Sensitivity of Global and Regional Poverty Rates to Alternative Purchasing Power Parities: Results from ICP, 2011

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Abstract

The motivation of this study is to examine the sensitivity of regional and world poverty rates to the Purchasing Power Parities (PPP) used in the calculations. While recent studies on world poverty differ with respect to the specification and use of national and international poverty lines, they universally use the PPPs available from the ICP. The present study provides alternative sets of PPPs that are compared with the ICP PPPs, and presents evidence of significant revision to the poverty rates if we depart from the use of the ICP PPPs. The study tests for the presence of serial correlation between price movements in different countries and investigates its impact on the PPPs. The results point to a new agenda for poverty calculations that has not been explored to date.

Keywords: Purchasing Power Parities, International Poverty Line, Global Poverty Rates, CPD Model, GEKS Price Indices.

1. Introduction

With 2015 marking the end of the era for the Millennium Development Goals (MDG) and the start of that for Sustainable Development Goals (SDG), with reduction of global poverty featuring prominently in both sets of goals, there has recently been a surge of studies that seek to quantify the magnitude of global poverty. Examples include Cruz et al. (2015), Ferreira et al. (2016), Jolliffe and Prydz (2015), Kakwani and Son (2016). The literature on estimating global poverty[1] can be traced back to Ahluwalia, Carter and Chenery (1979) with the next major contribution by Ravallion, Datt and van de Walle (1991). In the nearly 4 decades that have elapsed since the Ahluwalia et al. (1979) study, the complexity of the exercise has grown many fold with an increase in the number of countries included in the poverty enumeration. The complexity has been reflected in changes in the manner the 'international poverty line' (IPL) has been defined and implemented in successive poverty counts. While the Ahluwalia et al. (1979) study was based on the Indian poverty line used as the IPL, Ravallion et al. (1991) defined the IPL as the mean of the poverty lines of 33 countries, including both developing and developed countries, converted to the US dollar at the prevailing Purchasing Power Parity (PPP). This led to the IPL being specified as $1 a day at 1993 PPP of the various countries' currencies. With each round of the International Comparison Program (ICP) yielding a revised set of PPPs, the IPL has also been revised to reflect the PPP changes reflecting inflation in the various countries. Following the 2005 round of the ICP, Ravallion, Chen and Sangraula (2009) used an expanded set of 88 countries and the 2005 PPPs, to arrive at the IPL of $1.25 a day at 2005 PPP. The latest round of the ICP, namely, the 2011 ICP round led to another revision of the IPL. The IPL, now defined as the mean of the poverty lines of the 15 poorest countries mostly from Africa, yields IPL at around $1.90 a day at 2011 PPP. While Ferreira et al. (2016, Table 6) arrive at the IPL figure of $1.88 a day, Jolliffe and Prydz (2015, Table 2) arrive at a lower value of $1.82. Using a different methodology based on the concept of 'equivalent poverty lines', Kakwani and Son (2016) obtain the IPL as a weighted average of the equivalent poverty lines of 66 countries and arrive at the IPL figure of $1.78 a day. Since many of the households in the poverty count are bunched around the IPL, any movement in the IPL specification, however small, is likely to lead to large changes in the global poverty numbers.

[1] See Ravallion (2016) for a recent comprehensive review of poverty measures and the related literature.

While there is no consensus between Jolliffe and Prydz (2015), Ferreira et al. (2016) and Kakwani and Son (2016) on the exact figure to be used for the IPL, these three studies, as indeed all the global poverty enumerations so far, have all been based on the ICP PPPs. This raises the question: how robust are the global poverty numbers to departures from the ICP PPPs? There is no answer to this question in the literature nor is there any evidence on the robustness of the ICP PPPs themselves to changes in the ICP methodology. The motivation of this study is to provide evidence on these issues. The lack of any evidence on the robustness of the poverty numbers to PPPs is because the only PPPs that are available are those from the ICP. The issue has recently taken on an added importance with the Global Poverty Commission [World Bank (2016)] recommending that from now until 2030 the PPPs to be used in the poverty count should be frozen at the 2011 ICP values with the inflation adjustment made every year at the country level in line with the CPIs of each country. This makes it imperative to examine the accuracy of the 2011 ICP PPPs by benchmarking them against those from an alternative procedure that is based on the same data as the 2011 ICP PPPs. That is done in the present exercise by comparing the ICP PPPs, which uses the Gini-Elteto-Koves-Szulc (GEKS) multilateral price index, with the PPPs using the Country Product Dummy (CPD) method. Taking advantage of the fact that the CPD method allows stochastic formulation, this study provides further evidence on the sensitivity of the CPD PPPs and the corresponding poverty counts to allowing spatially correlated movements in prices between countries by admitting a more general error specification.

The plan of the rest of the paper is as follows. Section 2 describes briefly the GEKS and CPD procedures. The PPPs, the corresponding poverty counts of the ICP regions are compared in Section 3. Section 4 concludes the paper.

2. Description of the Alternative PPP Estimation Procedures

2.1 The ICP Methodology- GEKS Index

The ICP distinguishes between 'below basic headings' and 'above basic headings' in the procedures it uses to calculate the PPP. A full description of the ICP methodology is contained in World Bank (2013) – see, in particular, the contributions by Rao (Chapters 1, 4) and Diewert (Chapters 5, 6) in that volume. The ICP follows a hierarchical approach for estimating the PPPs. Basic Headings (BH) is the lowest level at which the PPPs are estimated. The BH PPPs are then aggregated to calculate PPPs for different uses in cross country comparisons. In this study we restrict ourselves to the PPP estimation procedure above the BH levels, building on the prices constructed from below the BH levels. While the unweighted CPD method (described below) is used by the ICP below the BH level to deal with the problem of missing price information, the commonly used methods of aggregation for computing PPPs for GDP and other major aggregates above the BH level are the Gini-Elteto-Koves and Szule (GEKS), Ikle, Geary-Khamis and the Rao or weighted CPD methods.

An important principle that multilateral PPP estimation ought to satisfy is the transitivity principle which is as follows:

$$PPP_{jk} = PPP_{jm} \,.\, PPP_{mk} \quad . \tag{1}$$

In words, the PPP between countries *j* and *k* can be obtained as the product of the PPP between *j* and *m*, and that between *m* and *k*. This property guarantees the level of internal consistency required in international comparisons. When PPPs are based on a single product, this property is guaranteed for simple price indices such as relative price. However, this is not so if we have multiproduct in the multilateral comparisons. Instead, the GEKS method is used by the ICP above the BH level.

The GEKS method is a generic method which generates transitive indexes from a matrix of binary indexes which satisfy the country reversal test but not transitivity. Let I_{jk} represent a price index (or PPP) for country *k* with country *j* as base such that $I_{jk}.I_{kj} = 1$. Then the GEKS index is given by:

$$GEKS_{jk} = \prod_{l=1}^{M} (I_{jl}.I_{lk})^{\frac{1}{M}} \tag{2}$$

The GEKS index can be implemented once the binary index number formula to compute I_{jk} is chosen. The Fisher binary index is the most commonly used index.[2]

[2] Note that if the Fisher index is replaced by Tornqvist formula, the GEKS index can be derived from the stochastic CPD approach of Rao described below. However, Balk (2009) recently provided an overview of various

2.2 The CPD PPP

The Country-Product Dummy (CPD) PPPs are estimated from the following equation:

$$y_{nc} \equiv \ln p_{nc} = \alpha_1 D_1 + \alpha_2 D_2 + ... + \alpha_M D_M + \eta_1 D_1^* + \eta_2 D_2^* + ... + \eta_N D_N^* + v_{nc}, \quad (3)$$

where D_c *(c=1,2,...,M)* and D_n^* *(n=1,2,.....,N)* are, respectively, country and commodity dummy variables and v_{nc}'s are random disturbance terms which are independently and identically (normally) distributed with zero mean and variance σ^2. The CPD procedure was introduced by Summers (1973) in the context of making international price comparisons in the presence of missing price information in some countries. The CPD procedure has been subsequently used in calculating PPPs between items below the basic heading levels. Diewert (2005) has shown that in a two country, two period framework some traditional price indices, namely, the Geary-Khamis, Walsh and Tornqvist price indices can be obtained as special cases of the CPD framework.

Under complete price information comparisons of price levels between two countries *c* and *d*, represented by PPP_{cd} can be derived as:

$$PPP_{cd} = \prod_{n=1}^{N} \left[\frac{p_{nd}}{p_{nc}} \right]^{1/N} . \quad (4)$$

However, Rao (1995), in the spirit of the standard index number approach, proposed that a more appropriate procedure would be to find estimates of the parameters that are likely to track the more important commodities more closely. This is achieved by minimising a weighted residual sum of squares, with each observation weighted according to the expenditure share of the commodity in a given country.

Thus, the generalized CPD method suggests that estimation of equation (3) be conducted after weighting each observation according to its value share. This is equivalent to application of ordinary least squares to the equation pre-multiplied by $\sqrt{w_{nc}}$, where w_{nc} is the budget share of item *n* in country *c.* The equation thus becomes:

$$\sqrt{w_{nc}} ln p_{nc} = \sqrt{w_{nc}} \sum_{i=1}^{M} \alpha_i D_i + \sqrt{w_{nc}} \sum_{j=1}^{N} \eta_i D_j^* + u_{nc} . \quad (5)$$

Rao (2005) has shown that *PPP*s resulting from the least squares estimation of the above weighted CPD equation are equivalent to a system of expenditure-share weighted log-change system. The Rao system is given by:

$$PPP_d = \prod_{n=1}^{N} \left(\frac{p_{nd}}{P_n}\right)^{w_{nd}}, \text{ setting one country as the numeraire,}$$

$$\text{and } P_n = \prod_{c=1}^{M} \left(\frac{p_{nc}}{PPP_c}\right)^{\frac{w_{nc}}{\sum_{c=1}^{M} w_{nc}}}. \quad (6)$$

Here P_n, *n=1,2,...,N* are the international average prices (at the numeraire country's currency) of commodities. PPP_d is the *PPP* of country *d* with respect to the numeraire country. Note that $\sum_{n=1}^{N} w_{nd} = 1$, the sum of budget shares in country *d*.

The basic CPD model, given by eq. (3) above, has the advantage that, as it is based on stochastic formulation, it allows the use of a range of econometric tools and techniques that are not normally used in the computation of PPPs. In particular, the regression approach provides estimated standard errors for all the coefficients. An added advantage is that the stochastic formulation of CPD given by (3) and (5) can be extended to allow regionally correlated price movements via admitting spatially correlated errors. The empirical literature on subnational and cross country PPPs is generally based on the assumption that there is no interdependence between the price movements in the various regions of a country or between that in the various countries. There is some evidence to the contrary in early work reported by Aten (1996) on subnational PPPs, and by Rao (2001) on cross country PPPs.

The Spatial CPD model is given by:

$$y_{cn} = \alpha_1 D_1 + \alpha_2 D_2 + ... \alpha_M D_M + \beta_1 D_1^* + \beta_2 D_2^* + ... + \beta_N D_N^* + \varepsilon_{cn}, \quad (7)$$

where D_c *(c=1,2,...,M)* and D_n^* *(n=1,2,.....,N)* are, respectively, the country and commodity (product) dummy variables. Here ε, the vector of ε_{cn}'s is specified as follows:

$$\varepsilon = \boldsymbol{\rho S} \varepsilon + \eta, \quad (7a)$$

where $\boldsymbol{\rho}$ is the overall spatial correlation and η_{cn}'s are i.i.d. with mean 0 and variance σ^2.

multilateral methods and endorsed the GEKS-Fisher method as a centre stage method, particularly from the economic approach to international comparisons.

$\boldsymbol{S}$ is a spatial weight matrix of order $\boldsymbol{NC \times NC}$. The spatial weight matrix can be of various types depending on the neighbourhood criteria, based on distance, in general. One possible neighbourhood criterion, in the cross-country context, can be defined as follows:

$\boldsymbol{S_{ij}}$=1 if i and j refer to the same ICP region and same item and $i \neq j$, $\boldsymbol{S_{ij}}$=0 otherwise.

$\boldsymbol{\rho}$ can be estimated using maximum likelihood methods in the joint estimation of the two equations.

Another possible neighbourhood criterion is to define neighbours in terms of inverse of distance between Centroids of two countries. We have calculated the PPPs employing both types of spatial CPD models, referred to as CPD-S1 (Region Cluster) and CPD-S2 (Inverse Distance between Centroids), respectively.

3. Data Sources and the Empirical Results

3.1 Data Source

The price and expenditure information for 2011 was made available by the ICP group in the World Bank. We constructed the prices for item groups at the basic heading (BH) level by considering the item prices (**in LCU**) within the BH taking into account the importance matrix provided by the World Bank.[3] The weighted CPD PPPs for each country (**with India as base**) were then calculated using these computed prices taking the expenditure shares as weights.

3.2 The Alternative Sets of PPPs

For all the countries participating in the 2011 ICP, comparison of the 4 sets of PPPs corresponding to the ICP, the weighted CPD (equation (6)) and its two spatially correlated generalisations given by equations (7)-(7a), with the Indian Rupee as the numeraire, shows the following.[4] First, while, within the CPD framework, the introduction of spatial correlation between price movements[5] in countries in the same region has little effect on the PPPs, the CPD PPPs differ quite significantly in many cases from that of the ICP PPPs. Although generalised statements cannot be made on the sign of the difference between the ICP and CPD PPPs that hold in all cases, in several countries the ICP PPPs exceed the CPD PPPs, often by quite a large margin. This is particularly true of several of the poorer countries in Africa, Asia and Latin America with consequent implications for the poverty rates. Second, the ICP and CPD PPPs are quite close to one another in case of the Eurostat countries which simply reflect the fact that the CPD was used by the ICP for this region.

3.3 Comparing the Poverty Lines and the Poverty Rates Between PPPs

Table 1 compares the International Poverty Lines (IPLs) (specified in Indian Rupees) between the values implied by the 4 sets of PPPs. The reader will recall that the IPL is defined as the mean of the national poverty lines of the 15 poorest countries converted to the Indian Rupee at PPP. This table also presents evidence for these 15 countries on the discrepancy between their national poverty lines and the IPL converted back to the Local Currency Units (LCU) of these countries, the divergence being considerable in some cases where the ratios in the last four columns are much away from 1. The table also shows that the ICP PPP understates the IPL in relation to the CPD PPPs. Though in absolute magnitude the difference is not considerable, since many of the globally poor households are very close to the IPL, this is likely to have a significant impact on the country specific poverty rates and on the distribution of the poor population between the ICP regions.

Table 2 compares the regional poverty rates, which are obtained as the population weighted averages of the poverty rates of the countries in the region. It also compares the regional composition of the 'extremely poor' global population, defined as those living on less than the IPL a day, under the 4 sets of PPPs. While generalised statements are again not possible, these tables show that the variation

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[3] For our analysis, we consider the average prices of similar items (having the same units of measurement) with the highest importance. It also needs to be mentioned that the World Bank makes available prices at the BH level, but these are PPPs (US $=1), not in LCUs.

[4] The table is not presented here, but may be available on request.

[5] The calculated Moran's (1950) I statistics for testing spatial correlation for each item and overall, are consistent with the results of Aten (1996), and Rao (2001), that establish the presence of spatially correlated prices though they are not having much of an impact on most of the PPPs. However, as we report later, depending on how the spatial correlation is introduced, it does lead to a significant upward revision of the world poverty rate.

between the poverty rates are more between the ICP and CPD PPPs than between the non-spatial and spatial CPD PPPs. There are large regional variations, e.g., Africa and South Asia. In contrast, these poverty rates are quite robust in Eurostat-OECD, Latin America and the Caribbean between the alterative sets of PPPs. Due to the large divergence between the CPD and ICP poverty rates in the more populous regions, namely, Africa, South Asia and East Asia and the Pacific, the world poverty rates differ as well. The global poverty rate corresponding to ICP is slightly higher than that corresponding to the non-spatial CPD and the two variants of the spatial CPD. This table also shows that at the aggregate world level the introduction of spatial correlation in the CPD framework does not lead to any significant revision in the world poverty rate. The population share varies significantly between the ICP and CPD PPPs for CIS, East Asia & the Pacific and South Asia, but is much more stable in the other regions.

4. Conclusion

While much of the sensitivity analyses of world and regional poverty rates has been with respect to variation in the national poverty lines and in the IPLs, what is lacking has been similar sensitivity exercise with respect to the PPPs used in the country level poverty calculations. Almost universally, the ICP PPPs have been used since they are the only ones that are publicly available. This study attempts to overcome this gap in the literature by (a) calculating and presenting alternative sets of PPPs to the ICP PPPs, (b) comparing them, and (c) presenting evidence on the sensitivity of the poverty rates and the regional share of the world's poor population to the PPPs used in the calculations. This study provides strong evidence of sensitivity of PPPs and the corresponding poverty rates between the ICP and CPD frameworks. The methodological contribution of this paper is to establish the close nexus between price indices and poverty rates via the PPPs.

References

- Ahluwalia, M., N. Carter and H. Chenery, "Growth and poverty in developing countries", *Journal of Development Economics*, 6(3), 299–341, (1979).
- Aten, B., "Evidence of Spatial Autocorrelation in International Prices", *Review of Income and Wealth*, 42, 149-163, (1996).
- Balk, B., 'Aggregation Methods in International Comparisons: An Evaluation', In *Purchasing Power Parities of Currencies: Recent Advances in Methods and Applications*, ed. D. S. Prasada Rao, 59–85. Cheltenham, U.K.: Edward Elgar, (2009).
- Cruz, M, J. Foster, B. Quillin and P. Schellekens, "Ending Extreme Poverty and Sharing Prosperity: Progress and Policies", Policy Research Note, *Development Economics*, World Bank Group, Washington DC, (2015).
- Diewert, W.E., "Weighted Country Product Dummy Variable Regressions and Index Number Formulae", *Review of Income and Wealth*, 51, 561-570, (2005).
- Ferreira, F., S. Chen, A. Dabalen, Y. Dikhanov, N. Hamadeh, D. Jolliffe, A. Narayan, E. Prydz, A. Revenga, P. Sangraula, U. Serajuddin and N. Yoshida, "A Global Count of the Extreme Poor in 2012: Data Issues, Methodology and Initial Results", *The Journal of Economic Inequality*, 14(2), 141–172, (2016).
- Jolliffe, D. and E. Prydz, "Global Poverty Goals and Prices: How Purchasing Power Parity Matters", *Policy Research Working Paper* 7256, Development Research Group, World Bank, (2015).
- Kakwani, N., and H. H. Son, "Global poverty estimates based on 2011 purchasing power parity: Where should the new poverty line be drawn?" *The Journal of Economic Inequality*, 14(2), 173–184, (2016).
- Moran, P.A.P., "Notes on continuous stochastic phenomena", Biometrika, 37, 17-23, (1950).
- Rao, D.S. P., "On the Equivalence of the Generalized Country-Product-Dummy (CPD) Method and the Rao-System for Multilateral Comparisons", Working Paper No. 5, Centre for International Comparisons, University of Pennsylvania, Philadelphia, (1995).
- Rao, D. S. P., "Weighted EKS and Generalised CPD Methods for Aggregation at Basic Heading Level and above Basic Heading Level", mimeographed, Joint World Bank- OECD Seminar on

Purchasing Power Parities: Recent Advances in Methods and Applications, Washington DC, available in http://www.oecd.org/std/prices-ppp/2424825.pdf, (2001).

- Rao, D. S. P, "On the Equivalence of Weighted Country-Product-Dummy CPD Method and the Rao-System for Multilateral Comparisons", *Review of Income and Wealth*, 51, 571-580, (2005).
- Ravallion, M.,"Toward better global poverty measures," *The Journal of Economic Inequality*, Springer; Society for the Study of Economic Inequality, 14(2), 227-248, (2016).
- Ravallion, M., G. Datt and D. van de Walle, "Quantifying Absolute Poverty in the Developing World", *Review of Income and Wealth*, 37, 345-361 (1991).
- Ravallion, Martin, Shaohua Chen and Prem Sangraula, "Dollar a Day Revisited," *World Bank Economic Review*, World Bank Group, 23(2), 163-184, (2009).
- Summers, R., "International Price Comparisons Based Upon Incomplete Data", *Review of Income and Wealth*, 191, 1-16, (1973).
- World Bank, "Measuring the Real Size of the World Economy: The Framework, Methodology, and Results of the International Comparison Program", *International Comparison Program*, World Bank, Washington DC, (2013).
- World Bank, "Monitoring Global Poverty", Report of the Commission on Global Poverty, World Bank, Washington DC, (2016).

Table 1: Poverty Lines of the 15 Poorest Countries using Alternative Methods: 2011

Region	Country	National Poverty Line (Local Currency Unit) **NPL(LCU)**	**Ratio of NPL(LCU)** to Converted Poverty Line in LCU using Mean Poverty Line in PPP (Numeraire: Indian Rupee)			
			ICP	**CPD**	**CPD-S1**	**CPD-S2**
AFRICA	Chad	295.79	0.68	0.71	0.73	0.72
	Ethiopia	10.02	1.08	1.05	1.08	1.05
	Gambia, The	17.77	0.97	0.93	0.95	0.97
	Ghana	2.20	1.64	1.76	1.75	1.75
	Guinea-Bissau	478.81	1.15	0.98	0.98	0.97
	Malawi	97.50	0.72	0.71	0.70	0.71
	Mali	434.75	1.15	1.13	1.12	1.12
	Mozambique	18.54	0.67	0.67	0.66	0.66
	Niger	312.95	0.80	0.72	0.72	0.72
	Rwanda	351.21	0.80	0.85	0.85	0.84
	Sierra Leone	4365.88	1.46	1.45	1.44	1.45
	Tanzania	474.46	0.47	0.48	0.48	0.48
	Uganda	1536.78	0.94	0.84	0.84	0.84
SOUTH ASIA	Nepal	34.96	0.78	1.17	1.18	1.17
CIS	Tajikistan	4.72	1.70	1.54	1.54	1.54

Table 2: Regional Poverty Rates (%) and Regional Composition of Poor Population (%) under Alternative PPPs: 2011

	Regional Poverty Rates (%)				**Regional Composition of Poor Population (%)**			
Region	**ICP**	**CPD**	**CPD-S1**	**CPD-S2**	**ICP**	**CPD**	**CPD-S1**	**CPD-S2**
Africa	35.38	33.53	33.55	33.64	40.92	39.71	39.93	39.58
CIS	0.17	1.30	1.30	1.31	0.02	0.19	0.19	0.19
East Asia and the	8.70	5.89	5.84	5.97	23.15	15.79	15.71	15.88
South Asia	14.66	17.15	16.98	17.29	29.79	38.77	38.56	38.83
Eurostat-OECD	1.05	0.95	0.95	0.96	2.06	1.89	1.90	1.88
Latin America	6.76	6.41	6.48	6.43	3.79	3.62	3.67	3.61
The Caribbean	5.69	5.69	5.68	5.63	0.04	0.04	0.04	0.04
WORLD	**11.62**	**11.34**	**11.29**	**11.42**	**100.00**	**100.00**	**100.00**	**100.00**