rates for one country (see supplementary material for details). In the case of Bulgaria's PPP rate, for example, it only takes a very modest 0.25% relative change to render the reference group results inconsistent (when the standard error for Bulgaria is estimated at around 3%).⁴

In our microsimulations the entire procedure of estimating the iPL is repeated 10,000 times and the PPPs for each repetition are drawn from 2005 PPP exchange rates using the log-normal error terms estimated by Rao et al. (2015). In 46.1% of the cases the consistency test fails. When we exclude criterion (c) from our microsimulations then only 1.8% of the cases fail to be consistent to criteria (a) and (b).

4. Discussion

Our results indicate that the solutions produced by the original criteria (a) and (b) are consistent at a very high rate of 98.2%. However, solutions that are only consistent according to criteria (a) and (b) cannot be deemed as overall consistent since in almost half the cases they will violate the sine-qua-non criterion (c) defined above, which is omitted in the original DAD procedure.

5. Conclusions

The Dollar-A-Day methodology for measuring global poverty is shown to be sensitive to very small fluctuations of the Purchasing Power Parity exchange rates, which are well within the error terms of the PPPs. We demonstrate this on the entire set of NPLs used in the derivation of the iPL by utilizing a complete set of criteria for consistency, contrary to the use of non-complete criteria in the original Dollar-A-Day method. The omission of criterion (c) in the original procedure by the World Bank researchers (Ravallion et al., 2009) appears to be critical. We conclude that the high rate of inconsistency in the Dollar-A-Day method is a worrying attribute for the method, particularly when it has been shown that the method as a whole (excluding its inconsistency problem) is remarkably prone to uncertainty (Moatsos and Lazopoulos, 2021).

Appendix. Supplementary material

A.1. Detailed discussion of consistency break down

The consistency breaks because of the C^* moving from slightly above the consumption per capita in the most affluent country in the reference group (Ghana), to slightly below it. Thus violating the consistency criterion (b) which requires that $C_j < C^*$ for all countries in the reference group. If we were to simply remove Ghana from the reference group and recalculate the iPL with the 14 remaining NPLs we would face the same problem, as also in this case criterion (b) is violated. See row 14 in Table 2, where C^* is 50.901 while consumption per month and per capita for the 14th country (Nepal) is 54.55, thus including Nepal in the reference group makes it inconsistent. We need to remove yet another country from the group (namely Nepal) to be consistent with criterion (b). However, in this case we will be violating consistency criterion (c), which requires that for any country j not in the reference group $C_j > C^*$, since there is a country (Nepal) not in the reference group that has consumption per capita lower than the C^* . Observe for this matter row 13 in Table 2, where C^* is 54.676 while consumption per month and per capita for Nepal is 54.55, thus requiring Nepal to be included in the reference group. As Table 2 shows, any threshold selection would fail to separate the reference from the non-reference group with this PPP draw, since there is no country at which both criteria (b) and (c) are met.

⁴ Appendix A.1 in supplementary material discusses the mechanics of the consistency break in detail.

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