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The Multidimensional Poverty Index: Achievements, Conceptual and Empirical Issues

Caroline Dotter & Stephan Klasen

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Stephan Klasen is professor of development economics and empirical economic research at the University of Göttingen, where he also heads the Ibero-American Institute. Previously he was professor of economics at the University of Munich as well as a fellow at King's College in Cambridge and an economist at the World Bank in South Africa. His research interests are in population, labor, welfare, and development economics. He holds a BA, MA, and Ph.D. from Harvard University. His current research interests include an assessment of the relation between labor market events and demographic decisions at the household level, an analysis of the determinants of undernutrition and child mortality in developing countries, the linkages between inequality, growth, and well-being, and the causes and consequences of gender inequality in developing countries.

Caroline Dotter, M. Sc., is the Research Associate at the University of Göttingen.

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ABSTRACT

The MPI has been an interesting and important effort to provide a household-level multidimensional poverty measure that can compete in depth and coverage with the widely used (and problematic) $1.25 a day income poverty indicator. We strongly suggest that Human Development Report Office (HDRO) continues to use an MPI-type indicator in its future Human Development Reports. At the same time, there are many open questions and issues regarding the conceptual underpinning and alternative formulations of the MPI. We suggest that these issues are carefully considered and possibly a revised MPI be produced that reflects different choices. Among the issues we would flag particularly are the use of the union (instead of the dual cut-off) method for identification and considering inequality in deprivations across people in the MPI (at least in some version of the MPI). We also believe that the headcount would be simpler and more transparent as the headline indicator, with a second measure reflecting intensity (and possibly inequality). Regarding the empirical implementation of the MPI, we propose a number of changes, including dropping the WHS as one of the data sources, dropping the BMI as a nutrition indicator, and changing the age ranges and cut-offs for the education and mortality indicators. In line with the request to simplify the living standards measure, we also recommend to focus on only three living standard indicators (water, floor, and assets). We illustrate the empirical relevance of these changes using the Demographic and Health Surveys (DHS) for Armenia, Ethiopia, and India. We believe that these changes would represent improvements over the current formulation but want to emphasize that one would need to investigate these proposed changes in more detail to come to more definitive conclusions about this. In a final section, we briefly present and comment on the way the HDRO has revised the MPI in the 2014 Human Development Report which has been partly based on the recommendations made in this paper.

1. Introduction

The Multidimensional Poverty Index (MPI) has been published by the HDRO in the annual Human Development Report since 2010. Until the 2014 Human Development Report (see below), it has been based on work done at the Oxford Poverty and Human Development Initiative (OPHI). This indicator which is still being used in this form by OPHI (and was also reported for comparison in the 2014 HDR) is presented and discussed in detail by Alkire and Santos (2010). It is a particular form of a class of multidimensional poverty indices proposed by Alkire and Foster (2011a) using a dual cut-off approach to identify the multidimensionally poor.

Since that time, there has been a vigorous debate on the conceptual and empirical merits and problems of the MPI (e.g. Lustig, 2011; Silber, 2011; Alkire and Foster, 2011b; Rippin 2010; Ravallion, 2011, Bossert, Chakravarty, and D'Ambrosio, 2012, among others). It is impossible to do

justice to all the points raised in those interesting and important debates. In particular, it will be very difficult to come to definitive judgments on the conceptual issues surrounding the MPI as many depend essentially on value judgments about desirable and undesirable features of the MPI, relative to potential 'competitors'; also, we are not well-placed to weigh in on those debates to which we have not contributed in a substantive manner to date.

Instead the aim of this paper will be first to briefly assess whether and to what extent a micro-based multidimensional poverty measure such as the MPI can and has enriched our understanding of poverty and deprivation across the world. Second, we will review the conceptual debates surrounding the MPI and suggest some further avenues of thinking about these issues. More importantly, however, this paper will, thirdly, deal with a range of open empirical questions regarding the MPI: the choice of indicators and cut-offs, the treatment of missing information, and ways to simplify the index. While we will discuss that there is some merit to consider reworking the MPI fundamentally using different conceptual approaches, the more specific recommendations will be on the empirical implementation of the index as currently conceived. The final purpose of the paper is to briefly present and comment on the changes HDRO has made to the MPI in the 2014 Human Development Report, some of which were partly based on recommendations made in this paper.

2. The MPI

The Multidimensional Poverty Index (MPI) has been developed by Alkire and Santos (2010) for the 2010 Human Development Report. It is an index of acute multidimensional poverty and is based on the Alkire and Foster (2011a) dual cut-off method for poverty identification.[1] The MPI (M) itself then can be thought of as the product of the MPI headcount H (measuring the share of the population that is multidimensionally poor), and the weighted deprivation share of multidimensionally poor households A (measuring the weighted percentage of indicators, in which the multidimensionally poor are on average deprived).

Alkire and Santos (2010) identify three dimensions to be included in the MPI: health, education, and the standard of living. These dimensions mirror the HDI. They have been chosen as there is consensus that any multidimensional poverty measure should at least include these three

[1] The Alkire-Foster method extends the traditional approaches of multidimensional poverty identification, the intersection and the union approach. The method employs two cut-offs: First a cut-off within each dimension or indicator is applied to identify who is poor within each dimension. Then poverty across dimensions is aggregated, and the second cut-off is applied to identify poverty across dimensions.

dimensions; for the ease of interpretability; and finally for reasons of data availability. While there are arguments to include additional dimensions such as powerlessness, deprivations of rights, violence, shame, time use, among others, there is often no data available and there is disagreement about which dimensions are appropriate. However, few would dispute the necessity of health, education, and a decent standard of living for a life free from poverty. Whether an individual may be considered deprived in each indicator is, largely for reasons of data availability of some of the indicators, determined at the household level.[2]

Following the Alkire-Foster method, Alkire and Santos first define cut-offs in each indicator, aggregate poverty using weights, and then apply a cross-dimensional poverty cut-off. The three dimensions are represented by ten indicators. Health is represented by child mortality and malnutrition. A household and, thus, all its members is deprived in mortality, if any child has died in the family. Similarly, all household members are deprived in nutrition, if there is at least one undernourished person in the household. Education is represented by years of schooling and child school enrolment. Years of schooling are used as a proxy for literacy and level of understanding of the household members. An individual is considered literate, if he or she has at least five years of education. Following Basu and Foster (1998) the MPI assumes all household members benefit from one literate household member (of any age). Therefore, the household is considered non-deprived, if at-least one household member has five years of schooling. With enrolment, a household is deprived if any of the children of primary school going age are not enrolled in school (see below). The living standard is represented by access to electricity, clean drinking water, improved sanitation, flooring (no dirt, sand, or dung floor), clean cooking fuel, and an asset index. Electricity and floor refer to the quality of housing, while drinking water, improved sanitation, and clean cooking fuel have health impacts and are part of the Millennium Development Goals (MDG 7). Finally, a household is deprived in assets if it does not own more than one small asset (radio, TV, telephone, bike, motorbike, or refrigerator) and does not own a car or truck.

After determining the indicator cut-offs, the Alkire-Foster method attaches weights to each deprivation. The MPI weighs each dimension equally (1/3) and within each dimension, each indicator is weighed equally. The weighted deprivations are then summed up, and the cross-dimensional cut-off is applied. The MPI uses a cross-dimensional cut-off of 1/3. Hence, a household is multidimensional poor, if its weighted deprivations sum up to 1/3 or more.

Alkire and Santos then aggregate poverty using a poverty index (M_0) of a class of Alkire-Foster poverty measures $M(\alpha)$, which can account for the incidence of multidimensional poverty (H) and

[2] For a proposal for an MPI at the individual level, see Vijaya, Lahoti, and Swaminathan (2014).

the average deprivation share among the poor (A). The M0 poverty measure fulfills several desirable poverty axioms and is decomposable by indicator and subgroup.

For this analysis we will illustrate our points regarding the MPI using DHS surveys for three countries: Armenia, Ethiopia, and India. While this sub-sample can by no means be representative, it provides interesting examples as we can see how our proposed changes affect households in countries with vastly different levels of multidimensional poverty and human development. Moreover, the demographic composition of households varies a lot across these three countries. As can be seen in Table 1 below, the three countries differ substantially in the rates of urbanization, the prevalence of small and large households, as well as the prevalence of 'older' households. Table 2 also shows vastly different incidence of multidimensional poverty for the three countries, ranging from 0.6% in Armenia to 90.5% in Ethiopia. Our total sample consists of nearly 600,000 observations, all stemming from the Demographic and Health Surveys (DHS) from these countries.

Table 1: Descriptive Statistics

	All	Armenia	India	Ethiopia
Urban	30.01%	62.30%	30.83%	11.97%
small household (1-3)	14.58%	24.54%	14.32%	12.92%
medium-sized household (4-6)	51.43%	60.75%	51.73%	45.81%
large household (7+)	33.99%	14.72%	33.96%	41.27%
male-headed household	87.83%	71.37%	89.27%	82.93%
„older“ household[3]	22.61%	32.97%	21.85%	24.54%
total observations	594,047	24,351	504,968	64,728

In the following, we will check the sensitivity of the MPI to changing some of the indicator definitions and cut-offs and will compare our results with the base calculation.[4]

[3] A household is considered old, if the average age of adult household members is above 35.

[4] We had to generate our own do-files for these analyses (although we were able to use do-files provided to us by Nicole Rippin as a starting point). We would like to thank Nicole for helping us in this way. Unfortunately, the do-files for the calculation of the MPI for individual countries, as produced by OPHI, are not publicly available. Our results are very close (usually to one decimal place) to the figures published by OPHI for the countries using the same survey. Without seeing the exact do-files that OPHI uses, we cannot be sure what the remaining sources of discrepancy might be.

Table 2: Multidimensional Poverty across sub-groups and countries

	H	A	MPI
All	54.85%	55.28%	0.303206
Urban	20.82%	48.47%	0.100921
Rural	69.44%	56.15%	0.389922
small household	44.31%	49.31%	0.218485
medium-sized household	50.46%	54.73%	0.276131
large household	66.03%	57.63%	0.380515
female-headed household	54.68%	56.51%	0.308982
"older" household	51.59%	55.78%	0.287795
young household[5]	55.81%	55.14%	0.307708
Armenia	0.57%	38.24%	0.002194
Ethiopia	90.48%	64.59%	0.584382
India	52.76%	53.17%	0.28055

3. Achievements of the MPI

The MPI has not been the first attempt in measuring multidimensional poverty. There have been many multidimensional poverty measures proposed in the literature and applied to individual countries (see also discussion below on conceptual issues). The main contribution of the MPI, as we see it, vis-à-vis the existing work, is its breadth of country-coverage and its international comparability. In 2010 the MPI was calculated for 104 developing countries using just 3 types of datasets (DHS, MICS, and WHS)[6] and since then a few dozen more countries have been added; for a rising number of countries multidimensional poverty at the household level have been calculated at two points in time (UNDP, 2014). Through this broad coverage, the MPI is, in principle, able to make statements about the extent of global multidimensional poverty in a way the World Bank's $1-a-day poverty line makes about global absolute income poverty. So far it has not been used in this way but this could be done, using appropriate methods to make plausible assumptions about MPI poverty in those countries where these survey data are not available.[7]

[5] A household is considered young, if the average age of adult household members is below the age of 35.

[6] For Mexico and Argentina, different datasets were used.

[7] The World Bank faces the same difficulty with their dollar-a-day calculations and has developed approaches for dealing with this. See, for example, Chen and Ravallion (2004)

In fact, the database upon which the MPI calculations are being made is likely to be somewhat more reliable than the one used for the income poverty measure, where the comparability of survey instruments across country and over time is much less certain (e.g. Devarajan, 2013). In that sense the MPI should, we believe, most sensibly be seen as the multidimensional analogue, or multidimensional 'competitor' of the international income poverty line. Just as the HDI is the multidimensional analogue to GDP per capita to measure average well-being, the MPI does that on the poverty front. In that sense, it is a real achievement for UNDP and HDRO (as well as, of course, OPHI, who created this measure in the first place) to be able to provide a multidimensional index that can compete with the $1-a-day poverty line in terms of coverage, but arguably has the advantages of measuring well-being outcomes directly, in line with Amartya Sen's functioning and capability approach (Sen, 1998). This way UNDP has a macro level well-being indicator based on the capability approach (the HDI and the IHDI to consider inequalities) and a micro-level deprivation indicator, the MPI, at its disposal.

Conversely, we do not see a clear role for the MPI in relation to the Millennium Development Goals and possible post-2015 development goals. The MDGs intentionally considered individual well-being dimensions separately to avoid the opacity and possible trade-offs that come with a composite index. In that sense, we would see the possible role of the MPI as an overall monitoring tool to measure multidimensional well-being, but not a measure for which goals or targets should be directly formulated.[8] And it should also not replace a focus on reducing deprivation in the individual dimensions of well-being covered by the MDGs.

A second major achievement is that the MPI, through its base on household survey information, is a much more actionable and policy-relevant indicator for countries and agencies than the HDI. One can decompose the MPI by region, by particular groups, and by indicator, thereby allowing countries to directly see which groups suffer most and in which dimensions they are deprived. To capitalize on this advantage, however, it would be important for UNDP (at the level of the HDRO as well as country offices charged with working on National HDRs and related policy documents) to build up capacity in the use and analysis of the micro data sets that underlie the calculation of the MPI, particularly the DHS and MICS (see discussion on WHS below). This has not happened to the extent necessary to benefit from this new tool.

[8] For example, one could of course propose that the overriding goal of the world could be halving the number of multidimensionally deprived in the next 20 years. But the MPI is not suitable for such goal-setting as then all the issues of vastly different and opaque marginal rates of substitution between indicators (see Ravallion, 2011) would suddenly gain significant policy-relevance. Also, many of the empirical issues we discuss below suggest that the MPI, even if reformed, would suffer from many empirical problems that would gain added significance when the MPI is a goal in itself. See also Klasen (2012) for some further discussion of these issues.

Third, by basing its analysis on households, the MPI is consistent with the axiomatic approaches to poverty measurement in ways that UNDP's Human Poverty Index proposed in 1996 (UNDP, 1996) was not. The Human Poverty Index combined three aggregate deprivations into a single measure. It was not possible to identify the number of poor people, study the extent of their deprivation, or their regional heterogeneity, or use different aggregation rules to build up the aggregate from the experience of individuals or households. It also allows an analysis of the joint distribution of deprivations which the Human Poverty Index could not do. In contrast to the MPI, the HPI remained an aggregate ill-being measure, akin to the HDI but just using different dimensions.

Fourth, the MPI does not, in principle, suffer from two defects, relative to other existing data and measures that have been raised in early discussions of it. One was questions regarding its accuracy. While it is surely the case that some of the indicators (particularly the health indicators but possibly also the education indicators) are measured with error, the data quality is likely to be no worse and often rather better than for aggregate indicators such as life expectancy or GDP per capita. As has been discussed by Jerven (2012), Devarajan (2012), and Harttgen, Klasen, and Vollmer (2013) GDP statistics in many parts of the world, but particularly in Africa, are very poor and subject to drastic revisions. As discussed in Klasen and Vollmer (2013), there is no credible adult mortality data for many developing countries (including again most of Africa) so that life expectancy data are usually simulated rather than measured. In fact, the DHS has become the main 'official' source for infant and child mortality data in many developing countries and thus is the main source of the simulations for life expectancy. Similarly, the DHS and MICS data generally are no less 'official' than aggregate statistics produced by national statistical offices. Usually, these surveys are done in conjunction with national statistical offices and in most countries these surveys are part of the regular survey program of national statistical offices.

To be sure these advantages and strengths are not particular to the precise formulation of the MPI, but they derive largely from the fact that the MPI is built up from micro data and uses standardized and roughly comparable household surveys as its base. Thus in principle one could construct very different multidimensional poverty measures that would still retain most or all of the advantages of the MPI just discussed.

4. Conceptual issues

The MPI is based on an ordinal version of the dual-cutoff multidimensional poverty measures proposed by Alkire and Foster (2011a). There have been closely related multidimensional poverty measures proposed in the literature before Alkire and Foster (2011a) suggested their measure. These are also based on the (weighted) aggregation of deprivations across dimensions, some using ordinal

data. As summarized by Subramanian (personal communication and Jayaraj and Subramanian, 2010), very similar formulations were proposed by Jayaraj and Subramanian (1997, 2002, 2005, 2007, 2010), Brandolini and D'Alessio (1998, 2010), Bourguignon and Chakravarty (2003), and Chakravarty and d'Ambrosio (2006); Bossert, Chakravarty, and D'Ambrosio (2012) pursued a similar approach in independent work. The main contribution of Alkire-Foster (2011a) is the dual cut-off approach which tries to navigate between the allegedly empirically unappealing union and intersection approaches to multidimensional poverty identification, where the former yields very high and the latter very low levels of poverty incidence (Alkire and Santos, 2010). Indeed, Jayaraj and Subramanian (2002, 2007), Rippin (2012), and Bossert, Chakravarty, and D'Ambrosio (2012) have all used the union approach for identifying the multidimensionally poor. What is to be preferred?

On the one hand, a strong case can be made for the dual cut-off approach on substantive and empirical grounds. On substantive grounds, one can argue that the simultaneity of deprivations is required for someone to be not only deprived, but multidimensionally poor (Santos et al. 2013). Moreover, the apparent empirical problem with the union method is real. As shown by Rippin (2012), if one uses the union approach and the MPI indicators and cut-offs, headcounts are upward of 90% in many countries; this is not only a difficult 'political' sell, but may also be simply a result of measurement error or instances where the indicators do not cover the particular deprivations well. For example the MPI presumes that households that do not report on the possession of a particular asset (yielding a missing observation in the survey) do not to own that asset. If the union approach were applied, a household would then be considered multidimensionally poor. Similar measurement errors might exist in the measurements of height and weight, correct ages for enrolment rates, and the like. Or it may be the case that a child has a low weight for age not due to undernutrition but a recent bout of illness or simply due to the fact that her parents had (genetically) very light body frames that were transmitted to her; after all, undernutrition definitions based on anthropometrics are based on a statistical likelihood that a person with a low weight for age is actually undernourished (Klasen, 2008). She could also be fasting for religious or other reasons (Alkire and Santos, 2010). Though nevertheless deprived in the functioning nutrition, a poverty measure may not want to focus on a fasting but otherwise affluent person. By raising the cut-off to 30% (or some other arbitrary figure that is higher than being deprived in just one dimension), one reduces the chance of such misclassifications[9] and it allows policy to focus on the simultaneously deprived.

[9] Of course, there might be other ways of dealing with this. One could reduce the number of dimensions, particularly omitting those where such misclassifications are more likely, or one could raise the cut-offs within a dimension. There are downsides to these potential remedies as well.

Both the substantive as well as empirical advantages of the dual cut-off approach over the union approach increase with the number of indicators chosen. If the MPI was composed of 30 indicators, the union approach would be very hard to justify as most people everywhere in the world are likely to appear deprived in one dimension (for reasons to do with a real deprivation suffered in that dimension, particular choices made that lead to an apparent deprivation, or mere measurement error)[10] and one would vastly inflate the problem of multidimensional poverty, rendering it essentially meaningless. Conversely, using the intersection approach probably no one would be poor as nearly everyone is likely to be non-deprived in one dimension if there are many dimensions considered. If the MPI was reduced to only 5 or 6 meaningful and well-measured indicators that signify important deprivations, this problem would be much less severe. Thus the conceptual and empirical issues of reducing the number of indicators (tackled below) are related and we will come back to this question at the end.

On the other hand, this dual-cut off approach can lead to a certain amount of confusion as it allows individuals to be identified as multidimensionally deprived but not poor. Moreover, it is problematic that this person's deprivation is considered entirely irrelevant for the assessment of multidimensional poverty in this society because it fails to surpass the second cut-off. We lose a lot of relevant information about multidimensional deprivations in this society if we solely focus on the MPI headcount and the censored deprivation headcounts. It also creates some formal problems. As discussed by Subramanian (personal communication), it violates monotonicity of poverty measurement among the deprived.[11] As long as people do not surpass the second threshold, we do not care whether they are deprived in one, two or three dimensions and treat them all equally as non-poor and ignore their deprivations entirely.[12] One solution would be to consider people who are deprived in at least one dimension but below the cut-off as 'vulnerable' (OPHI is working on proposals in this direction), but this then adds another arbitrary cut-off.

[10] See Alkire et al. (2013) for examples of 'deprivations' due to choices or measurement error.

[11] As shown by Santos et al. (2013) and formally shown in Alkire and Foster (2011a), it is of course entirely possible to generate a set of axioms that are satisfied by the dual cut-off approach and the aggregation procedure of the MPI. These axioms imply a strong separation between identification and aggregation. In the identification step, the focus axiom implies that we should only focus on those who pass the threshold of being multidimensionally poor; if we do that, then the resulting measure will obey monotonicity in the sense that increasing the deprivation of a poor person increases the MPI. But this is only because we chose to ignore the deprivations suffered by those who do not pass the second cut-off (to obey the focus axiom)! More generally, the strict separation between identification and aggregation, which makes a lot of sense in uni-dimensional poverty measurement, is less compelling in the case of multidimensional poverty measurement as the adding of up dimensions where a household is poor can already be seen as a form of aggregation; conversely, one may think of identification not as a yes/no question, but a question of degree as proposed by Rippin (2012).

[12] Related to this, discontinuities arise at the cut-off that could have been avoided had the union approach been chosen (Subramanian, personal communication).

The additional aggregation of deprivations in the dual cut-off approach also adds the problem of choosing weights, and the possibility of potential trade-offs between deprivations (cf. among others Ravallion, 2011; Ravallion, 2012). Moreover, deprivations are treated as perfect substitutes below the cut-off and as perfect complements above the cut-off, giving substantial importance to this arbitrarily set cut-off (Rippin, 2012). Finally, the discontinuous nature of the dual cut-off approach clouds the effects that improvements or deteriorations in a specific indicator have on aggregate poverty. The impact of specific policies is much harder to pinpoint and changes in poverty are much harder to understand.

The main advantages of the dual cut-off approach, as we see it, are that it is generally open to an unlimited number of indicators. It therefore is open to a much broader definition of poverty and can possibly accommodate several culturally-specific concepts of poverty (i.e. including indicators deemed less relevant in some cultures, but more relevant in others). Conversely, if the MPI was focused on fewer indicators (as suggested below) this advantage is not as compelling.

The dual-cut off method is also less sensitive to misclassifications and mismeasurement. Most importantly perhaps, the method enables politicians to focus on the simultaneously deprived. However, considering someone deprived but not poor is somewhat confusing, and the dilemma of choosing weights and the possibilities of trade-offs between indicators is real.

We therefore believe that a stronger utilization of the poverty intensity (in terms of the number of dimensions one is poor) and possibly inequality (see discussion below) would circumvent the issue of very high poverty headcounts when the union approach is used. The resulting aggregate measures would still allow country and individual rankings and a policy focus on those deprived in many dimensions. One would then need to choose indicators and indicator cut-offs more carefully. Some of these empirical issues are discussed below (cf. section 5).

A second major conceptual problem has been the neglect of inequality in the spread of dimensions across the population. Similar to FGT1 in the uni-dimensional case, only average deprivations and deprivation headcounts matter, but not which of the multidimensionally poor are deprived in how many dimensions. If deprivations were 'redistributed' in a regressive fashion among the multidimensionally poor (e.g. those with most deprivations got a few more while those with fewer deprivations got a few less but remained multidimensionally poor), this would not change the MPI at all. Several researchers have pointed to this issue (e.g. Silber, 2011) and there have been a range of proposals to deal with this issue, including Chakravarty and D'Ambrosio (2006), Jayaraj and Subramanian (2010), and Rippin (2012). Alkire and Foster themselves are also working on an approach incorporating inequality in the assessment. Each of these proposals has particular strengths and weaknesses and it goes beyond the scope of this paper to discuss them in detail. A particularly straight-forward solution proposed to this problem has been the suggestion by Rippin

(2012) where, in the identification step, she no longer just decides whether a person is poor or not (as is usually done) but assigns different 'degrees' of poverty to households which is simply based on the square of the weighted share of deprivations suffered by households. The aggregation step then adds these deprivation scores over the population. This way inequality in the distribution of deprivations across the population is explicitly considered and in households with many deprivations the marginal impact of an additional deprivation is larger than in households with lower deprivations. A particular advantage of this approach is that the resulting Correlation-Sensitive Poverty Index can be readily decomposed into a headcount component, an intensity component, and an inequality component. This might be one way to take this issue forward and should be studied more carefully, alongside the other proposals that have been made to address this issue.[13]

A third conceptual issue that might be worth considering relates more to which part of the MPI ought to be the headline indicator. The MPI is a multidimensional analogue to the $1-a-day measure (where usually only the headcount is reported which has also been the target for the 1st MDG), it might therefore be worth focusing on the headcount of the MPI as the headline indicator rather than the product of headcount and average intensity. Moreover, the variation in the MPI between countries and over time is largely driven by the headcount and much less so by the intensity; this can be readily seen in Alkire and Santos (2010) where it is clearly the case that the variance of the poverty intensity A across countries is much smaller than the variance in the headcount H (see also Table 2). Moreover, the intensity is truncated from below by the value of the second cut-off (if the second cut-off is 30%, the average intensity among the poor must, by definition, be larger than 30%). To the extent that this second cut-off is clearly arbitrary and controversial (as suggested above), the intensity measured in this way is quite problematic.

Of course, using the dual cut-off method, the headcount conveys a much stronger political message and may be able to compete with the $1-a-day measure more directly. If one chooses the union approach however, as suggested above, the headcount is not a very intelligible statistic, as many people are likely to suffer some deprivation. There are two ways out of this dilemma: one is to use the union approach for the headcount but generate second measure that measures intensity and deprivation (covering all deprived). We then consider the entire depth of deprivations, not just the one below the arbitrary cut-off and empirically the variance in intensity (and possibly inequality) is likely to be much larger. A second, much less elegant, way out would be to use a dual-cut off

[13] There are, of course, downsides to this approach as well. First, it uses a union-approach to identify who is poor with all the advantages and disadvantages; second, it presumes a particular relationship or substitutability or complementarity between dimensions which is empirically hard to verify and might in any case differ across dimensions.

approach for the headline indicator, and a union approach that considers intensity and inequality (such as the one suggested by Rippin, 2012) as a second measure.

A fourth conceptual issue to consider is the question of relativity of the dimensional cut-offs. Similar to the international income poverty line which is less and less relevant for an increasing number of countries whose national poverty lines are substantially above the $1.25 line, one might consider whether one should similarly construct a (weakly) relative MPI cut-off that rises with average well-being in a country (see Ravallion and Chen, 2011 for a 'weakly relative' international income poverty line). In the multidimensional context one could either adjust the dimensional cut-off to reflect rising average standards, or one could lower the second cut-off of the weighted deprivation share necessary to be poor. Given that the data used for the MPI is categorical and cannot be adjusted smoothly, this would be a conceptually and empirically difficult exercise but well-worth considering. If such a 'smooth' adjustment of the cut-offs proves impossible due to the categorical nature of the data, an alternative would be to at least define a second MPI that chooses higher a higher cut-off for each indicator or a lower second cut-off, comparable to the $2 or $4 poverty lines used in some analyses for richer developing countries.

Also here, one has to carefully consider the merits and problems of such an approach (Santos et al. 2013). First, there is the apparent counter-argument, going back famously to Sen's article 'poor, relatively speaking' (Sen, 1984), where he suggests that in the space of capability, absolute poverty measures are more relevant. In contrast, the resources required to reach such capabilities will differ by country so that in the income space a relative poverty measure is to be preferred. While this argument might plausibly hold for the health dimension which indeed tries to measure at least functionings, in the standard of living dimension, the MPI does not measure functionings or capabilities, but access to goods that might enable some functionings. This is most clearly the case with the asset count which does not have an absolute functioning interpretation at all and whether they are enough for an 'adequate' living standard really depends on the prevailing standards in a society. Similar arguments can be made regarding floor material, electricity access, and possibly even with water, sanitation, and cooking fuel, where in richer countries the standards chosen might simply be too low.[14] Similar arguments could be made regarding education. While at some level, education (for example literacy) itself can be seen as an absolute capability, whether education allows active participation in society, business or the economy will also depend on the average level of education prevailing in a society. This would suggest that the standards in health may be

[14] To take the example of water access, while clean water is the key issue here, whether it is acceptable in a upper middle-income country to have access to clean water 20 minutes away from the house is a legitimate question. Thus the cut-off chosen for the MPI could be relevant for poorer countries and a higher standard would be appropriate for richer countries.

considered universal and absolute but the ones for the standard of living and education could be higher in countries with higher average achievements. It would also suggest that the logic of Sen's argument would imply higher first deprivation cut-offs for the indicators in the education and living standards dimensions rather that a lower second cut-off for calling someone multidimensionally poor in a better-off society (Dotter and Klasen, 2014).

To conclude this section, it is important to point out that the particular choices inherent in the dual-cut off method underlying the MPI are controversial; one could easily consider the union approach more relevant for identification and then think about weighted deprivation counts as poverty measures that also consider inequality between dimensions. We would also submit that the intensity component of the MPI, within the current dual cut-off framework, is less relevant and that work should begin on considering relative versions of the MPI. It is also important to reiterate two points. First, many of the critiques and suggestions are essentially judgment calls about merits and problems of particular ways of framing the issue. Ultimately, pragmatic decisions will need to be taken by HDRO that also consider data, communication, and interpretability issues. Second, the conceptual issues are linked, and also linked with the empirical issues. For example, the union approach with the headcount as the main indicator (and an intensity and inequality adjusted second measure) might make a lot more sense if the MPI consists of few very well-measured and meaningful dimensions; conversely, the more indicators, and the more empirical problems with them, the less useful would this proposal be.

5. Empirical Issues

We will now turn to some empirical issues relating to the particular decisions that have been made about the use of data sets, the choice of indicators, and the dimension- and indicator-specific cut-offs; here we will simply consider the MPI in its current formulation and thus no longer consider the conceptual issues we had just raised; we will return to this issue below as the conceptual and empirical issues are linked as we have just shown above. We will not discuss the weights or the basic three-component set-up of the MPI (health, education, and standard of living) as this would go beyond the scope of the paper. We broadly agree with these choices and particularly see a compelling rationale that the dimensions and weights should closely mirror similar decisions made with the HDI.

a. Problematic use of WHS

A first serious problem arises with the use of the three different datasets. While the DHS basically allows a complete assessment of all indicators, the MICS lacks information on the nutritional status of adults. More seriously, the WHS lacks information on nutrition of children (and

just has it on the respondent), and also lacks data on school attendance. While the MPI adjusts for these data gaps by reweighting the other component of the subindex (e.g. if attendance is missing, the years of schooling indicator gets a higher weight), this is not without problems as the different components have different mean deprivation levels and thus the reweighting systematically biases the results. Also, the implicit assumption is that one of the components can proxy for the other one in a sub-index which is empirically not the case. There are many households who are deprived in schooling years but not in attendance and vice versa; similarly not all households who lost a child also have a person who is undernourished (and vice versa). A second problem arises particularly with the nutrition indicator: in surveys where only adults are measured there is an automatically lower probability that this household will be deprived compared to a household where adults and children are measured. It is quite clear that the WHS is the more limiting dataset here and we would strongly suggest that the MPI be based solely on the DHS and MICS, supplemented by individual surveys that meet all the criteria of the DHS and MICS. This would reduce the country coverage somewhat but ensure better comparability and reliability of the results.[15]

b. Dynamics

One might suspect that the MPI would suffer from the problem of great inertia and low dynamics. This would be particularly relevant in the case of the mortality indicator, which is a backward-looking stock measure, the education stock variable, and most of the standard of living indicators. But results from a recent workshop on dynamic comparisons, organized by OPHI and the University of Göttingen, (http://www.ophi.org.uk/workshop-on-monetary-and-multidimensional-poverty-measures/) suggested that there is surprising dynamics in the MPI over time using new waves of the DHS or MICS. In fact, in some country case studies the dynamics of the MPI are as large as the income poverty dynamics. To some degree this is surprising and the source of this dynamics is not well understood yet. This is an area of urgent further investigation and work in this area is on-going.

c. Robustness checks and alternative empirical approaches

In the remainder of the paper, we will now consider the individual indicators and the cut-offs chosen. One goal expressed by HDRO has been to look for ways to simplify the MPI, particularly the standard of living dimension. In addition, we will check the robustness of particular choices regarding indicators and cut-offs, and suggest an alternative treatment of ineligible population. We

[15] As raised by Alkire et al. (2013) who broadly support the idea to drop the WHS, of particular concern would the omission of China from the MPI. One option might be to consider whether the China Health and Nutrition survey would be suitable to calculate the MPI; it has limited coverage but is considered quite reliable.

then propose an alternative version of the MPI that would have some advantages relative to the current formulation.

Standard of Living

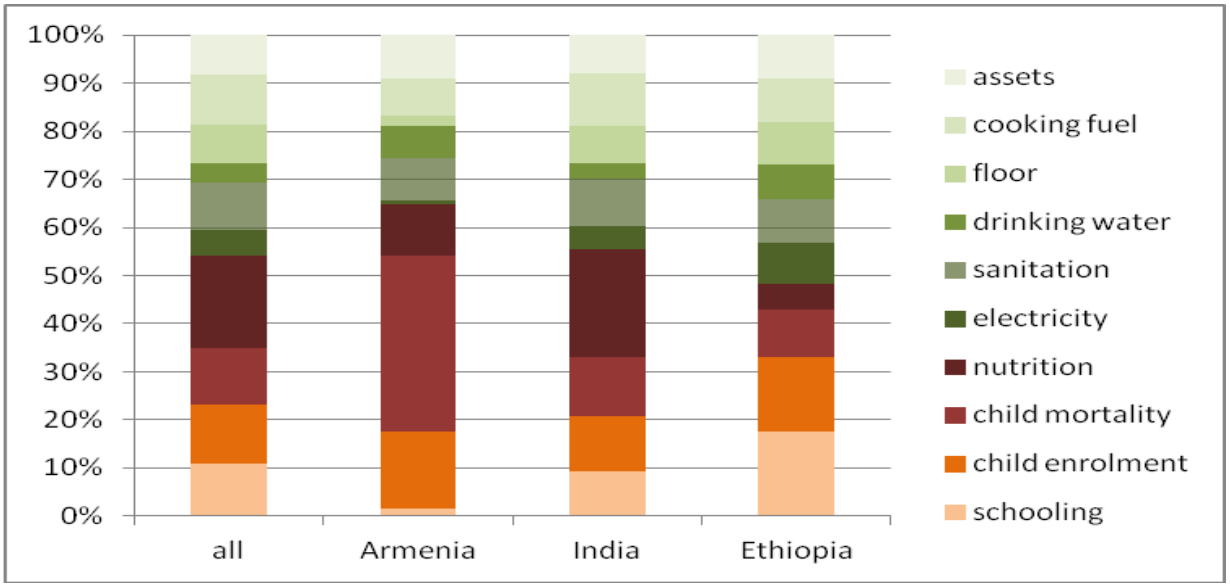
While the health and education dimension consist of two indicators each, the standard of living of the household is captured by six indicators and HDRO specifically requested to investigate opportunities for constraining the number of indicators in this dimension. The original living standards dimension is measured by:

- Asset index: The household is deprived in this indicator if they do not own more than one of a group of small assets (radio, TV, telephone, bike, motorbike, or refrigerator) and do not own a car or truck.
- Cooking fuel: The household is deprived if they cook with wood, coal, straw or dung.
- Electricity: The household is deprived if they do not have access to electricity.
- Drinking water: The household is deprived if its main source of water does not meet MDG standards[16], or they require more than 30 minutes to fetch water.
- Floor: The household is deprived if it has a dirt floor (earth, sand, or dung).
- Sanitation: The household is deprived if its toilet does not meet MDG standards or is shared with another household.[17]

[16] If the water source is not protected (i.e. open or not protected wells or spring , or surface water such as a river, damn, pond, etc.) or the household relies on an irregular water source such as bottled water or a tanker truck the household is deprived. A protected well or spring (and the use of rainwater) would however suffice to meet this definition of clean water.

[17] A flush toilet or improved pit latrine (ventilated and with slab) would meet this requirement. A household with no sanitation facilities or rudimentary facilities (open lit, pit latrine without slab, composting toilet, etc.) is deprived.

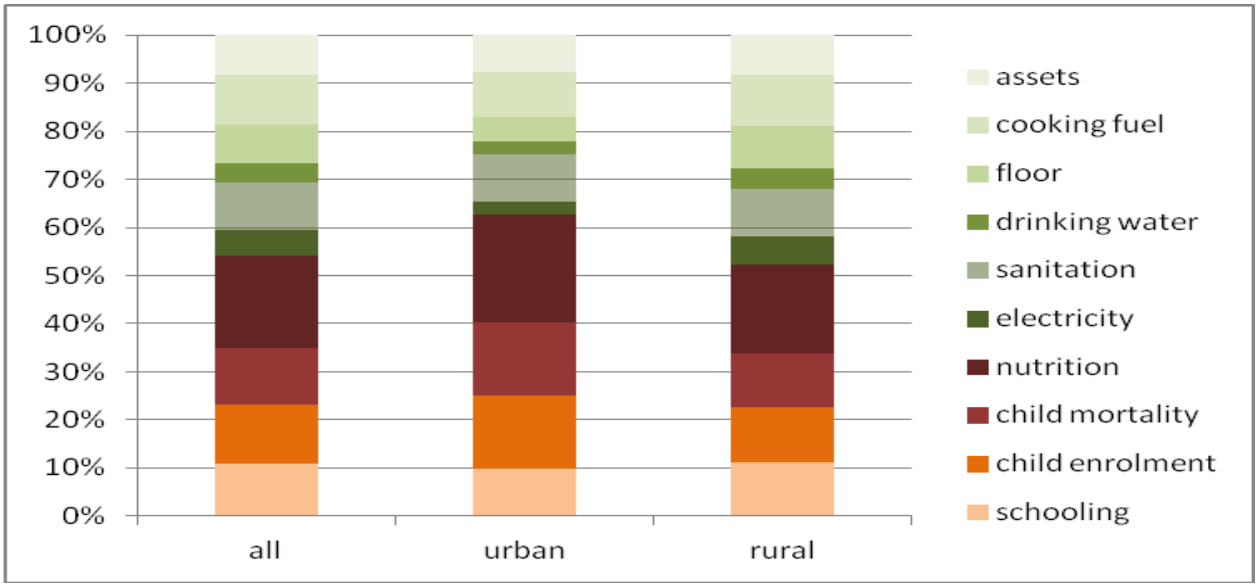
Figure 1: Contribution of indicators to the MPI across countries (base)



In poorer countries, one typically observes that the standard of living indicators have by far the strongest contribution to multidimensional poverty. For the example of Ethiopia the living standard indicators contribute more than 50% to multidimensional poverty (cf. Graph A).

Moreover, households in rural areas also suffer more in these indicators than households in urban areas do. Comparing the contributions of indicators across regions for the whole sample, we observe the living standard indicators contribute nearly 50% to overall poverty in rural areas, though they contribute only around 36% in urban areas (cf. Graph B). So the living standards indicators are quite important for the overall MPI and it is therefore important to scrutinize them carefully.

Figure 2: Contribution of indicators to the MPI across regions (base)



In principle, the living standard indicators cover separate dimensions of well-being that are all important (some more important than others) and are generally well-derived using the literature on the consequences of deprivation in these dimensions and their linkages to the MDGs (see Alkire and Santos, 2010 and Santos et al. 2013). Each of them represent an important constituency and it is not obvious that one can easily streamline them.

At the same time, some of the indicators are weaker, either conceptually or empirically and (at least for the countries in our analysis) they are relatively closely correlated (see below), so that some simplification is conceptually and empirically feasible. We do recognize the importance of each dimension, though we question whether each indicator can capture what they intend to measure.

When thinking about simplifications, some of the standard of living indicators are disputable. They are hard to measure, as the household's benefit depends on the quality of the service. Moreover, if there are substantive differences in needs for access (between urban and rural areas and across countries) which might bias the results. We will discuss the indicators in turn.

The household's benefit of access to the electricity grid will depend on the quality and price of the service, as access to electricity is hardly a goal in itself. Though electricity has manifold advantages, this cannot be equated with access to the grid. Frequent power outages are common in several developing countries and a low reliability of the grid diminishes the potential use of electricity significantly; in some countries the cost of electricity is very high and access does not actually imply use; in fact, in a substantial number of African countries, households have access but do not use it and in other countries household access is not provided precisely because household

incomes are too low to pay for it (even if the hook-up is subsidized). The link to a particular functioning that access to electricity ensures is also somewhat more tenuous.

The sanitation indicator suffers from the problem of different necessities across countries and regions. In more densely populated regions and urban areas improved sanitation facilities are more important to prevent the spread of infectious diseases.

Finally, the indicator cooking fuel appears to be an indicator that is among the last ones to improve[18] and the indicator cut-offs are disputable. The household is non-deprived in this indicator, if the cooking fuel used has a low environmental impact[19] and low effect on indoor air pollution.[20] Only to the extent it causes indoor air pollution can this indicator be seen as an important well-being indicator, mainly due its health impact. But health is already captured elsewhere so – independent of the undoubted importance of cooking fuel for respiratory diseases – it is unclear why one wants to capture it in the living standard dimension again particularly if the health argument is the main justification. Whether health effects exist may also depend on whether cooking takes place outside or inside (which depends largely on the climate and cultural practices), and what kind of cooking implements (stoves, open fire, etc) is used. As a result it is somewhat unclear to what extent use of non-modern fuel sources should invariably be seen as an indicator of deprivation.

In contrast, the categories drinking water[21] and floor are easy to measure, arguably more objective measures of living standards, and comparable across countries. We therefore recommend considering only three instead of six living standard indicators: floor; drinking water; and assets as a category capturing household wealth and potentially also reflecting several indicators that are correlated with these asset possession (similar to the function of the income component in the HDI);[22] conversely, the weights of the three standard of living indicators would then be increased to

[18] This is a result of a recent workshop on dynamic comparisons between multidimensional and monetary poverty (http://www.ophi.org.uk/workshop-on-monetary-and-multidimensional-poverty-measures/).

[19] One reason to include cooking fuel was its association with MDG 7.

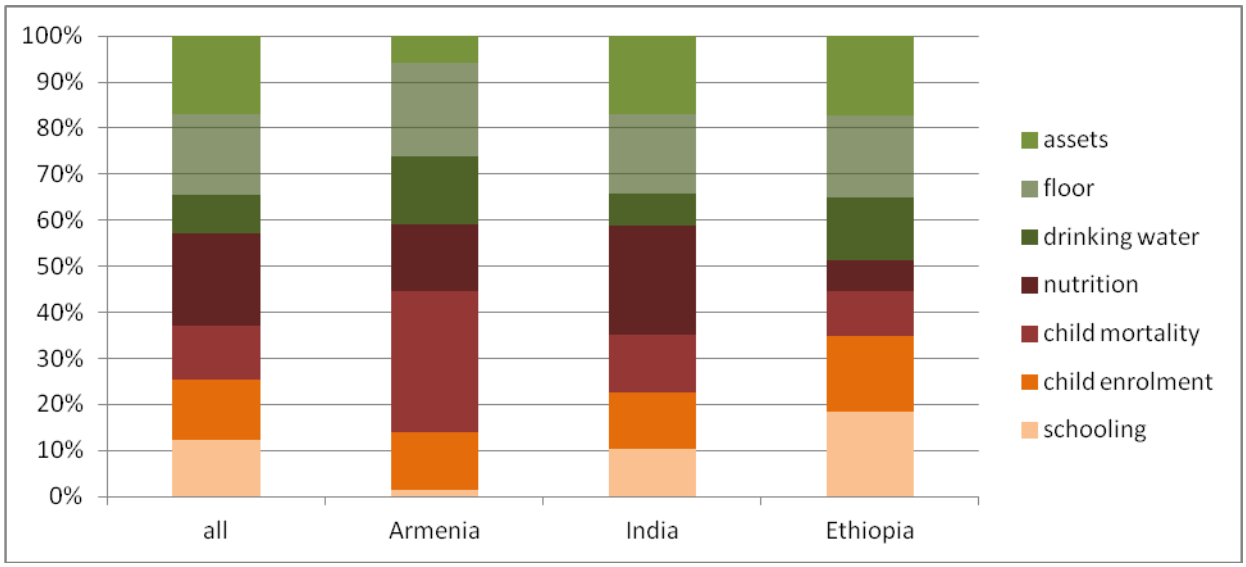
[20] Therefore, coal, wood, and animal dung are poor categories, while kerosene is not.

[21] The main problem with the water indicator is that it is based on water source, not on whether the water is actually clean. As shown in Klasen, Lechtenfeld, Maier, and Riekmann (2012), providing piped water access when quality cannot be assured can significantly lead to worse health outcomes than when households purchase the water from tankers. Also, often water gets contaminated in transport or during storage in the household, issues that are neglected here (for which there is, however, no comparable data).

[22] There is the question whether the assets included also suffer from some urban bias and whether rural assets should be included. The DHS surveys include some information on land and livestock ownership. But it is very hard to include this data in a systematic fashion. Not owning land or livestock is neither a necessary nor a sufficient condition for deprivation in rural areas (many in rural areas do not work on agriculture) and livestock

maintain the total weight of that component of 1/3. This would also reduce the complexity of the living standards indicator and the overall MPI.[23] Note also that in these three countries the three remaining indicators are least correlated with each other, while the three indicators we propose to drop are more highly correlated with each other, and with the indicators we retain (see correlation coefficients in appendix A.2). Due to the high correlation with the indicators we retain, we do not lose very much information on the distribution of deprivation across the population.[24]

Figure 3: Contributions across indicators to the MPI across countries (three standard of living indicators)



Using only these three indicators in the standard of living dimension, we observe the standard of living indicators are still relatively important to explain multidimensional poverty. However, the influence of the living standards indicators on the MPI is less strong in the three countries (only about 40% contribution to the MPI) and more in line with its weight of 1/3 which may be seen as an

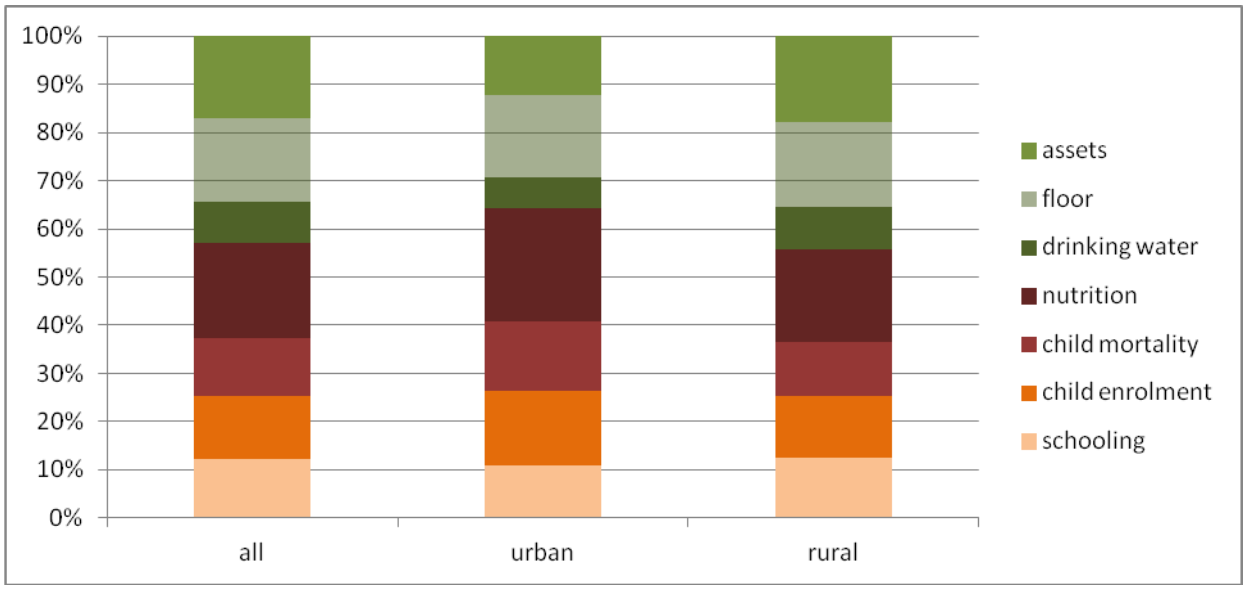
ownership also depends on geographic endowments, population density, religious traditions, and the like. As a result it is very hard to deduce deprivation from these assets and we propose to keep the current list of assets.

[23] There is also the question whether one should use some statistical data reduction technique (such as principal component analysis or factor analysis) to create an asset index and use that instead of the individual indicators (see e.g. Alkire and Santos 2010 for a discussion). We caution against the use of such indices for the MPI for several reasons: first, they increase the complexity (and opacity) of the MPI; second, one cannot replace a normative judgment about the importance of certain assets with a statistical procedure (see also Ngufack, Klasen, and Zucchini, 2010 for a discussion). And third, it is unclear whether such an index should be created at the national level, sub-national level, international level, and whether one should pool data for different time periods to create such an index.

[24] We should emphasize that even the three indicators we propose to retain could be improved once additional data was available. In the case of water, indicators of water quality would be an important addition and in the case of assets, some sense of age, current value, and state of repair would be useful additions.

advantage of this simplification (in addition to the arguments made above). It also varies less across countries compared to the initial situation with six indicators, but retains substantial variation in the contribution of the individual living standard indicators.

Figure 4: Contributions across indicators to the MPI across regions (three standard of living indicators)



Similarly, the relative contribution of the living standard indicators across region is smaller and varies less. While the relative contribution of the standard of living indicators in urban areas hardly changed, the cumulative contribution in rural areas was reduced by 3 percentage points.

Table 3: Multidimensional poverty estimation with three standard of living indicators

	H	A	MPI
All	44.54%	57.02%	0.253985
Urban	14.04%	51.86%	0.07282
Rural	57.61%	57.56%	0.331648
small household	35.71%	50.51%	0.180376
medium-sized household	40.99%	56.57%	0.231878
large household	53.70%	59.41%	0.319012
female-headed household	45.82%	57.66%	0.264172
„older“ household	43.14%	57.28%	0.247089
young household	44.95%	56.95%	0.256
Armenia	0.56%	41.77%	0.002336
Ethiopia	85.64%	65.62%	0.56203
India	41.23%	54.67%	0.22539

Reducing the number of living standard indicators reduces the incidence of multidimensional poverty by approx. 10 percentage points; though the average intensity of deprivations (A) increases. The strongest reductions are observed for large and rural households, and for households in India.

Enrollment

The enrolment indicator considers a household deprived, if *any* school aged-child is not currently enrolled. The school age is determined by looking at the primary school entrance age[25] plus one year[26] and assuming necessary enrolment to be up to grade 8[27]. In many developing countries however children enroll at a later age than the official school entrance age, even if they will be enrolled for his or her whole school life (grades 1-8).

There are manifold reasons why children are enrolled late. Several studies find boys are more likely to be stunted and enrolled later than girls, and more generally poor physical and cognitive development leads to later enrollment (cf. Glewwe and Jacoby, 1995, and Bommier and Lambert, 2000). Parents consider their children as not ready for school, if they are too small for their age (Fentiman et al., 1999). Moreover, boys often complete some form of religious education or apprenticeship before enrolling in formal education in some countries.[28] In many countries there are also financial barriers that can lead to delayed enrolment. While some children who are enrolled late are less likely to complete the education or will perform worse in school (see Santos et al. 2013), this is not invariably the case and drop-out would be captured in any case by the enrolment measure. Thus, we think that it is too strong an assumption that a child that is not enrolled in time, but a year later is suffering from such a deprivation that the *entire* household is now deprived in the enrolment dimension.

Table 4: Share of population deprived in enrolment

	Whole population	Population with school-aged children (original category)
Original enrolment window	25.32	38.87
Shorter enrolment window	17.42	26.71

We allow for later enrolment by shortening the enrolment window by two years (i.e. a child in India was considered to be at school age, if it was aged between 7 and 15. Now, we only consider

[25] Derived from the UNESCO education statistics.

[26] As children with birthdays in the current school year can only enter school in the next school year.

[27] This covers primary and lower secondary education in most countries.

[28] In many parts of Africa, young boys are sent to Madrassas for few years. Similarly, in some East Asian countries it is common for young boys to live in a monastery before enrolling in school.

children between 9 and 15.). This significantly reduces the share of households deprived in enrolment, though it has only modest effects on the overall poverty headcount (but a larger impact on poverty intensity). But this suggests that late enrolment is a serious issue and it is problematic to automatically classify entire households as poor if they enroll their children late.

Table 5: Multidimensional poverty estimation allowing for late enrollment

	H	A	MPI
All	54.36%	54.60%	0.296764
Urban	20.33%	48.04%	0.097695
Rural	68.94%	55.43%	0.382102
small household	44.23%	48.93%	0.216432
medium-sized household	49.95%	53.76%	0.268534
large household	65.36%	57.21%	0.373938
female-headed household	54.38%	55.79%	0.303397
„older“ household	51.28%	55.38%	0.283962
young household	55.25%	54.39%	0.300503
Armenia	0.56%	38.22%	0.002143
Ethiopia	90.21%	63.56%	0.573376
India	52.21%	52.56%	0.274402

Mortality:

In its current design, the multidimensional poverty index does not apply a cut-off period for child mortality. Hence, a household may theoretically be deprived in child mortality, if it suffered a child death 50 years prior to the survey. This choice was mainly data-driven, as DHS surveys with information on the time of death for each child were not available for all countries. Nevertheless, this definitely is a second-best solution to accounting for child mortality and this problem is fully acknowledged in Alkire and Santos (2010).

Table 6: Multidimensional poverty estimation using the improved mortality indicator

	H	A	MPI
All	51.52%	51.91%	0.267444
Urban	18.00%	45.80%	0.082461
Rural	65.88%	52.63%	0.346744
small household	41.99%	47.32%	0.198682
medium-sized household	47.27%	51.57%	0.243758
large household	62.03%	53.65%	0.33278
female-headed household	52.08%	53.42%	0.278245
„older“ household	48.28%	52.27%	0.252401
young household	52.46%	51.82%	0.271839
Armenia	0.24%	35.20%	0.000862
Ethiopia	89.56%	59.92%	0.536635
India	48.96%	49.98%	0.24471

We suggest to only consider under five mortality in the household in the past five years.[29] We observe, poverty incidence and intensity reduces if one only considers the deaths of children below the age of five in the past five years for the restricted sample of three countries. The observed reductions in poverty are similar among all sub-groups, but the effect is stronger in India and Armenia compared to Ethiopia. In the MICS, the information about year of death is not available in most surveys. But one could get closer to the concept of more recent deaths if one included only the deaths of children born to younger women in the household (for example women who are below age 40).[30]

Nutrition

Malnutrition is a direct indicator of the functioning 'nutrition'. Malnourished individuals are also more susceptible to other health risks and are less able to perform well at work. Moreover, malnutrition at an early age has life-long effects on development. The MPI considers a household deprived, if any household member is malnourished.[31] While the importance of malnutrition itself is indisputable, the indicators used in the MPI are imperfect.

The MPI uses the BMI for adults and weight-for-age for children to determine whether the household is deprived. Both indicators cannot reflect micronutrient deficiencies and especially the BMI is prone to inclusion errors, particularly related to the nutrition transition which also biases the underweight indicator (see below); there are also questions regarding the international comparability of BMI cut-offs and its comparability between males and females. Moreover, this indicator is not available in the MICS to begin with and thus there is an in-built bias from the use of different surveys; as this is the only inconsistency left between the surveys (if the WHS is dropped), it is not worth generating a bias by using this problematic indicator.[32]

[29] Whether to limit it to children under five years or not, is debatable. Empirically it does not make a large difference (Santos et al. 2013).

[30] This is a suboptimal solution and would leave out some recent child deaths but possibly better than the current solution where the deaths might have occurred more than 20 years ago.

[31] This differs across surveys used: If a DHS survey is available for the country, this refers to any child below the age of five or women in reproductive age. When the MICS survey is used, the indicator definition refers to any child below the age of five. For some countries only WHS surveys are used. In this case the household is deprived, if the respondent (men or women of any age) is undernourished.

[32] This is a more general issue also for other indicators where more comprehensive information is used where-ever available and not used where it is not which can lead to incomparabilities. These issues mainly affect the category lists in the water, sanitation, and cooking fuel indicators. These problem do not lead to large changes in the MPI and are much less serious than the issue discussed here (although it would be recommended to be as consistent as possible throughout).

To prevent these potential inclusion errors and deal with the measurement error issues, one could consider determining the household's nutrition status using only observations on children. Combined with dropping the WHS as a data source, this would make the MPI more transparent and more comparable. This, however, increases the issue of the treatment of households without children in the respective age range, an issue that already exists but would get worse if adults were excluded.[33] This is addressed below.

Table 7: Multidimensional poverty estimation without BMI

	H	A	MPI
all	46.43%	54.50%	0.253042
urban	15.62%	48.14%	0.075169
rural	59.64%	55.22%	0.329293
small household	39.55%	47.56%	0.188069
medium-sized household	41.42%	53.97%	0.223558
large household	56.95%	57.16%	0.325526
female-headed household	47.90%	55.42%	0.265454
„older" household	47.13%	54.19%	0.25537
young household	46.22%	54.60%	0.252362
Armenia	0.48%	35.93%	0.001716
Ethiopia	89.92%	63.32%	0.569353
India	42.89%	52.07%	0.223338

The change reduces overall poverty levels, as households without children are automatically considered non-deprived (see discussion below). But also in the population of households with children below the age of five one observes significant movements: Nearly 17% of individuals in households with eligible children were considered deprived in the base calculation, but are considered nutrition non-poor when we exclude the BMI. This result is mostly driven by households in India, but also in Ethiopia over 16% of individuals in households with children below the age of five are considered deprived in the base calculation, but are non-deprived if we exclude the BMI.

Moreover, one could only consider children above the age of 6 months to reflect the very distinct age pattern of anthropometric shortfalls which emerges between 4-6 months, deteriorates until about 24 months and stabilized thereafter (see e.g. Wiesenfarth, Klasen, Krivobokova, Sperlich, 2012). Households with children below 6 months might therefore erroneously be considered non-deprived as the anthropometric shortfall has not materialized yet.

[33] It is also, of course, problematic that the health portion would then entirely focus on children with no apparent concern for other age groups. Clearly it would be useful to think more fundamentally about a different health indicator such as a health status response by all members of the household. But such data is currently not available in reliable and comparable form.

Table 8: Multidimensional poverty estimation without BMI and changed age-cutoff

	H	A	MPI
all	43.45%	52.12%	0.226499
urban	13.93%	45.64%	0.06359
rural	56.11%	52.81%	0.296335
small household	38.70%	47.00%	0.181905
medium-sized household	38.96%	51.91%	0.20228
large household	52.29%	53.98%	0.282276
female-headed household	45.82%	53.14%	0.2435
„older“ household	46.32%	52.94%	0.245229
young household	42.62%	51.86%	0.221027
Armenia	0.48%	35.93%	0.001716
Ethiopia	89.91%	63.11%	0.567452
India	39.38%	48.81%	0.192252

Incidence and intensity of multidimensional poverty further reduces when we exclude these children. This indicates that, contrary to our expectation, several children below six months are already underweight at that age. These are likely to be children that were already born with low birth weight, some of which are indeed malnourished (while for others, the low birth weight may relate to genetic transmission of body stature, see Klasen 2008 and deHaen et al. 2011 for a discussion).

Additionally one could use stunting as an indicator of child malnutrition. Stunting is an indicator of chronic undernutrition. The main reason for doing that is that it is less susceptible to influences form the so-called nutrition transition where households across the world (including many poor countries) are switching to foods that contain more calories, fats, and sugar. Those households then gain weight without being substantively better nourished and still often lack required micronutrients. As a result one can actually see many children that are stunted but of normal weight, and even some children that are stunted and overweight (WHO, 2006; Popkin, 2006). Stunting is a much better indicator of undernutrition as it reacts sensitively to not only the quantity but also the quality of nutrition. In fact one can show that underweight rates fall over time with the nutrition transition, while stunting rates remain high in many countries suggesting that the quality of nutrition has not improved (Misselhorn, 2010; deHaen et al. 2011). Thus the use of stunting as the indicator of undernutrition is to be preferred on conceptual and empirical grounds. Even though this would not significantly affect country rankings (cf. Alkire and Santos 2010), it increases the observed incidence and intensity of multidimensional poverty.

Table 9: Multidimensional poverty estimation using stunting (without BMI and improved age-cutoff)

	H	A	MPI
all	46.34%	54.25%	0.251405
urban	15.49%	47.98%	0.074307
rural	59.57%	54.95%	0.327325
small household	39.53%	47.52%	0.187865
medium-sized household	41.41%	53.73%	0.222493
large household	56.72%	56.84%	0.32241
female-headed household	47.78%	55.18%	0.263657
„older“ household	47.10%	54.17%	0.255158
young household	46.12%	54.27%	0.250309
Armenia	0.50%	37.18%	0.001851
Ethiopia	90.01%	63.70%	0.573411
India	42.78%	51.63%	0.220862

Finally, when we use the stunting indicator, the inclusion error also appears to be lower. Fewer children below 6 months are considered malnourished[34] when stunting is used which sets in around the age of six months. This effect is particularly strong for India.

Table 10: Percentage of children below 6 months, which are malnourished:

	All countries	Armenia	India	Ethiopia
Stunting	15.93%	15.03%	16.21%	12.14%
Weight-for-age	21.92%	6.51%	23.0%	12.92%

Economies of scale

The MPI assumes full economies of scale apply to literacy (measured by schooling years) and in the living standard indicators. For most living standard indicators the public good assumption is indisputable; though we will observe some rivalry in consumption of assets (and potentially sanitation). Moreover, the household is non-deprived, if any household member has at least five years of education. This follows the concept of effective literacy defined by Basu and Foster (1998), they argue one literate household member is a kind of public good for illiterate members. Their hypothesis is supported by several studies explaining farm-level productivity with household literacy (cf. among other Foster and Rosenzweig, 1996).

[34] This is true for all countries, but Armenia. However, in the case of Armenia only an additional 64 children are considered deprived using stunting. One may not want to attach too much weight to these observations.

Unfortunately, it is impossible to test the robustness of the MPI to the public good assumption in assets, because the DHS only asks whether or not a household owns a specific asset, not how many assets of a type are owned. Nevertheless, we can test the assumption for the education indicator. While it is sensible to assume that illiterate household members benefit from one literate member in the household, the benefit for the illiterate members will presumably be smaller, the larger the household. It is also problematic from a human rights perspective to argue that an entire household is doing fine in terms of education if just one of its members has five years of education.

Table 11: Multidimensional poverty estimation assuming 50% of adult (15+) household members need to be literate

	H	A	MPI
All	65.39%	59.54%	0.389364
Urban	30.59%	51.65%	0.158022
Rural	80.31%	60.83%	0.488537
small household	53.70%	50.11%	0.269054
medium-sized household	62.07%	58.17%	0.36107
large household	75.43%	64.13%	0.483782
female-headed household	63.79%	59.14%	0.377235
„older“ household	61.28%	58.57%	0.358964
young household	66.59%	59.81%	0.398244
Armenia	1.33%	40.75%	0.005432
Ethiopia	93.90%	68.61%	0.644285
India	64.71%	57.82%	0.374186

We consider it necessary for at least half of all household members to have five years of education, for the whole household to be *not* deprived in the education indicator.[35] This increases the poverty headcount significantly (approx. 10 percentage points). The change especially increases the multidimensional poverty incidence for medium-sized households and for households in Armenia.

As a lower bound for household literacy, we assume that at least one out of five household members needs to be literate. This causes a modest increase in multidimensional poverty incidence and intensity (around 2 percentage points). Similar to the more restrictive assumption above, the increase is strongest for medium-sized households.

[35] Possibly it would be better to restrict this cut-off to adult members (15+) and in future work we will consider this option.

Table 12: Multidimensional poverty estimation assuming 20% of household members need to be literate

	H	A	MPI
all	56.62%	57.71%	0.326761
urban	22.31%	50.36%	0.112343
rural	71.34%	58.69%	0.418678
small household	44.31%	49.31%	0.218485
medium-sized household	52.83%	56.81%	0.300101
large household	67.65%	61.13%	0.413544
female-headed household	55.97%	58.15%	0.32548
„older" household	52.96%	57.62%	0.305158
young household	57.70%	57.73%	0.333071
Armenia	0.57%	38.24%	0.002194
Ethiopia	91.27%	67.43%	0.615374
India	54.75%	55.57%	0.304258

Size adjustment for nutrition, mortality, and enrolment indicator

In some indicators the whole household is deprived, if one household member suffers from a deprivation in this indicator (i.e. is malnourished). Hence, larger households have a potentially higher chance of being deprived (nutrition, mortality, child enrolment). The argument for considering the whole household deprived is that the household as a whole experiences a negative external effect by the presence of a person deprived in one of these indicators. Also, a human rights perspective would support such an approach (Santos et al. 2013).

Nevertheless, all of these indicators will measure deprivations imperfectly (as discussed in the sections above on enrolment, nutrition and mortality). While the dual cut-off method allows for inclusion errors in one indicator, households falsely categorized in two of the health and education indicators will be considered multidimensional poor. Larger households with more eligible household members in each indicator have a potentially higher chance of being falsely considered poor.

Also, the inconsistency of, on the one hand, calling a household poor if *one* member is undernourished, one child died, or one child is not in school, while, on the other hand, calling the entire household non-poor if one member has 5 years of education, appears equivocal, not well-motivated, not consistent with a human rights perspective, and biased. Thus these different cut-offs have to be seen in relation to each other (see also below).

Here we test, whether the original assumption regarding child deaths, nutrition, and enrolments disproportionately affects the poverty status of large households, by changing the indicator definitions for enrolment, nutrition, and mortality:

- A household is deprived, if at least 20% of all (not only children below 5) children in the household died.
- A household is deprived, if at least 20% of all school-aged children are not enrolled.
- A household is deprived, if at least 20% of all eligible household members are undernourished.

Table 13: Multidimensional poverty estimation with 20% cut-off in mortality, enrollment, malnourishment

	H	A	MPI
All	53.95%	54.56%	0.294392
Urban	19.97%	47.89%	0.095624
Rural	68.52%	55.40%	0.379601
small household	44.22%	49.26%	0.217804
medium-sized household	50.17%	54.47%	0.273313
large household	63.85%	56.24%	0.359139
female-headed household	54.17%	56.36%	0.30531
„older“ household	51.20%	55.11%	0.282169
young household	54.76%	54.41%	0.297963
Armenia	0.57%	38.24%	0.002194
Ethiopia	90.38%	63.63%	0.575022
India	51.71%	52.48%	0.271382

This reduces overall poverty modestly (approximately 1 percentage point for whole sample) for all sub-groups and countries. The reduction is strongest in the sub-group of large households (nearly 3 percent). Hence, with the initial, more restrictive assumption larger households had a higher chance of being considered multidimensional poor. Most of the observed changes in poverty status are in the mortality indicator: Three percent of the whole populations are no longer deprived in mortality, when the suggested size adjustment is applied.[36] Most of the changes were observed for households in India, though the change in the overall poverty rate for India is negligible.

Moreover, we also consider a more conservative cut-off. The household is severely deprived in the respective indicator, if more than half of the eligible population (i.e. school-aged children) suffer from a deprivation in the indicator. In this case, the average household member needs to be deprived for the whole household to be deprived. This significantly reduces the multidimensional poverty headcount (more than 6 percentage points) for all subgroups and countries. As above, poverty reduces especially in the group of large households.

[36] Note: NOT using the improved mortality indicator suggested above.

Table 14: Multidimensional poverty estimation with 50% cut-off in mortality, enrollment, malnourishment

	H	A	MPI
All	48.55%	52.64%	0.255535
Urban	16.29%	46.55%	0.075828
Rural	62.37%	53.32%	0.332573
small household	43.60%	49.06%	0.213898
medium-sized household	46.10%	52.86%	0.243656
large household	54.38%	53.58%	0.291369
female-headed household	50.79%	55.54%	0.282081
„older" household	47.50%	53.30%	0.253166
young household	48.85%	52.45%	0.256227
Armenia	0.43%	35.71%	0.00155
Ethiopia	89.04%	60.63%	0.539841
India	45.51%	50.58%	0.230193

Households without eligible population:

Several indicators of the MPI explicitly refer to a specific eligible population. The nutrition indicator considers children below the age of five and women at the reproductive age. The mortality indicator refers to households with men and women at the reproductive age. Moreover, households that never had children cannot suffer from the death of a child. The enrolment indicator considers only households with school-age children. Households without eligible population are considered non-deprived in the respective indicator. The household's demographic composition may therefore determine its chances to be considered poor or not. As shown in Table 15, this is not a marginal problem but affects a large share of households. It is more severe in the enrolment indicator where over a third of households do not contain children of school-going age and therefore automatically non-poor in this dimension. In fact, if they have no children at all, it is going to be quite hard for them to be multidimensionally poor since they are automatically called non-deprived in 50% of dimensions![37]

The relative importance of these households differs across the indicators and countries. Older households are more likely to have no eligible population in the three indicators. Typically this is more of an issue in middle-income and transition countries like Armenia. In Ethiopia several households only consist of children and grand-parents and have no men or women at the reproductive age. This is a potentially even bigger problem in countries with a higher HIV prevalence than Ethiopia.

[37] This is particularly the case if the MICS are used (where adult nutrition information is not included).

Table 15: Relative importance of households without eligible population

	Nutrition (health)	Mortality (health)	Enrollment (education)
All	9.1%	17.84%	36.97%
Armenia	14.81%	23.58%	51.25%
India	8.57%	17.13%	37.90%
Ethiopia	11.07%	21.23%	24.38%
"older" household	28.44%	32.48%	38.24%

In the following we will shortly discuss other approaches to deal with non-eligible population in the MPI (see also related discussion in Alkire and Santos, 2010): First of all, one could drop households without eligible population. This however not only reduces the sample, but the outcomes are also no longer representative since we exclude a significant share of the population. One could also substitute the missing indicator with an indicator from the same dimension, i.e. substitute the enrollment indicator with the literacy indicator for households without children at school-age. This essentially doubles the weight attached to literacy for this specific household, hence a sensible decomposition by indicator will no longer be possible. Nevertheless, we could still decompose by dimension which would be quite useful. One could also consider substituting these indicators for children with indicators for adults (ideally all household members). However, comparable adult indicators in these dimensions are not available for all countries, and indicators that are equally relevant for all household members are also hard to come by. Finally, we could also consider changing the poverty cut-off (k) for households without eligible population. As the individual can only be deprived in less than ten weighted indicators, one would lower the overall poverty cut-off respectively.

We follow a hybrid approach, combining substitution and change of the poverty cut-off. First, we substitute the missing indicators with available indicators from the same dimension. If this is also not available, we lower the poverty cut-off for households with no eligible population in either indicator of the dimension (no eligible population for the nutrition and for the mortality indicator). The advantage of this approach is that it makes maximum use of the data without having to rely on imputations or on dubious assumptions of non-deprivation of childless households. The disadvantage is that decompositions by dimensions are no longer possible for those households that have no eligible information for the entire health dimension.

Table 16: Multidimensional poverty estimation – new treatment of non-response (hybrid approach)

	H	A	MPI
All	56.38%	57.37%	0.323502
Urban	22.44%	50.34%	0.112964
Rural	70.10%	58.69%	0.411409
small household	47.36%	58.50%	0.277043
medium-sized household	51.19%	57.15%	0.29253
large household	66.40%	58.05%	0.385462
female-headed household	56.06%	59.86%	0.335588
„older“ household	52.97%	58.97%	0.312377
young household	56.63%	57.33%	0.324628
Armenia	0.88%	39.28%	0.00345
Ethiopia	90.66%	67.67%	0.613465
India	53.84%	55.47%	0.298663

This increases the overall poverty incidence and intensity by approximately two percentage points. Multidimensional poverty increases disproportionately for small households. We also observe an increase in multidimensional poverty for Armenia.

Though, these changes are relatively modest, the share of households without eligible population is larger, when using the revised nutrition and mortality variables proposed above. The majority of households have no eligible population in the nutrition indicator (67.94%), and even in the mortality indicator the share of households without eligible population increases (cf. Appendix table A.1). Hence, a change in the treatment of households without eligible children has a stronger effect on overall poverty incidence and intensity, and affects households in all sub-groups.

6. A revised MPI based on the empirical assessment

On the basis of the sensitivity tests above, we propose a revised multidimensional poverty measure that addresses some of the issues discussed. In essence we put together what we learned from the previous empirical assessment. In this measure we still follow the Alkire-Foster dual cut-off method, apply the same normative weights, and also consider an overall cut-off of 1/3; of course, these choices could also be reviewed in light of our conceptual discussion above and will be taken up below. We suggest to apply the new indicator only to the DHS and MICS and to drop the WHS from consideration.

However, new indicator definitions are applied. We consider three living standard indicators instead of six: floor (the household is deprived if it has a dirt floor); drinking water (the household is deprived if it has no access to clean drinking water, or they require more than 30 minutes to fetch

water); assets (the household is deprived if they do not own more than one small asset and do not own a car or truck). These indicators are arguably more objective, easy to measure, as the household's benefit does not depend on the quality of the service, are highly correlated with the three dropped indicators, and comparable across countries and regions. Moreover, the relative contribution of the living standard dimension varies less across countries and regions when these three indicators are used.

Moreover, we suggest shortening the enrollment window by two years to allow for the late enrollment of children in school. It is common practice in many developing countries for younger children to enter school at a later age for a range of reasons. The original indicator would have considered these households as deprived, while the shorter enrollment window does not. A household is deprived in the new enrollment indicator if more than 20% of its school-age children (when the new enrollment window is applied) are not enrolled.

The suggested nutrition indicator does not include adult BMI, as this measure is prone to mis-categorization. Stunting is the preferred malnutrition indicator for children. The household is considered deprived in the new nutrition indicator if at least one out of five of the household's children between 6 months and 5 years are stunted. For the mortality indicator, we only account for the death of children below the age of five in the past five years. The original indicator was a stock variable as it considered the death of any child in the household without age or time cut-off. The MPI is however supposed to reflect *acute* multidimensional poverty. A household is deprived in the mortality indicator if at least 1/5 of the children under 5 in the household died in the past five years.

In the education indicator, we only consider a household as *non*-deprived if at least half of its adult members have 5 years of schooling. We, thus, assume some economies of scale for education in the household, but do not consider education as a pure public good. The original education indicator considered a household with one household member with five years of schooling as non-deprived.

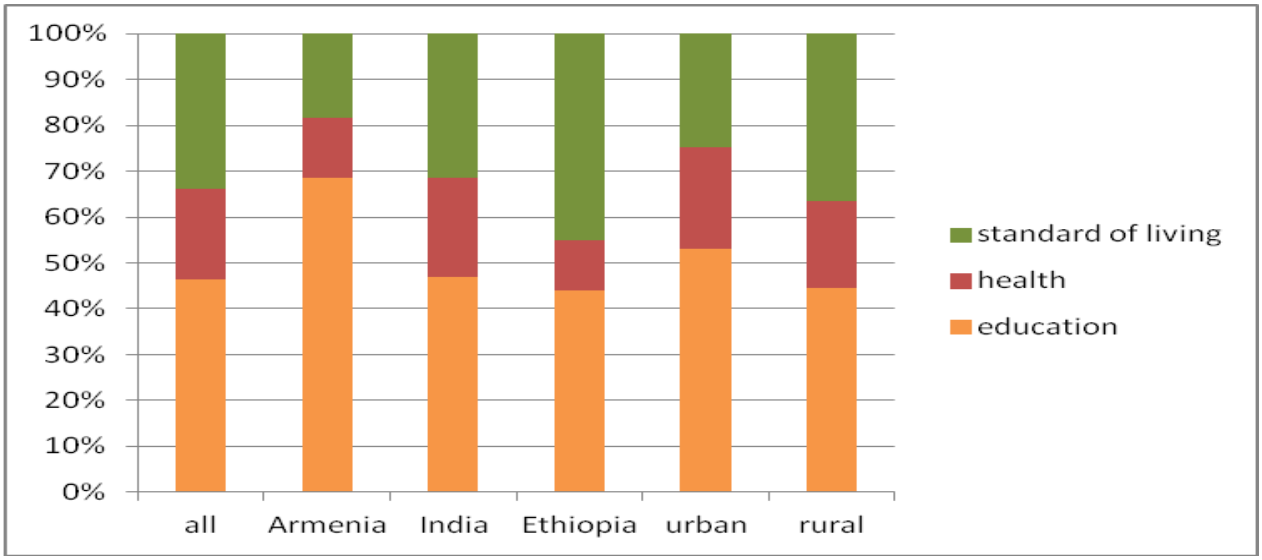
Finally, we also propose a new treatment for households without eligible population. In the original MPI, households without eligible population were considered non-deprived in the respective indicator. This reduced the chances of these households to be considered multidimensional poor. Our strategy follows a hybrid approach. First, we proxy malnourishment with adult BMI for households without children. Then, we substitute missing indicators with indicators from the same dimension, i.e. for households without children at school-age we double the weight on the education indicator. Finally, we re-scale the overall cut-off k for households were both indicators in one dimension were missing. Households without eligible population in both health indicators (mortality and malnourishment) can only be deprived in the education and standard of living dimension. We, thus, lower the overall cut-off (k) they face. These households are deprived if the sum of weighted deprivations is above 2/9 (2/9=1/3 * 2/3).

Table 17: Revised multidimensional poverty estimation

	H	A	MPI
all	60.28%	61.46%	0.370522
urban	27.22%	55.57%	0.151271
rural	73.24%	62.89%	0.460657
small household	53.53%	59.77%	0.319907
medium-sized household	57.58%	61.70%	0.355257
large household	64.78%	62.89%	0.407391
female-headed household	59.98%	61.41%	0.368327
„older“ household	57.44%	60.77%	0.349068
young household	60.02%	62.20%	0.373302
Armenia	2.96%	46.89%	0.013863
Ethiopia	92.25%	69.25%	0.638847
India	57.82%	60.37%	0.349068

Our revised MPI measure finds the intensity and incidence of multidimensional poverty is higher when we apply all the proposed changes. The increase in the headcount of multidimensional poor is strongest for small households and households in Armenia. Moreover, the poverty rate in large households is lower in the revised measure compared with the base estimation.

Figure 5: Decomposition by dimension



Since we apply a hybrid approach for indicators without eligible population, a sensible decomposition by indicator is no longer possible. Instead we decompose the MPI by dimension. Though poverty profiles differ by country and region, we observe education contributes by far the most to multidimensional poverty. In contrast to that, deprivations in the health dimension contribute the least to being identified as multidimensional poor. The increase in the relative contribution of education may to some extent be attributed to the change in the education indicator.

In the original MPI, the household was non-deprived if at least one household member had five years of education. We however propose a more stringent criterion, considering households as non-deprived where at least 50% of household members had five years of education.

7. Severe multidimensional poverty

Alkire and Santos consider households to be severely poor, if they are deprived in more than 50% of the sum of weighted indicators. Hence, households need to be deprived in several dimensions to be identified as severely poor. We suggest to no longer define severe poverty as multiple deprivations, but to consider the frequency of deprivations within the household.

Considering multiple deprivations as severe poverty, makes it harder to fall *into* severe poverty as several original indicators are stock indicators (education, most of the original living standard indicators). Thus, the original severe poverty indicator reflects chronic, severe poverty.[38] Moreover, it was nearly impossible for households without eligible population (i.e. without children) to be severely deprived as these households are considered non-deprived in some indicators already.

A household is considered severely deprived in education, if less than 20% of its household members have 5 years of schooling. Similarly, the household is severely deprived in enrollment, malnourishment, or mortality, if more than 50% of its eligible household members are deprived in the respective indicator. Moreover, the household is deprived in assets, if it owns *no* assets. Finally, a household is considered severely multidimensional poor, if the weighted severe poverty indicators sum up to one third.

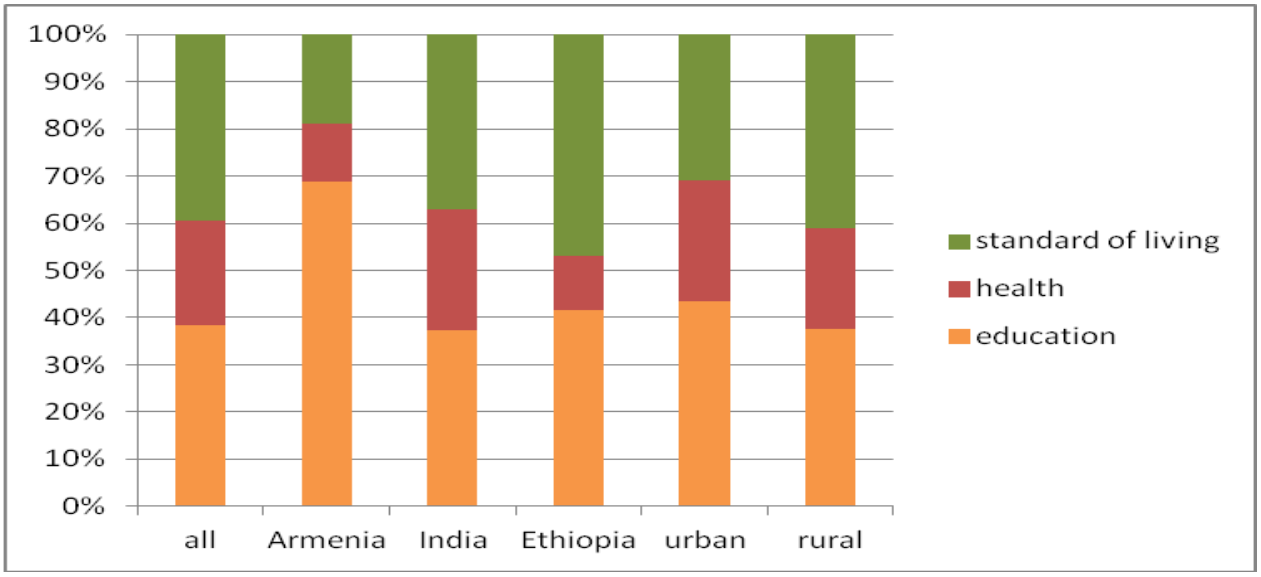
Table 18: Severe multidimensional poverty estimation

	H	A	MPI
all	40.29%	58.46%	0.235532
urban	12.06%	54.28%	0.065448
rural	51.38%	59.41%	0.305242
small household	36.76%	58.21%	0.213948
medium-sized household	38.17%	59.49%	0.227105
large household	42.92%	58.47%	0.250946
female-headed household	43.12%	59.89%	0.258286
„older“ household	40.92%	58.87%	0.240913
young household	39.19%	58.97%	0.231063
Armenia	0.21%	44.79%	0.000959
Ethiopia	83.28%	65.45%	0.54512
India	35.70%	56.94%	0.203261

[38] Though we still may observe movement out of severe poverty.

In our restricted sample over 40% of the population live in households which are severely multidimensional poor. Severe multidimensional poverty is more prevalent in rural households, large households and female-headed households. In Ethiopia, most households that are considered multidimensional poor may also be considered severely poor. This is less the case in India, were only around half of the multidimensional poor are also severely poor. In Armenia, less than 10% of the multidimensional poor are severely poor.

Figure 6: Decomposition by dimension



The poverty profile of the severely poor is similar to the multidimensional poverty profile discussed above (see above section 6). However, deprivations in the living standard and health contribute more to severe poverty compared to multidimensional poverty. Hence, health and the standard of living are more important in understanding severe multidimensional poverty.

8. Conclusions: Combining Conceptual and Empirical Proposals

The MPI has been an interesting and important effort to provide a multidimensional poverty measure that competes in depth and coverage with the widely used (and problematic) $1.25 a day income poverty indicator. We strongly suggest that HDRO continues to use an MPI-type indicator in its future Human Development Reports. As we have suggested in this paper, there are many open

questions and issues regarding the conceptual underpinning and alternative formulations of the MPI. We suggest that these issues are carefully considered and possibly a revised MPI be produced that reflects different choices. Among the issue we would flag particularly are the use of the union (instead of the dual cut-off) method for identification and considering inequality in deprivations across people in the MPI (at least in some version of the MPI). We also believe that the headcount is in principle understood better and easier to communicate as headline indicator in contrast to the current product of headcount and intensity; it should nevertheless be complemented with a measure that also considers intensity and inequality such as the one proposed by Rippin (2012) or a similar measure. These proposals (particularly concerning the union approach) would make more sense if, at the same time, changes in the empirical implementation were made to reduce the indicators used to a set which are of particular importance and are particularly well-measured.

In that vein, we propose a number of changes, including dropping the WHS as one of the data sources, dropping the BMI as a nutrition indicator, and changing the age ranges and cut-offs for the education and mortality indicators. We also recommend to focus on only three living standard indicators (water, floor, and assets). We believe that these changes would represent improvements over the current formulation but want to emphasize that one would need to investigate these proposed changes in more detail to come to more definitive conclusions about this.

9. Revisions made to the MPI in the 2014 Human Development Report

In the 2014 Human Development Report, HDRO presented a revised MPI that addresses some of the issues raised above. For ease of comparison, it also published the MPI using the previous method (that is also still used by OPHI) and presented data for changes in the MPI over time using the new approach. HDRO did not change the basic conceptual underpinning of the MPI. It remains based on the dual cut-off approach, it continues to use the product of headcount and intensity, and inequality is not considered. Thus the conceptual issues raised here have not been addressed in the revision. This is with some justification as these issues require more discussion and analysis before such fundamental changes can be implemented. All the changes refer to the empirical issues and all tackle issues identified in the paper above (although sometimes deviating from our proposals in terms of solutions).

A first important change is that, as recommended here, the World Health Survey has indeed been dropped as a survey to track the MPI in countries without a DHS or a MICS. In China, the China Health and Nutrition Survey for 2009 has been used for the MPI calculation which is a good

(and more recent) substitute although it only covers part of the country. In other selected countries, national surveys that contain the relevant information have been added.

There are more changes to the indicators and cut-offs, many of which relate to the discussion above. More specifically, in the health dimension, the childhood underweight indicator was replaced by a stunting indicator for the reasons outlined above. Moreover, the child mortality indicator now refers to deaths of children that occurred in the past 5 years, as suggested above. In the education dimension, the minimum years of schooling to be non-deprived was raised to 6 years (from 5). This issue was not identified here as a particular problem but it appears to be a sensible change since it links the minimum years of schooling to completed primary education (which is six years in most countries). Also, some allowance was made for overage children in the enrolment indicator, as proposed above. Now a household is only deprived if the children 8-15 are not all in school (rather than 7-15), thereby allowing for late entry to schooling (by one year) that may not be a sign of deprivation. In the standards of living dimension, all six indicators were retained. The only change was that ownership of arable land and livestock is now included as possible assets in the asset indicator to better capture asset holdings in rural areas.

Lastly, HDRO also addresses the issue of the ineligible population that was also raised above. It picks up some of the suggestions made above and reweights information of indicators within a dimension. For households lacking information on both indicators in the health or education dimension (which affects a substantial share of households), HDRO chose a different route to the one proposed above. Instead, these households are now dropped from the sample, and the remaining sample is reweighted to make sure that it is still representative to the entire population. Essentially this implies that the households without education information are now proxied by similar households that are similar but have this education information. Details on this procedure can be found in Calderon and Kovacevic (2014).

Overall, the changes made to the MPI all appear sensible. They address many of the issues identified in this paper and implement solutions that address the problems within the constraints of data availability. It would be best now to learn from the experience of thse revisions over the next few years and, in the meantime, consider tackling some of the conceptual issues raised in this paper to see whether they merit more fundamental revisions to the MPI.

Appendix:

Table A.1: Relative importance of households without eligible population – improved nutrition and mortality indicators

base	Nutrition (health)	Mortality (health)	Enrollment (education)
all	67.94%	11.82%	36.97%
Armenia	78.51%	15.45%	51.25%
India	66.35%	11.55%	37.90%
Ethiopia	76.38%	12.58%	24.38%
Old hh (above35)	85.30%	33.70%	38.24%

Appendix A.2: Correlation coefficients between living standard indicators

Spearman (rank) correlation:

	electricity	sanitation	drinking water	Floor	cooking fuel	assets
electricity	1***					
sanitation	0.3855***	1***				
drinking water	0.3196***	0.2205***	1***			
floor	0.5767***	0.4613***	0.3153***	1***		
cooking fuel	0.4524***	0.4855***	0.2837***	0.5668***	1***	
assets	0.4861***	0.4469***	0.2802***	0.4672***	0.4795***	1***

Tetrachoric correlation (for binary variables):

	electricity	sanitation	drinking water	Floor	cooking fuel	assets
electricity	1***					
sanitation	0.6870***	1***				
drinking water	0.5183***	0.4053***	1***			
floor	0.8336***	0.7011***	0.5191***	1***		
cooking fuel	0.8518***	0.6965***	0.5342***	0.8424***	1***	
assets	0.7440***	0.6693***	0.4710***	0.6728***	0.7147***	1***

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UNDP Human Development Report Office
304 E. 45th Street, 12th Floor
New York, NY 10017, USA
Tel: +1 212-906-3661
Fax: +1 212-906-5161
http://hdr.undp.org/