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# Monitoring Progress in Multi-dimensional Poverty Reduction: A Person-Focused and Inequality-sensitive Approach with Evidence from Nicaragua

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**Monitoring progress in multi-dimensional poverty reduction: A person-focused and inequality-sensitive approach with evidence from Nicaragua** (*preliminary version*)

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Abstract

In this paper, considering the overarching concern of the 2030 sustainable development agenda, leaving no one behind, and the targets 1.2 and 10.1 of the SDGs, we point out that the mainstream approach to the multi-dimensional poverty measurement in developing countries is deficient to properly monitor progress in multi-dimensional poverty reduction mainly because it uses the household as the unit of analysis, ignoring thus intra-household inequalities, and is totally insensitive to inequality among the multi-dimensionally poor individuals, a serious defect of any poverty measure. Consequently, we propose to depart somewhat from the mainstream approach and to adopt a person-focused and inequality-sensitive framework, which is applied to the case of Nicaragua. Overall, we find that in this country, multi-dimensional poverty decreased by at least 17% between 2001 and 2014, but inequality among the multi-dimensionally poor individuals, an issue that is ignored by the mainstream approach, increased by at least 24% during that period, which suggests that progress in multi-dimensional poverty reduction in Nicaragua seems to be leaving behind the poorest of the poor.

Keywords: multi-dimensional poverty, individual-based measures, inequality-sensitive measures, Nicaragua, Latin America and the Caribbean

JEL Codes: I3, I32, D1, D13, D6, D63, O5, O54

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## 1. Introduction

The 2018 global multi-dimensional poverty index (global MPI) reveals that about 1.3 billion persons globally live in multi-dimensional poverty; it also shows that 83% of the multi-dimensionally poor in the world live in Sub-Saharan Africa and South Asia and 50% of them are children (OPHI-UNDP, 2018). Therefore, the elimination of poverty has been and will remain one of the major international development policies for a large number of people in the world, even in the second decade of the twenty-first century (Chakravarty, 2018; Chakravarty & Silber, 2008); it is actually "the greatest global challenge and an indispensable requirement for sustainable development" (UN, 2017, p. 1). In this regard, the 2030 Agenda for Sustainable Development, a normative framework with international consensus, which was passed in 2015, has put particular emphasis on this issue (UN, 2015), and Goal 1 of the Sustainable Development Goals (SDGs) demands the ending of "poverty in all its forms everywhere" (UN, 2015, p. 15). In this context, the measurement of poverty, our central concern in this paper, is of great importance for targeting and monitoring of poverty alleviation policies; it is, as noted by Deaton (2016, p. 1221), necessary if not sufficient for any reasoned appraisal of these policies.

Over the last decade or so, poverty measurement has shifted the emphasis from a unidimensional to a multi-dimensional approach (Datt, 2018; Pogge & Wisor, 2016), due in large part to Sen's influential work (see, for instance, Sen, 1985, 1992, 1997, 2000, 2010). Currently, the dominating (mainstream) approach in developing countries is the counting methodology put forward by Alkire and Foster (2011) (henceforth AF) (Datt, 2018; Duclos & Tiberti, 2016; Espinoza-Delgado & Silber, 2018), largely due to the extraordinary work done at the Oxford Poverty and Human Development Initiative (OPHI).[1] In 2010, OPHI, in collaboration with the United Nations Development Program (UNDP), developed the global MPI, which is a particular case ["the adjusted headcount ratio ($M_0$)"] of the AF family of multidimensional poverty measures (Alkire & Foster, 2011, p. 479), the most famous and influential empirical application of the AF methodology, computed for over 100 developing countries (see Alkire & Santos, 2010, 2014). Since 2010, the global MPI has been incorporated into the Human Development Report of the UNDP (UNDP, 2010) and is beginning to be seen as a "serious competitor to the World Bank's $1.90-a-day monetary poverty indicator" (Klasen, 2018, p. 2); further, a new version of the global MPI that

[1] See [online] https://ophi.org.uk/

considers improvements for some indicators has been proposed to monitor progress toward the SDGs and in achieving Goal 1 of these (OPHI, 2015; Alkire & Jahan, 2018). The AF approach (the $M_0$ measure) has also been adopted by several countries, particularly from Latin America and the Caribbean, to produce their official multi-dimensional poverty measures;[2] likewise, Santos and Villatoro (2018) have recently developed a new multidimensional poverty index for Latin America (MPI-LA) that follows the same functional form as the global MPI (the $M_0$ measure).

Certainly, the AF approach, and therefore its $M_0$ measure, has quite a nice number of interesting properties (see Alkire & Foster, 2011; Alkire, Foster, Seth, Santos, Roche, & Ballón, 2015), in addition to the fact that it has the advantage of flexibility, simplicity, and clarity, when compared to other multidimensional poverty methodologies (Espinoza-Delgado & Silber, 2018; Thorbecke, 2011).[3] However, this methodology ($M_0$ measure) does suffer from several unattractive methodological features that have not yet been sufficiently observed in the literature, as discussed by Duclos and Tiberti (2016), which may lead to biased estimates and wrong assessments of overall multi-dimensional poverty in the society.

Firstly, since the AF methodology employs a "dual cutoff method" for the identification of the multi-dimensionally poor individuals (Alkire & Foster, 2011, p. 478), a first cutoff within each dimension (indicator) to determine whether an individual is deprived in that dimension (indicator), and a second cutoff, or multi-dimensional poverty line (k), across dimensions (indicators) that identifies the multi-dimensionally poor by counting the dimensions (indicators) in which an individual is deprived, the AF identification function is discrete, creates two types of discontinuities, and thus violates the axiom of continuity (Duclos & Tiberti, 2016). Although when using ordinal variables (dimensions or indicators), the commonest case, the first discontinuity can be considered as irrelevant, the discontinuity created by the second cutoff (k) can be of great relevance for multi-dimensional poverty measurement: A small change in k can change from 0 to 1, or from 1 to 0, the contribution of any person to overall poverty, which "may penalize welfare-equalizing policies and development processes" (Duclos & Tiberti, 2016, p. 696). Additionally, as noted by Rippin (2017, p. 37), the dual cutoff identification method assumes implicitly that up to k the

[2] For example: Chile (Ministerio de Desarrollo Social, 2016), Colombia (DANE-DIMPE, 2014), Costa Rica (INEC-CR, 2015), Ecuador (Castillo & Jácome, 2015), El Salvador (STPP & MINEC-DIGESTYC, 2015), Honduras (SCGG-INE, 2016), México (CONEVAL, 2011), and Panamá (MEF, 2017).

[3] Other methodologies can be found, for instance, in Alkire et al. (2015); Lemmi and Betti (2006, 2013); Kakwani and Silber (2008).

dimensions (indicators) are "perfect substitutes", whereas the same dimensions (indicators) are "perfect complements" from such a threshold onwards, an issue theoretically questionable.

Secondly, the $M_0$ index pays no attention to the distribution of deprivations; it is thus totally insensitive to inequality among the multi-dimensionally poor individuals (actually any measure grounded on the AF methodology) (Datt, 2018; Rippin, 2013, 2017), a serious shortcoming of any poverty measure, according to Sen's (1976, 1979, 1992) influential arguments that overall poverty indices should be sensitive to inequality, which may lead to leaving behind the poorest of the poor: An inequality insensitive poverty measure "can deflect anti-poverty policy by ignoring the greater misery of the poorer among the poor" (Sen, 1992, p. 105). Note also that Goal 10 of the SDGs calls for reducing "inequality within and among countries" (UN, 2015, p. 21). Formally, as observed by Rippin (2017, p. 47), this index (and actually any AF index), due to the dual cutoff approach, does not fulfill the strongest and the weakest versions of the axiom of "Sensitivity to Inequality Increasing Switch (SIIS)", which is also supposed to capture the interaction between allocation efficiency and distributive justice (see Sen, 1992).[4] For example, an inequality increasing switch that lessens the weighted deprivation score of the less multi-dimensionally poor person below the multi-dimensional poverty line (k) will always lead to a reduction of the multi-dimensional poverty rates, regardless of the relationship between dimensions (indicators) (Rippin, 2017); accordingly, this weakness may lead to biased assessments of the extent of multi-dimensional poverty and hence have an impact on antipoverty programs, and targeting (Espinoza-Delgado & Silber, 2018).

With regard to applied work, another feature of the mainstream practice of the multi-dimensional poverty measurement (and really of the vast majority of studies on multi-dimensional poverty) is the fact that it uses the household rather than the individual as the unit of analysis (Espinoza-Delgado & Klasen, 2018; Vijaya, Lahoti, & Swaminathan, 2014); this means that it considers equal the multi-dimensional poverty condition of the household with the multi-dimensional poverty condition of all persons belonging to the household,

[4] As observed by Rippin (2017, p. 33-34): "Poverty measures can even decrease in the face of increasing inequality if and only if the degree of complementarity between poverty dimensions is so strong that the gains in allocation efficiency outweigh the sacrifices on the side of distributional justice. In other words, changes in poverty measures ought not to be reduced to considerations of who gains and who loses from redistributions (distributive justice) but should also take into account how efficient resources are distributed among the poor (allocation efficiency)".

ignoring, therefore, the intra-household inequalities[5] and producing indexes that are insensitive to gender (Bessell, 2015; Espinoza-Delgado & Klasen, 2018; Pogge & Wisor, 2016). As observed by Deaton (1997, p. 223), poverty is a feature of individuals, not households, and "if one is serious about what should be the ultimate object of welfare analysis–that is, the welfare of *individuals*–then limiting the theoretical and empirical analysis at the level of the household is simply unacceptable" (Chiappori, 2016, p. 840). Household-based measures may provide biased estimates of the extent of multi-dimensional poverty in aggregate: For example, if females are systematically poorer than males, or if children and elderly are systematically worse-off than other household members, overall poverty may be understated when one employs a measure that treats everybody in the household equally (Deaton, 1997); furthermore, when these measures are used, valuable information about the composition of the multi-dimensionally poor may be overlooked (Jenkins, 1991), which may thus affect targeting and effectiveness of poverty alleviation policies (see, for example, Brown, Ravallion, & van de Walle, 2018). Hence, household-based multi-dimensional poverty measures are "unreliable at best, and deeply flawed at worst" (Chiappori & Meghir, 2015, p. 1371), and these are not suitable to monitor progress in achieving target 1.2 of the SDGs: "By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions" (UN, 2015, p. 15); the poverty analysis should therefore be moved from the household to the individual (Espinoza-Delgado & Klasen, 2018; Vijaya et al., 2014).

In consequence, in this paper, we propose to adopt a person-focused and inequality-sensitive approach to monitoring progress in multi-dimensional poverty reduction in developing countries in the context of Goal 1 of the SDGs and in line with the central overarching concern of the SDGs agenda: Leaving no one behind (Klasen & Fleurbaey, 2018); that is, we suggest an approach that departs somehow from the mainstream multi-dimensional poverty analysis. Our approach is based on the general framework proposed by Silber and Yalonetzky (2014) and the methodology, with ordinal (dichotomized) dimensions (variables), developed by Rippin (2013, 2014); it uses a "fuzzy" identification function and a class of multi-dimensional poverty measures that take into account efficiency and distributive considerations and can be decomposed into the three "dimensions" of poverty: Incidence, intensity, and inequality (Jenkins & Lambert, 1997, p. 317). We apply such an approach to

[5] See, for instance, Asfaw, Klasen, and Lamanna (2010); Bradshaw, Chant, and Linneker (2018); Chant (2008); Klasen and Wink (2002, 2003); Rodríguez (2016).

assess the progress in multi-dimensional poverty reduction in Nicaragua between 2001 and 2014; this country is an interesting study case because it is the multi-dimensionally poorest country in Latin America (Santos & Villatoro, 2018) and the only one country in Central America that has not yet adopted officially a multi-dimensional poverty approach. To the best of our knowledge, this is the first attempt in the literature on multi-dimensional poverty analysis that evaluates progress in multi-dimensional poverty reduction across the whole population by using a person-focused and inequality-sensitive framework.

## 2. An inequality-sensitive framework for the measurement of multi-dimensional poverty

In this paper, we follow the framework for the measurement of multi-dimensional poverty proposed by Espinoza-Delgado and Silber (2018), which is based on the work by Silber and Yalonetzky (2014) and on Rippin's (2013, 2017) methodology with ordinal (dichotomized) variables. This framework entails two stages: 1) The construction of an individual multi-dimensional poverty function, which comprises an identification function and a function defining the multi-dimensional poverty breadth; and 2) the construction of a social multi-dimensional poverty function by aggregating the individual multi-dimensional poverty functions.

Before describing the stages of the framework to be used in the paper, let us first introduce some notations and definitions.

Let $\mathbf{N} = \{1, \dots, n\} \subset \mathbb{N}$ represent the set of n individuals, and let $\mathbf{D} = \{1, \dots, d\} \subset \mathbb{N}$ denote the set of d ordinal variables (dimensions or indicators) measuring different aspects of person's well-being. Let $\mathbf{X} = [x_{ij}]$ be the $n \times d$ achievement matrix, where $x_{ij}$ $(\in \mathbb{N}_{++})$ represents the attainment of the $i^{th}$ person for the jth variable (dimension or indicator). In this matrix, each row vector $\mathbf{x}_{i.} = (x_{i1}, \dots, x_{id})$ gives the attainments of the $i^{th}$ person, while each column vector $\mathbf{x}_{.j} = (x_{1j}, \dots, x_{nj})$ provides the distribution of the $j^{th}$ variable across the whole population. Let $\mathbf{z} = (z_1, \dots, z_d)$ be a row vector defining the variable-specific deprivation lines and $\mathbf{w} = (w_1, \dots, w_d)$ the vector of variable-specific weights, with $w_j > 0 \; \forall j \in [1, d]$ and $\sum_{j=1}^{d} w_j = 1$. Finally k indicates the real-valued scalar cutoff, with $0 \leq k \leq 1$; it is the minimal deprivation score a person needs to obtain in order to be identified as multi-dimensionally poor.

## 2.1. The individual multi-dimensional poverty function

Two sequential steps are involved in constructing the individual multi-dimensional poverty function. The first step assesses whether a person is deprived in each variable j by comparing the person's achievement ($x_{ij}$) with the defined deprivation threshold ($z_j$): If $x_{ij} < z_j$, person i is deemed to be deprived in variable j. By combining $\mathbf{X} = [x_{ij}]$ and $\mathbf{z} = (z_1, \dots, z_d)$, a (0-1)-matrix $\mathbf{g^0}[g_{ij}^0]$ is obtained, such that $g_{ij}^0 = 1$ if $x_{ij} < z_j$, and $g_{ij}^0 = 0$ if $x_{ij} \geq z_j$, for all $j = 1, \dots, d$ and for $i = 1, \dots, n$. Then, a weighted deprivations score [$c_i(x_i; z; w)$], "the real-valued counting function", is calculated for each person as the weighted sum of the deprivations suffered by each of them (Silber & Yalonetzky, 2014, p. 11). If person i does not suffer from any deprivation, $c_i(x_i; z; w) = 0$; conversely, if they are deprived in all the variables considered in the analysis $c_i(x_i; z; w) = 1$.

The second step is concerned with the identification of the multi-dimensionally poor individuals; generally speaking, under this step, the real-valued counting function [$c_i(x_i; z; w)$] is compared with the multi-dimensional poverty line (k): If the former is greater or equal to the latter, then person i is regarded as multi-dimensionally poor; this step requires, therefore, the choice of an identification function to determine who is multi-dimensionally poor and who is not. There are, basically, two type of identification functions: Discrete identification functions, which dichotomize (0-1) the distribution of weighted deprivations scores (e.g., the one used by the AF methodology), considering the previous condition, and "fuzzy" identification functions, which differentiate between the multi-dimensionally non-poor individuals, on the one hand, and different degrees of multi-dimensional poverty severity among the remaining individuals, on the other hand (Rippin, 2017, p. 42); in other words, this second type of identification functions considers multi-dimensional poverty as a "matter of degree" rather than an all or nothing state (Betti, Cheli, Lemmi, & Verma, 2008, p. 30), avoinding thus the discontinuity created by the another type of identification functions.

Particularly, as discussed in the introduction, in this paper, as opposed to the mainstream approach to the measurement of multi-dimensional poverty in the developing world, we employ a fuzzy identification function that makes explicit the relationship between the ordinal variables considered in the assessment and does not cause a discontinuity in the distribution of weighted deprivations scores. This function has been proposed by Rippin (2013, 2017) and is defined as

$$\psi^{\text{fuzzy}}(x_i; z; w; k) = [c_i(x_i; z; w)]^{\gamma} \quad (1)$$

where $[c_i(x_i; z; w)]^{\gamma}$ satisfies the conditions of being non-decreasing in $c_i(x_i; z; w)$ and of having a non-decreasing (non-increasing) marginal if the variables are assumed to be substitutes (complements).[6] Note that the overall form of the fuzzy identification function is conditioned to the value of the parameter gamma ($\gamma$), which can be interpreted as an indicator of "inequality aversion" (Rippin, 2013, p. 27); it can be concave, if the parameter gamma is between 0 and 1, or can be convex, if gamma is higher than 1. The first case corresponds to the case when the variables are considered as complements, while the second one corresponds to the case when the variables are regarded as substitutes.[7]

Certainly, the choice of a particular relationship between the variables (dimensions or indicators) is not a simple task (Espinoza-Delgado & Silber, 2018); as noted by Thorbecke (2008, p. 17), the variables "can be substitutes in the short run while being complementary and re-enforcing in the long run", which has fundamental implications for the multi-dimensional poverty measurement over time. Considering this, in this paper, we suppose different degrees of substitutability ($\gamma = 1.25, 1.50, 1.75, 2.00$) and complementarity ($\gamma = 0.25, 0.50, 0.75$) among the variables in order to verify the robustness of our main findings to these assumptions.

As observed by Silber and Yalonetzky (2014, p. 13), the literature on multi-dimensional poverty measurement with ordinal (dichotomized) variables requires the individual multi-dimensional poverty function not only to determine who is multi-dimensionally poor and who is not, but also to capture the multi-dimensional poverty breadth. In this vein, we make the individual multi-dimensional poverty function depends on "the

[6] "A function f(x) has a non-decreasing marginal if $f(x_g + 1) - f(x_g) \geq f(x_h + 1) - f(x_h)$ whenever $x_g \geq x_h$" (Rippin, 2017, p. 61). The conditions that have to be satisfied by $[c_i]^{\gamma}$ are based on the "Theorem 1" proposed by Rippin (2013, p. 27). The proof of the Theorem can be found in Rippin (2017, p. 62-64).

[7] As observed by Espinoza-Delgado and Silber (2018, p. 9), based on Rippin (2013, 2017), if the variables are considered as complements, the increase in poverty severity is marginally decreasing in $c_i(x_i; z; w)$ as the loss in even one variable (dimension or indicator) can hardly be compensated. In other words, as soon as a person suffers from deprivation in one variable, he/she must suffer from some degree of poverty. If the variables are perfect complements, there is no compensation, and we obtain the union case; but if they are imperfect complements, we get the more general case approximated by a concave identification function. If, on the contrary, the variables are substitutes, there is compensation, and then the shortage in only one variable leads to a rather low degree of poverty severity as other variables can compensate for the deprivation. However, overall, the compensation capacity decreases as the number of deprivation increases; consequently, the poverty severity level is marginally increasing in $c_i(x_i; z; w)$. Therefore, if they are imperfect substitutes, we obtain the more general case of a convex function; but, if they are perfect substitutes, there is full compensation: As long as a person is not deprived in all variables his/her overall score will be equal to zero, which corresponds to the intersection case.

number of deprivations", so we finally define this function as the product of the identification function and a function $g(x_i; z; w)$ that captures the poverty breadth. Let $p_i(x_i; z; w; k)$ be the individual multi-dimensional poverty function; then it can be expressed as

$$p_i(x_i; z; w; k) = \psi^{Fuzzy}(x_i; z; w; k) g(x_i; z; w) \tag{2}$$

In this paper, we use the multi-dimensional poverty breadth suggested by Alkire and Foster (2011), which is defined as

$$g(x_i; z; w) = c_i(x_i; z; w) \tag{3}$$

Then, the individual multi-dimensional poverty function to be used in this paper is defined as

$$p_i(x_I; z; w; k) = [c_i(x_i; z; w)]^{\gamma} c_i(x_i; z; w) = [c_i(x_i; z; w)]^{\gamma+1} \tag{4}$$

2.2. The social multi-dimensional poverty function

The second stage of the framework entails the construction of a social multi-dimensional poverty function $[P(X; z; w; k)]$ by aggregating the individual multi-dimensional poverty functions. Although in the literature there are various routes of carrying out this aggregation (Silber & Yalonetzky, 2014), we define the social multi-dimensional poverty function as the average of the individual multi-dimensional poverty functions; it is, therefore, defined as

$$P(X; z; w; k) = \frac{1}{n} \sum_{i=1}^{n} \sum_{j=1}^{d} p_i(x_i; z; w; k) = \frac{1}{n} \sum_{i=1}^{n} \sum_{j=1}^{d} \psi^{Fuzzy}(x_i; z; w; k) g(x_i; z; w) \tag{5}$$

Then, replacing (4) in (5), we obtain the "Multi-dimensional Correlation-Sensitive Class of Poverty Measures" $[P_{CS}^{\gamma}(X; z; w; k)]$ with ordinal (dichotomized) variables derived by Rippin (2017, p. 46):

$$P_{CS}^{\gamma}(X; z; w; k) = \frac{1}{n} \sum_{i=1}^{n} \sum_{j=1}^{d} [c_i(x_i; z; w)]^{\gamma} c_i(x_i; z; w) = \frac{1}{n} \sum_{i=1}^{n} [c_i(x_i; z; w)]^{\gamma+1} \tag{6}$$

As demonstrated by Rippin (2013, 2017), this class of measures $[P_{CS}^{\gamma}(X; z; w; k)]$ satisfies a number of appealing axioms such as anonymity (AN), monotonicity (MN), principle of population (PP), strong focus (SF), normalization (NM), subgroup decomposability (SD), factor decomposability (FD), and sensitivity to inequality increasing switches (SIIS); it is also the only one in the literature on multi-dimensional poverty measurement that can be decomposed into the "three 'I's of poverty": Incidence, intensity, and inequality (Jenkins & Lambert, 1997, p. 317).

Let $\mathrm{q}$ be the number of multi-dimensionally poor individuals; let $\mathrm{H}=\mathrm{q}/\mathrm{n}$ be the multi-dimensional headcount ratio that measures the incidence of multi-dimensional poverty; let $\mathrm{A}=\left[\sum_{\mathrm{i}=1}^{\mathrm{q}}\mathrm{c_i}(\mathrm{x_i};\mathrm{z};\mathrm{w})\right]/\mathrm{q}$ be the average deprivation score across the multi-dimensionally poor people that measures the poverty intensity (Alkire et al., 2015, p. 157), and let $\mathrm{GE}_{\gamma+1}(\mathrm{c})$ be the generalized entropy inequality index among the multi-dimensionally poor individuals (Bérenger, 2017, p. 148), Eq. (6) can also be defined as

$$\mathrm{P}_{\mathrm{CS}}^{\gamma}(\mathrm{X};\mathrm{z};\mathrm{w};\mathrm{k})=\mathrm{HA}^{\gamma+1}\left\{1+\left[(\gamma+1)^2-(\gamma+1)\right]\mathrm{GE}_{\gamma+1}(\mathrm{c})\right\} \tag{7}$$

In line with Rippin (2013, 2017), it is worth mentioning that the resulting multi-dimensional poverty incidence is, in fact, the headcount of the deprivation-affected in the society and coincides with the multi-dimensionally poor people as identified by the union approach (see Atkinson, 2003); this incidence may, therefore, be "too high to be useful" (Rippin, 2017, p. 43), particularly for targeting and prioritization of poverty alleviation policies and programs. To address this, in this paper, we propose to examine how the overall multi-dimensional poverty is distributed across the population, to rank individuals from the poorest to the richest, considering the individual multi-dimensional poverty functions, and to focus policies and programs addressed to poverty alleviation on the bottom 40 percent of the population; that is, to prioritize the poorest of the poor. Our suggestion is based on the targets 1.2 ("By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions") and 10.1 ("By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average") of the SDGs (UN, 2015, 2017).

It is also worthy of note that the $\mathrm{M}_0$ measure is computed as the product of the incidence (H) and the intensity (A) of multi-dimensional poverty, so the Eq. 7 can also be expressed as

$$\mathrm{P}_{\mathrm{CS}}^{\gamma}(\mathrm{X};\mathrm{z};\mathrm{w};\mathrm{k})=\mathrm{M}_0\mathrm{A}^{\gamma}\left\{1+\left[(\gamma+1)^2-(\gamma+1)\right]\mathrm{GE}_{\gamma+1}(\mathrm{c})\right\} \tag{8}$$

Accordingly, as noted by Espinoza-Delgado and Silber (2018, p. 12), the expression $A^{\gamma}\{1 + [(\gamma + 1)^2 - (\gamma + 1)]\, GE_{\gamma+1}(c)\}$ constitutes the substantive information that the $M_0$ measure totally overlooks when compared to the measure to be used in this paper; let us call the expression in curly brackets as inequality component (Bérenger, 2017; Rippin, 2013, 2017). Note that this information is especially important in the context of the SDGs, and its targets, and for gender inequality analysis (UN, 2015, 2017); in fact, ignoring such information may lead to biased assessments of multi-dimensional poverty in the society and of anti-poverty programs and may also lead to leaving behind the poorest of the poor.

## 3. Data, dimensions, indicators and deprivation indicators

The data analyzed are drawn from the four most recent available rounds of the Nicaragua National Household Survey on Living Standards Measurement (EMNV in Spanish), conducted by the National Institute of Development Information (former National Institute of Statistics and Censuses) with support from the World Bank in 2001, 2005, 2009, and 2014. The survey is nationally representative and is the one used by the Government of Nicaragua to monitor progress in monetary poverty reduction and in the coverage of some basic needs such as water, sanitation, and housing (see INIDE, 2015, 2016). We use the person as the unit of analysis and include the household members who completed a full interview (22,589 people in 2001, 36,383 people in 2005, 30,258 people in 2009, and 29,381 people in 2014).

Our multi-dimensional poverty measure comprises the same three dimensions as the global MPI (education, health, and standard of living) (Alkire & Jahan, 2018; Alkire & Santos, 2014), which are certainly among the most important aspect of people's well-being (Stiglitz, Sen, & Fitoussi, 2009a, 2009b); these can be considered as basic capabilities (Sen, 1993, 2000) and can also be framed into the "Central Human Capabilities" suggested by Nussbaum (2003, p. 41). The three dimensions are equally weighted, and the indicators used to measure each of them are described and defined in Espinoza-Delgado and Klasen (2018). Table 1 shows the dimensions, indicators, and the corresponding deprivation indicators.

**Table 1:** Dimensions, indicators, deprivation indicators

| Dimension (weight) | Indicator (weight) | Deprivation indicators |
|---|---|---|
| **Education (1/3)** | **Schooling achievement (1/3)** | He/she is not attending nursery school or pre-school or primary school and the head of the household has not completed the lower secondary school level (for children aged below 6 years)* |
| | | He/she is not on track to complete the lower secondary school level by 17 years old (for children aged between 6 and 17 years)** |
| | | He/she has not completed the lower secondary school level (for people aged 18 years or older) |
| **Health (1/3)** | **Health functioning failure (1/3)** | He/she suffered from a chronic disease or multiple diseases or an accident and/or an aggression in the month preceding the survey |
| **Standard of Living (1/3)** | **Housing (1/18)** | He/she is living in a house with dirt floor and/or precarious roof (waste, straw, palm and similar, other precarious material) and/or precarious wall materials (waste, cardboard, tin, cane, palm, straw, other precarious material) |
| | **Water (1/18)** | He/she does not have access to an improved drinking water source (public tap or standpipe, public or private well, piped water into dwelling, piped water to yard/plot) or has access to it, but out of the house and yard/plot |
| | **Sanitation (1/18)** | He/she only has access to an unimproved sanitation facility (a toilet or latrine without treatment or a toilet flushed without treatment to a river or a ravine) or to a shared toilet facility |
| | **Electricity (1/18)** | He/she does not have access to electricity |
| | **Energy (1/18)** | He/she is living in a household which uses wood and/or coal and/or dung as main cooking fuel |
| | **Assets (1/18)** | He/she has only access to less than two assets of the following list: Radio, TV, bicycle, refrigerator, and motorized vehicle |

* In Latin America, the empirical evidence has suggested that there is a positive correlation between the children's educational attainments and their parents' schooling years: The proportion of children that completes secondary school is over 60% when their parents have finished 10 or more years of schooling (Villatoro, 2007).
** In Nicaragua, the primary school entrance age is 6-7 years, so that children are expected to finish the lower secondary school level by 15-16 years old; hence, we provide a buffer of about two years to account for delayed progression, mainly in the rural areas. For example, a child aged 9 years will be considered to be deprived in education if he or she is currently attending first grade of primary school (Espinoza-Delgado & Klasen, 2018, p. 471).

In brief, the education dimension consists of schooling achievement, which considers the lower secondary school level as the normative target to define deprivation in this indicator (approx. nine years of schooling), in line with target 4.1 of the SDGs (UN, 2015); the health dimension consists of health functioning failure, which exploits the scare information available on health in the datasets used and is mainly concerned with the prevalence of chronic diseases or multiple diseases among the Nicaraguan population; and the standard of living dimension consists of housing (quality of building materials), water, sanitation, electricity, energy (main cooking fuel), and asset ownership, which are similar to the ones included in the global MPI (Alkire & Santos, 2014).

It is worthy of note that we assume that the living standard indicators are non-rivals and non-excludable; in other words, these are considered to be public goods accessible equally to every person within the household (Espinoza-Delgado & Klasen, 2018; Espinoza-Delgado & Silber, 2018; Vijaya et al., 2014). This is, of course, a strong assumption and clearly unsatisfactory, but in the absence of the information required to individualize these indicators, "it is not clear that one can do much better than that" (Klasen, 2007, p. 180). Therefore, we also take this paper to emphasize the necessity of collecting more and better individual data (Bradshaw et al., 2018; Espinoza-Delgado & Klasen, 2018; Pogge & Wisor, 2016; World Bank, 2017), mainly in the context of the 2030 sustainable development agenda.

## 4. Results

We first examine the overall progress in multi-dimensional poverty reduction in Nicaragua between 2001 and 2014, as well as by sub-periods: 2001-2005, 2005-2009, and 2009-2014. Table 2 shows the overall estimates of multi-dimensional poverty in this country, from 2001 to 2014, and the variations in relative terms, considering several degrees of inequality aversion.

The results from Table 2 suggest that overall multi-dimensional poverty in Nicaragua decreased by at least 17% between 2001 and 2014, mainly driven by the progress achieved in the first sub-period (2001-2005) and in the third sub-period (2009-2014) of our analysis; note that a relatively small decline (less than 2%) is observed between 2005 and 2009. In other words, multi-dimensional poverty in Nicaragua lessened by, approximately, 1.47% per year between 2001 and 2014, which means that this country will need, *ceteris paribus*, more than four decades to reduce multi-dimensional poverty by half. Focusing on the relative variations (Panel II of Table 2), the results reveals interesting findings that support the argument that an inequality-sensitive measure would be required to properly monitor progress in multi-dimensional poverty reduction, as inequality might be a non-neutral (and non-minor) issue over time, particularly in regions such as Latin American and the Caribbean (see, e.g., ECLAC, 2018).

**Table 2:** Level and variation in multi-dimensional poverty in Nicaragua between 2001 and 2014, as well as between 2001-2005, 2005-2009, and 2009-2014. *Source*: Author's estimates based on 2001-EMNV, 2005-EMNV, 2009-EMNV, and 2014-EMNV.

| Panel I: Estimates of inequality-sensitive multi-dimensional poverty index | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Value of $\gamma$ | | | | | | | | |
| | 0.00 | 0.25 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 |
| 2001 | 0.4322 | 0.3755 | 0.3297 | 0.2922 | 0.2610 | 0.2347 | 0.2126 | 0.1935 | 0.1771 |
| | (0.0017) | (0.0016) | (0.0016) | (0.0015) | (0.0016) | (0.0015) | (0.0015) | (0.0014) | (0.0014) |
| 2005 | 0.3996 | 0.3435 | 0.2988 | 0.2624 | 0.2323 | 0.2073 | 0.1861 | 0.1682 | 0.1529 |
| | (0.0013) | (0.0013) | (0.0012) | (0.0011) | (0.0011) | (0.0011) | (0.0010) | (0.0009) | (0.0010) |
| 2009 | 0.3923 | 0.3373 | 0.2936 | 0.2580 | 0.2288 | 0.2044 | 0.1839 | 0.1663 | 0.1514 |
| | (0.0015) | (0.0015) | (0.0015) | (0.0015) | (0.0015) | (0.0014) | (0.0013) | (0.0014) | (0.0013) |
| 2014 | 0.3561 | 0.3036 | 0.2624 | 0.2292 | 0.2022 | 0.1797 | 0.1610 | 0.1452 | 0.1317 |
| | (0.0016) | (0.0016) | (0.0015) | (0.0015) | (0.0015) | (0.0015) | (0.0014) | (0.0015) | (0.0014) |

| Panel II: Variations in relative terms (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Period | Value of $\gamma$ | | | | | | | | |
| | 0.00 | 0.25 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 |
| 2001-2005 | -7.6*** | -8.5*** | -9.4*** | -10.2*** | -11.0*** | -11.7*** | -12.5*** | -13.1*** | -13.7*** |
| 2005-2009 | -1.8*** | -1.8*** | -1.7*** | -1.7*** | -1.5*** | -1.4*** | -1.2*** | -1.1*** | -1.0*** |
| 2009-2014 | -9.2*** | -10.0*** | -10.6*** | -11.2*** | -11.6*** | -12.1*** | -12.4*** | -12.7*** | -13.0*** |
| 2001-2014 | -17.6*** | -19.2*** | -20.4*** | -21.6*** | -22.5*** | -23.4*** | -24.3*** | -25.0*** | -25.7*** |

*Notes*: Survey weights used; note that when $\gamma$ takes a value of zero, the multi-dimensional poverty index becomes HA (the incidence times the intensity); that is, it is equal to the adjusted headcount measure ($M_0$ measure). The values in parentheses are the bootstrap estimates of the standard errors, which were computed following Efron's work (1981, pp. 139-143), with 1,000 stratified bootstrap replications.

*Significance levels*: *p < 0.1.; **p < 0.05; ***p < 0.01.

It can be seen from Table 2 that, between 2001 and 2014, the size of the variations, in relative terms, of multi-dimensional poverty becomes more substantial as the degree of inequality aversion increases, vis-à-vis the case in which inequality is completely disregarded ($\gamma$ equal to zero); this reflects that inequality among the multi-dimensionally poor people has not remained unchanged over the period under scrutiny (when comparing two years, the ratio obtained is not equal to 1). Note that, only in the case of the second sub-period (2005-2009), the relative variations are quite similar, indicating that in this case, inequality has only slightly changed in the sub-period compared to what has happened in the other two sub-periods. Of course, we cannot reach a conclusion about the size and the direction of the inequality among the multi-dimensionally poor people by considering only the information displayed in the Panel II of Table 2, we must decompose the estimates into the three 'I's of multi-dimensional poverty (see Table A.1 in Appendix A), but the main reflection here is that inequality among the multi-dimensionally poor individuals does matter and should be incorporated into the multi-dimensional poverty analysis. We will discuss the inequality trend later on in this section; let us first investigate the distribution of multi-dimensional poverty across the population.

In line with the overarching concern of the 2030 sustainable development agenda, leaving no one behind (Klasen & Fleurbaey, 2018), we also try to find out how the overall multi-dimensional poverty estimates are distributed across the population. To do this, in each case, we construct a concave curve that looks like the three 'I's of poverty curves of Jenkins and Lambert (1997, p. 319); we obtain this curve by ranking individuals from poorest to richest, cumulating the average of multi-dimensional poverty by percentile, and plotting them on the base of these "100 observations" (see Espinoza-Delgado & Silber, 2018). The curve becomes horizontal at a point (percentile) that corresponds on the horizontal axis to the multi-dimensional headcount ratio ($q/n$); that is, the multi-dimensional poverty incidence is summarized by the length of the curve's non-horizontal section. The vertical height at which the curve becomes horizontal gives us the overall estimate of the multi-dimensional poverty index (Panel I of Table 2); in other words, the overall multi-dimensional poverty is summarized by the height of the curve: The vertical intercept at 100th percentile. The inequality among the multi-dimensionally poor individuals is summed up by the degree of concavity of the non-horizontal section of the curve. Figure 1 displays the resulting curves for

2001, 2005, 2009, and 2014, considering three representative degrees of inequality aversion (0.50, 1.00, and 1.50).[8]

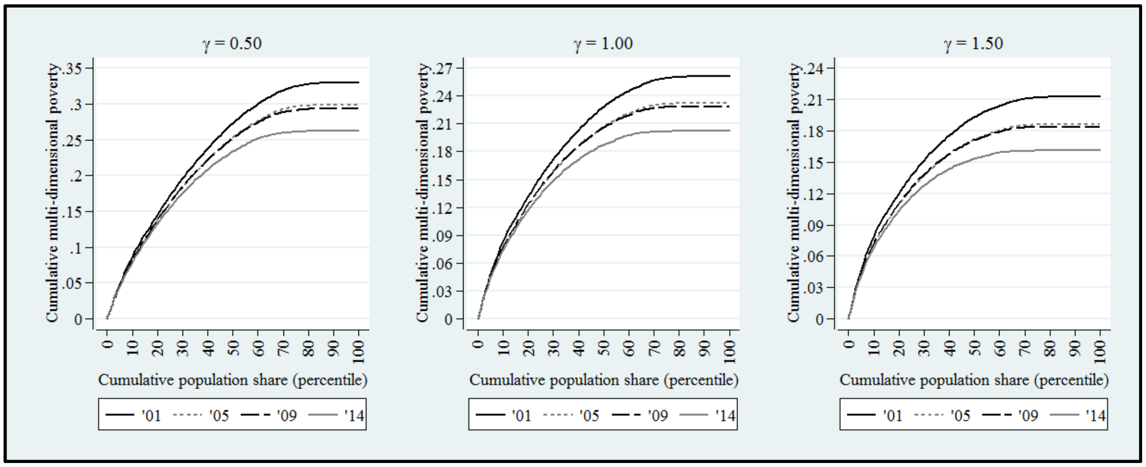


**Fig. 1:** Cumulative multi-dimensional poverty by population percentile, ordered from the poorest to the richest.
*Source:* Authors' estimates based on 2001-EMNV, 2005-EMNV, 2009-EMNV, and 2014-EMNV.
*Notes:* In each case, the overall multi-dimensional poverty corresponds to the height of the curve; the incidence of multi-dimensional poverty (the headcount ratio) corresponds to the length of the non-horizontal section of the curve, that is, the percentile at which the curve becomes horizontal; while inequality among the multi-dimensionally poor individuals is represented by the degree of concavity of the non-horizontal section of the curve (see Jenkins & Lambert, 1997).

Figure 1 provides a more revealing picture of the overall multi-dimensional poverty in Nicaragua and of the progress made in the reduction of this issue over the period of analysis. Overall, it can be noted from the figure that whatever the percentile considered, multi-dimensional poverty in Nicaragua dropped between 2001 and 2014, but the observed progress was not evenly achieved: The reduction in relative terms of the multi-dimensional poverty for the bottom (poorest) 20 percent seems not to be substantial compared with the overall estimated decline. When considering the three sub-periods separately, a similar performance can also be observed in the first sub-period (2001-2005) and in the third one (2009-2014); however, in the second sub-period (2005-2009), it can be seen that the 2009 curve intersects the 2005 curve once from above at around the 40th percentile, which means that the overall multi-dimensional poverty drop registered in this sub-period was only true from the 40th percentile onward: In Nicaragua, the poorest of the poor became even poorer between 2005 and 2009.

As far as inequality among the multi-dimensionally poor people is concerned, by comparing the curvatures of the curves, Figure 1 suggests that it increased between 2001 and

[8] Similar curves are obtained when considering other degrees of inequality aversion, and the same conclusions can be drawn.

2014, and did so in each of the three sub-periods, particularly in the first sub-period (2001-2005) and in the third one (2005-2009); in other words, people's deprivation scores (individual multi-dimensional poverty) were less unequally distributed in 2001 than in 2014, which should be a concern for policy-makers as progress in multi-dimensional poverty reduction in Nicaragua seems to be leaving behind the poorest of the poor. This finding can be corroborated by looking at the results in Table A.1 in Appendix A, which exhibits the decomposition of the overall multi-dimensional poverty estimates into the three dimensions of poverty (incidence, intensity, and inequality): The inequality among the multi-dimensionally poor individuals in Nicaragua increased by at least 24% between 2001 and 2014, despite the fact that in this country the incidence (-7.5%) and the intensity (-11%) of multi-dimensional poverty declined in this period.

As pointed out in Section 2, it can be seen from Table A.1 that the estimated multi-dimensional poverty incidence in each year is too high (90.2% in 2001, 87.8% in 2005, 86.8% in 2009, and 83.4% in 2014) and thus might be not useful for the prioritization of poverty alleviation policies in Nicaragua; therefore, to this purpose, based on the targets 1.2 and 10.1 of the SDGs (UN, 2015, 2017), we suggest that the country focuses on the bottom 40 percent of the population and conducts a dashboard approach to the design of social policies. In this vein, Table A.2 in Appendix A presents, for 2001 and 2014, the percentage of individuals deprived in each of the eight indicators considered in the analysis, as well as the variations in relative terms between 2001 and 2014, considering the bottom 40 percent of the population and the whole population. Overall, we find statistically significant progress in the reduction of deprivation in each of the eight indicators, but the size of the decreasing is, in relative terms, quite dissimilar across the indicators: For example, considering the estimates for the bottom 40 percent, the results show that between 2001 and 2014, Nicaragua made an extraordinary progress in reducing deprivations in electricity (-55.2%) and in assets (-28.5%), but at the same time it only registered a marginal progress in education (-2.3%) and in housing (-3.4%).

The design of the proposed multi-dimensional poverty measure also allows us to assess the progress in poverty reduction among children, adults, and elderly. Table 3 exhibits the variations in relative terms of multi-dimensional poverty among children, adults, and elderly between 2001 and 2014, considering several degrees of inequality aversion.[9] The results indicate that in Nicaragua, the progress in multi-dimensional poverty in the period under analysis was not evenly achieved among the age groups: The highest drop (more than 27%) is observed among children, while the lowest one is registered among elderly (less than 12%). Therefore, we find that in Nicaragua, multi-dimensional poverty among children has decreased the fastest, which can be considered as good news and an encouraging finding. However, it is worth mentioning that inequality among the multi-dimensionally poor people in each of the three age groups has increased, which means that they have a pocket of multi-dimensionally poor that is being left behind.

**Table 3:** Progress in relative terms (%) in multi-dimensional poverty reduction among children, adults, and elderly between 2001 and 2014, considering several degrees of inequality aversion (values of gamma).
*Source*: Author's estimates based on 2001-EMNV and 2014-EMNV.

| Value of gamma | Children | Adults | Elderly | The whole population |
|---|---|---|---|---|
| 0.00 | -27.39*** | -17.87*** | -7.69*** | -17.60*** |
| 0.25 | -30.32*** | -19.58*** | -8.54*** | -19.15*** |
| 0.50 | -32.81*** | -21.06*** | -9.13*** | -20.40*** |
| 0.75 | -34.95*** | -22.34*** | -9.81*** | -21.56*** |
| 1.00 | -36.90*** | -23.47*** | -10.35*** | -22.52*** |
| 1.25 | -38.65*** | -24.64*** | -10.77*** | -23.41*** |
| 1.50 | -40.20*** | -25.66*** | -11.20*** | -24.26*** |
| 1.75 | -41.54*** | -26.48*** | -11.69*** | -24.97*** |
| 2.00 | -42.71*** | -27.32*** | -11.95*** | -25.66*** |

*Notes*: Survey weights used.
*Significance levels*: *p < 0.1.; **p < 0.05; ***p < 0.01.

## 4. Concluding remarks

Considering the overarching concern of the 2030 sustainable development agenda, leaving no one behind (Klasen & Fleurbaey, 2018), and the targets 1.2 and 10.1 of the SDGs, in this paper, we have pointed out that the mainstream approach to the multi-dimensional poverty analysis in developing countries is deficient to properly monitor progress in multi-dimensional poverty reduction because it uses the household as the unit of analysis, ignoring thus intra-household inequalities, and is totally insensitive to inequality among the multi-dimensionally poor individuals, a serious defect of any poverty measure, according to Sen's (1976, 1979, 1992) discussion. Consequently, in the light of that concern, we have proposed to depart somewhat from the mainstream approach and to adopt a person-focused and inequality-sensitive framework, which we have applied to the case of Nicaragua.

[9] The point estimates and the corresponding bootstrap estimates of the standard errors are shown in Table A.3 in Appendix A.

We have found that in Nicaragua, multi-dimensional poverty decreased by at least 17% between 2001 and 2014, but this observed progress was not evenly achieved: The reduction in relative terms of the multi-dimensional poverty for the bottom (poorest) 20 percent seems not to be substantial compared with the overall estimated decline. As far as inequality among the multi-dimensionally poor is concerned, we have also found that it increased by at least 24% in this period; that is, people's deprivation scores were less unequally distributed in 2001 than in 2014, which suggests that progress in multi-dimensional poverty reduction in Nicaragua seems to be leaving behind the poorest of the poor.

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## Appendix A

**Table A.1:** The three I's of multi-dimensional poverty in Nicaragua in 2001, 2005, 2009, and 2014, as well as the corresponding variations in relative terms.
*Source*: Author's estimates based on 2001-EMNV, 2005-EMNV, 2009-EMNV, and 2014-EMNV.

| Panel I: Estimates of Incidence (H), Intensity (A), and Inequality [$GE_{\gamma+1}(c)$] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | H (%) | A | $GE_{\gamma+1}(c)$, considering several values of $\gamma$ | | | | | | | |
| | | | 0.25 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 |
| 2001 | 90.2 | 0.4794 | 0.1405 | 0.1355 | 0.1320 | 0.1297 | 0.1285 | 0.1284 | 0.1291 | 0.1305 |
| | (0.2144) | (0.0016) | (0.0017) | (0.0015) | (0.0016) | (0.0015) | (0.0015) | (0.0016) | (0.0016) | (0.0016) |
| 2005 | 87.8 | 0.4548 | 0.1506 | 0.1452 | 0.1416 | 0.1393 | 0.1383 | 0.1385 | 0.1395 | 0.1416 |
| | (0.1933) | (0.0013) | (0.0014) | (0.0014) | (0.0013) | (0.0013) | (0.0014) | (0.0013) | (0.0014) | (0.0014) |
| 2009 | 86.8 | 0.4520 | 0.1563 | 0.1511 | 0.1474 | 0.1453 | 0.1444 | 0.1446 | 0.1459 | 0.1483 |
| | (0.1769) | (0.0016) | (0.0016) | (0.0015) | (0.0015) | (0.0015) | (0.0016) | (0.0015) | (0.0017) | (0.0018) |
| 2014 | 83.4 | 0.4269 | 0.1753 | 0.1701 | 0.1666 | 0.1648 | 0.1646 | 0.1655 | 0.1679 | 0.1715 |
| | (0.1697) | (0.0017) | (0.0017) | (0.0016) | (0.0017) | (0.0018) | (0.0018) | (0.0019) | (0.0020) | (0.0021) |
| Panel II: Variations in relative terms (%) | | | | | | | | | | |
| Period | H | A | $GE_{\gamma+1}(c)$, considering several values of $\gamma$ | | | | | | | |
| | | | 0.25 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 |
| 2001-2005 | -2.6*** | -5.1*** | 7.2*** | 7.1*** | 7.3*** | 7.4*** | 7.7*** | 7.9*** | 8.1*** | 8.5*** |
| 2005-2009 | -1.2*** | -0.6*** | 3.8*** | 4.0*** | 4.1*** | 4.3*** | 4.4*** | 4.5*** | 4.6*** | 4.7*** |
| 2009-2014 | -3.9*** | -5.6*** | 12.2*** | 12.6*** | 13.1*** | 13.4*** | 14.0*** | 14.5*** | 15.1*** | 15.7*** |
| 2001-2014 | -7.5*** | -11.0*** | 24.8*** | 25.5*** | 26.2*** | 27.1*** | 28.1*** | 29.0*** | 30.1*** | 31.4*** |

*Notes*: Survey weights used; H: The multi-dimensional headcount ratio; A: The average deprivation share among the multi-dimensionally poor individuals; $GE_{\gamma+1}(c)$: The generalized entropy inequality index among the multi-dimensionally poor individuals. The values in parentheses are the bootstrap estimates of the standard errors, which were computed following Efron's work (1981, pp. 139-143), with 1,000 stratified bootstrap replications. The multi-dimensional poverty levels shown in Table 2 can be calculated as follows: $(H/100)A^{\gamma+1}\{1+[(\gamma+1)^2-(\gamma+1)]GE_{\gamma+1}(c)\}$.
*Significance levels*: *p < 0.1.; **p < 0.05; ***p < 0.01.

**Table A.2:** Percentage of individuals deprived in several indicators in 2001 and 2014, and variations in relative terms.
*Source*: Author's estimates based on 2001-EMNV and 2014-EMNV.

| Indicator | The bottom 40 percent | | | The whole population | | |
|---|---|---|---|---|---|---|
| | 2001 | 2014 | Variation in relative terms (%) | 2001 | 2014 | Variation in relative terms (%) |
| Education | 95.5<br>(0.2248) | 93.3<br>(0.2754) | -2.3*** | 60.7<br>(0.3279) | 48.7<br>(0.3260) | -19.7*** |
| Health | 42.3<br>(0.4318) | 39.2<br>(0.5082) | -7.3*** | 22.1<br>(0.3012) | 21.7<br>(0.2908) | -1.4*** |
| Housing | 67.5<br>(0.4192) | 65.2<br>(0.5018) | -3.4*** | 47.1<br>(0.3155) | 40.7<br>(0.2984) | -13.6*** |
| Water | 68.8<br>(0.3022) | 56.9<br>(0.4038) | -17.3*** | 41.3<br>(0.1990) | 35.0<br>(0.2504) | -15.3*** |
| Sanitation | 72.0<br>(0.4280) | 66.3<br>(0.5145) | -7.9*** | 54.6<br>(0.3224) | 44.5<br>(0.3265) | -18.5*** |
| Electricity | 60.5<br>(0.3339) | 27.1<br>(0.4985) | -55.2*** | 30.7<br>(0.1964) | 14.3<br>(0.2537) | -53.6*** |
| Energy | 90.5<br>(0.1933) | 83.9<br>(0.1873) | -7.3*** | 68.4<br>(0.2346) | 54.5<br>(0.1746) | -20.3*** |
| Assets | 68.7<br>(0.3858) | 49.1<br>(0.5520) | -28.5*** | 39.5<br>(0.3073) | 29.3<br>(0.3118) | -25.9*** |

*Notes*: Survey weights used; the values in parentheses are the bootstrap estimates of the standard errors, which were computed following Efron's work (1981, pp. 139-143), with 1,000 stratified bootstrap replications. *Significance levels*: *p < 0.1.; **p < 0.05; ***p < 0.01.

**Table A.3:** Level and variation in multi-dimensional poverty in Nicaragua between 2001 and 2014, by age group.
*Source*: Author's estimates based on 2001-EMNV and 2014-EMNV.

| Panel I: Multi-dimensional poverty among children and variation in relative terms (%) between 2001 and 2014 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Value of γ | | | | | | | | |
| | 0.00 | 0.25 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 |
| 2001 | 0.3797 | 0.3225 | 0.2776 | 0.2417 | 0.2127 | 0.1888 | 0.1687 | 0.1519 | 0.1375 |
| | (0.0025) | (0.0023) | (0.0022) | (0.0021) | (0.0021) | (0.0020) | (0.0020) | (0.0019) | (0.0019) |
| 2014 | 0.2757 | 0.2247 | 0.1865 | 0.1572 | 0.1342 | 0.1158 | 0.1009 | 0.0888 | 0.0788 |
| | (0.0025) | (0.0027) | (0.0024) | (0.0024) | (0.0023) | (0.0022) | (0.0021) | (0.0020) | (0.0020) |
| 2014-2001 | -27.39*** | -30.32*** | -32.81*** | -34.95*** | -36.90*** | -38.65*** | -40.20*** | -41.54*** | -42.71*** |
| **Panel I: Multi-dimensional poverty among adults and variation in relative terms (%) between 2001 and 2014** | | | | | | | | | |
| Year | Value of γ | | | | | | | | |
| | 0.00 | 0.25 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 |
| 2001 | 0.4563 | 0.3998 | 0.3534 | 0.3145 | 0.2819 | 0.2543 | 0.2308 | 0.2102 | 0.1925 |
| | (0.0026) | (0.0026) | (0.0025) | (0.0024) | (0.0025) | (0.0024) | (0.0022) | (0.0023) | (0.0022) |
| 2014 | 0.3748 | 0.3216 | 0.2790 | 0.2443 | 0.2157 | 0.1917 | 0.1715 | 0.1545 | 0.1399 |
| | (0.0021) | (0.0022) | (0.0022) | (0.0022) | (0.0021) | (0.0021) | (0.0021) | (0.0021) | (0.0020) |
| 2014-2001 | -17.87*** | -19.58*** | -21.06*** | -22.34*** | -23.47*** | -24.64*** | -25.66*** | -26.48*** | -27.32*** |
| **Panel I: Multi-dimensional poverty among adults and variation in relative terms (%) between 2001 and 2014** | | | | | | | | | |
| Year | Value of γ | | | | | | | | |
| | 0.00 | 0.25 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 |
| 2001 | 0.6508 | 0.5963 | 0.5486 | 0.5076 | 0.4711 | 0.4389 | 0.4105 | 0.3854 | 0.3627 |
| | (0.0038) | (0.0042) | (0.0043) | (0.0045) | (0.0044) | (0.0046) | (0.0045) | (0.0047) | (0.0048) |
| 2014 | 0.6007 | 0.5453 | 0.4985 | 0.4578 | 0.4223 | 0.3917 | 0.3645 | 0.3403 | 0.3193 |
| | (0.0044) | (0.0046) | (0.0048) | (0.0053) | (0.0053) | (0.0056) | (0.0056) | (0.0057) | (0.0057) |
| 2014-2001 | -7.69*** | -8.54*** | -9.13*** | -9.81*** | -10.35*** | -10.77*** | -11.20*** | -11.69*** | -11.95*** |

*Notes*: Survey weights used; note that when γ takes a value of zero, the multi-dimensional poverty index becomes HA (the incidence times the intensity); that is, it is equal to the adjusted headcount measure ($M_0$ measure). The values in parentheses are the bootstrap estimates of the standard errors, which were computed following Efron's work (1981, pp. 139-143), with 1,000 stratified bootstrap replications.
*Significance levels*: *p < 0.1.; **p < 0.05; ***p < 0.01.