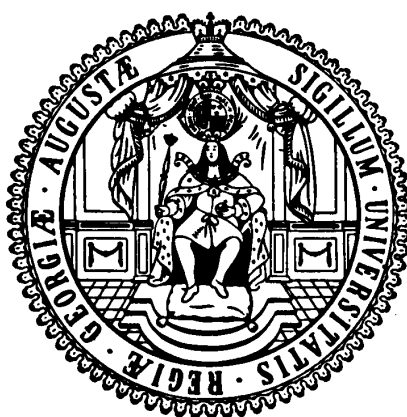# Courant Research Centre
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Monitoring progress in multi-dimensional poverty reduction: a person-focused and inequality-sensitive approach with evidence from Nicaragua

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Monitoring progress in multi-dimensional poverty reduction: a person-focused and inequality-sensitive approach with evidence from Nicaragua

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Abstract

In this paper, considering the overarching concern of the 2030 sustainable development agenda, "leaving no one behind", and targets 1.2 and 10.1 of the SDGs, we stress that the mainstream approach to multidimensional poverty measurement in developing countries faces some deficiencies to properly monitor progress in multidimensional poverty reduction, mainly because it uses the household as the unit of identification, 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, multidimensional poverty decreased between 2001 and 2014, but inequality among the multi-dimensionally poor individuals, an issue that has been ignored by the mainstream approach, increased substantially during that period; in other words, people's deprivation scores were less unequally distributed in 2001 than in 2014. These findings suggest that progress in multidimensional poverty reduction in Nicaragua seems to be leaving behind the poorest of the poor, challenging thus the overarching concern of the SDGs agenda.

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 global multidimensional poverty index (global MPI) reveals that around 1.3 billion individuals live in multidimensional poverty; it also shows that about 83% of the multi-dimensionally poor in the world live in Sub-Saharan Africa and South Asia, and that 50% of multidimensionally poor people 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 multidimensional approach (Datt, 2018; Pogge & Wisor, 2016), due in large part to Sen's influential work (see, for instance, Sen, 1985, 1992, 1997, 2000a, 2010). Currently, the dominating (mainstream) approach in developing countries is the counting methodology proposed by Alkire and Foster (2011a) (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, which

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

considers improvements for some indicators, has been proposed to monitor progress toward the achievement of Goal 1 of the SDGs (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 multidimensional poverty measures;[2] likewise, Santos and Villatoro (2018) have recently developed a new multidimensional poverty index for Latin America (MPI-LA), which follows the same functional form as the global MPI (the M_0 measure).

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) suffers 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 erroneous assessments of overall multidimensional 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 one, or multidimensional poverty line (k), across dimensions (indicators) that identifies the multi-dimensionally poor people by counting the dimensions (indicators) in which they are deprived, the AF identification function is discrete, creates two types of discontinuities, and thus violates the axiom of continuity (Duclos & Tiberti, 2016). Although when ordinal variables (dimensions or indicators) are used, the most common case, the first discontinuity can be considered irrelevant, the discontinuity created by the second cutoff (k) can be of great relevance for the measurement of multidimensional poverty: for instance, a small variation in k can change from 0 to 1, or from 1 to 0, the contribution of any person to overall incidence of poverty, which "may penalize welfare-equalizing policies and development processes" (Duclos & Tiberti, 2016, p. 696).

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[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).

Additionally, as noted by Rippin (2017, p. 37), the dual cutoff identification method assumes implicitly that up to k the dimensions (indicators) are "perfect substitutes", while they are considered "perfect complements" from this threshold onwards, a question that is theoretically controversial.[4]

Secondly, the M_0 measure 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)[5] (Datt, 2018; Rippin, 2013, 2017), a serious shortcoming of any poverty measure, according to Sen's (1976, 1979, 1992) influential arguments that overall poverty measures 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 measure, and actually any AF measure, does not fulfill the strongest and the weakest versions of the axiom of "Sensitivity to Inequality Increasing Switch (SIIS)", due to the use of the dual cutoff approach, which is supposed to capture the interaction between allocation efficiency and distributive justice (see Sen, 1992).[6] However, it should be acknowledged that, as pointed by Alkire et al. (2015), as well as by Alkire and Foster (2019), satisfying association sensitive properties in their strict form is incompatible with a full dimensional breakdown property; therefore, until now in the literature, incorporating sensitivity to inequality into the measure of poverty has had a cost.

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[4] In a graph plotting on the horizontal axis the cumulative percentage of deprivations and on the vertical axis the probability of being considered as multidimensionally poor, the curve obtained would be identical to the horizontal axis up to the multidimensional poverty cutoff (since an individual is not poor as long as the share of his/her deprivations in the total number of possible deprivations is smaller than the cutoff) while the curve will become horizontal at height 1 as soon as the percentage of deprivations of the individual is equal to or higher than the cutoff. This special curve implies that the deprivations are perfect substitutes up to the cutoff and perfect complements beyond the cutoff.

[5] However, it should be stressed that Alkire and Foster (2011, p. 485) had mentioned the possibility of extending their analysis, since they wrote: "It is sometimes argued that the cross partials should be positive, reflecting a form of complementarity across dimensions; alternatively, they might be negative so as to yield a form of substitutability. Since M_α is neutral, it is a trivial matter to convert M_α into a measure that satisfies one or the other requirement: replace the individual poverty function $M_\alpha(y_i, z)$ with $[M_\alpha(y_i, z)]^\gamma$ for some $\gamma > 0$ and average across persons. The resulting poverty index regards all pairs of dimensions as substitutes when $\gamma < 1$, and as complements when $\gamma > 1$, with $\gamma = 1$ being our basic neutral case".

[6] 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)".

With regard to empirical work on multidimensional poverty measurement, another feature of mainstream practice, and actually of the vast majority of studies in the literature, is the fact that the household, rather than the individual, has been used as the unit of identification of the poor (Espinoza-Delgado & Klasen, 2018; Vijaya, Lahoti, & Swaminathan, 2014), which means that the standard practice equates the multidimensional poverty condition of the household with the multidimensional poverty condition of all persons belonging to this household, disregarding, therefore, intra-household inequalities[7] and producing indices insensitive to gender (Bessell, 2015; Espinoza-Delgado & Klasen, 2018; Pogge & Wisor, 2016). Poverty is, however, a feature of individuals, not households, as noted by Deaton (1997, p. 223), 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 multidimensional poverty in aggregate: for example, if females are systematically poorer than males, or if children and elderly are systematically worse-off than other members of the household, overall poverty may be understated when a measure that treats everybody in the household equally is used (Deaton, 1997); furthermore, when these measures are utilized, valuable information on the composition of the multi-dimensionally poor individuals may be overlooked (Jenkins, 1991), which may thus affect the targeting and effectiveness of poverty alleviation policies (see, for example, Brown, Ravallion, & van de Walle, 2018). Hence, household-based multidimensional poverty measures are "unreliable at best, and deeply flawed at worst" (Chiappori & Meghir, 2015, p. 1371) and are not adequate to monitor progress toward meeting 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). Poverty analysis should therefore be moved from the household to the individual.

In consequence, in this paper, we make a case for the adoption of a person-focused and inequality-sensitive approach to monitoring progress in multidimensional poverty reduction in developing countries, considering Goal 1 of the SDGs and in line with the central overarching concern of the 2030 Agenda: leaving no one behind (Klasen & Fleurbaey, 2018); that is, in this context, we propose to follow an approach that departs somewhat from

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

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the mainstream multidimensional poverty analysis. In line with Espinoza-Delgado and Silber (2018), and the general framework proposed by Silber and Yalonetzky (2014) and the approach proposed by Rippin (2013, 2014), with ordinal or dichotomized variables, this paper suggest to use a "fuzzy" identification function and a class of multi-dimensional poverty measures that take into account efficiency and distributive considerations and can also be decomposed into the three "dimensions" of poverty: incidence, intensity, and inequality (Jenkins & Lambert, 1997, p. 317). We apply this approach to assess progress in multi-dimensional poverty reduction in Nicaragua between 2001 and 2014 (the most recent year for which data are available); this country is an interesting case study because it is the multi-dimensionally poorest country in Latin America, according to some recent regional works (see, for instance, Santos & Villatoro, 2018), and it is also the only country in Central America that has not yet officially adopted a multi-dimensional poverty approach. To the best of our knowledge, this is the first attempt in the literature on multidimensional poverty analysis to evaluate progress in multidimensional poverty reduction for the whole population using a person-centered and inequality-sensitive framework.

The rest of the paper is organized as follows. Section 2 explains the framework proposed; Section 3 introduces the data and justifies the dimensions, indicators, and deprivation cuttoffs, as well as the weighting structure used; Section 4 discusses the main results, while Section 5 provides some concluding remarks.

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

The framework proposed in this paper entails two stages: 1) The construction of an individual multidimensional poverty function, which comprises an identification function and a function defining the multidimensional poverty breadth; and 2) the construction of a social multidimensional poverty function by aggregating the individual multidimensional poverty functions. In what follows, we describe briefly the framework to be applied, but first introduce some notations and definitions.

2.1. Notations and definitions

Let $\mathbf{N} = \{1, ..., n\} \subset \mathbb{N}$ represent the set of n individuals, and let $\mathbf{D} = \{1, ..., d\} \subset \mathbb{N}$ 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 ith person for the jth variable; given that we assume that all the variables are dichotomous, x_{ij} will always be equal to either 1 or 0. In this matrix, each row vector $\mathbf{x}_{i.} = (x_{i1}, ..., x_{id})$ gives the attainments of the ith person, while each column vector $\mathbf{x}_{.j} = (x_{1j}, ..., x_{nj})$ provides the distribution of the jth variable across the population. Let also $\mathbf{w} = (w_1, ..., w_d)$ be 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 threshold, with $0 \leq k \leq 1$, which represents the minimal deprivation score a person needs to have in order to be identified as multi-dimensionally poor.

2.2. The function that accounts for individual multidimensional poverty

The construction of the individual multidimensional poverty function involves two sequential steps. The first step assesses for each dimension j whether the person i is deprived, that is, whether x_{ij} is equal to 1 or 0. Then, a weighted deprivations score (c_i) is calculated for each person as the weighted sum of the deprivations suffered by each of them; Silber and Yalonetzky (2014, p. 11) call this score "(real-valued) counting function", and it can be written as

$$c_i = \sum_{j=1}^{d} w_j x_{ij} \tag{1}$$

The focus of the second step is on the identification of the multi-dimensionally poor people. In the AF methodology, the real-valued counting function (c_i) is compared with the multidimensional poverty line (k): if $c_i \geq k$, then the person i is regarded as multidimensionally poor. Evidently, the choice of any multidimensional poverty threshold is arbitrary; Alkire and Foster (2011, p. 478) suggest setting k "somewhere" between 0 and 1. Let $\psi^{AF}(\mathbf{x}_{i.}; w; k)$ be the identification function proposed by Alkire and Foster (2011); then, in our case of dichotomous variables, we can write that:

$$\psi^{AF}(x_{i.}; w; k) = \begin{cases} 1 \text{ if } c_i \geq k \\ 0 \text{ if } c_i < k \end{cases} \tag{2}$$

It is worthy of note that ψ^{AF} contains as particular cases the two conventional approaches of identification suggested by Atkinson (2003) in the context of multi-dimensional poverty analysis: the union and the intersection approaches. The former assumes that the variables are perfect complements while the latter supposes that the variables are perfect substitutes (Rippin, 2013, 2017).[8] This is why Alkire and Foster (2011, p. 478) proposed an intermediate approach as "a natural alternative" to the two extreme methods of identification.

In this paper, as opposed to the mainstream approach to the measurement of multidimensional poverty in the developing world, we prefer to adopt a "fuzzy" identification funtion that makes explicit the relationship between the dichotomous variables considered in the analysis (Rippin, 2013, 2017). Let γ be a parameter describing the relationship between the attributes, the identification function is then defined as

$$\psi^{fuzzy}(x_{i.}; w) = [c_i]^{\gamma} \tag{3}$$

where $[c_i]^{\gamma}$ satisfies the conditions of being non-decreasing in c_i and of having a non-increasing marginal if the variables are assumed to be complements ($\gamma < 1$) and non-decreasing marginal if the variables are assumed to be substitutes ($\gamma > 1$).[9]

Therefore, instead of dichotomizing the distribution of weighted deprivations scores, as suggested by Alkire and Foster (2011), and creating another discontinuity, the proposed "fuzzy" identification function distinguishes between the multi-dimensionally non-poor

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[8] Here, the concepts of "substitutability" and "complementarity" follow the Auspitz-Lieben-Edgeworth-Pareto (ALEP) definition and not the well-known approach proposed by Hicks and Allen (1934a, 1934b). The ALEP definition considers that two attributes are substitutes (complements) if their second cross-partial derivatives are larger (less) than zero and independent if they are equal to zero (Rippin, 2013, 2017). Intuitively, on the basis of the ALEP definition, if two attributes are substitutes, poverty will decrease less with a rise in attribute 1 for individuals with larger quantities of attribute 2. The contrary is evidently true when the two attributes are supposed to be complements (Silber, 2007). For instance, assuming that income and education are substitutes, the reduction in poverty due to a unit increase in income is less important for individuals who have an educational level close to the education deprivation threshold than for individuals with very low education. Conversely, the drop in poverty would be more substantial for individuals with a larger level of education if income and education were considered to be complements, as observed by Bourguignon and Chakravarty (2003).

[9] "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).

people, on one hand, and "different degrees of poverty severity", on the other hand (Rippin, 2017, p. 42); in other words, the function considers that multidimensional poverty is a "matter of degree" rather than an all or nothing state (Betti, Cheli, Lemmi, & Verma, 2008, p. 30).

It is worth mentioning that our indentification function is regarded to be fuzzy, because, unless $c_i = 0$ or $c_i = 1$, each person is "somewhat" multi-dimensionally poor, depending on i) the number of variables in which he/she is simultaneously deprived, and ii) the type of relationship that exists among these variables. If γ is greater than 1, the curve describing c_i has a convex shape, while if γ is between 0 and 1, this curve has a concave shape; the first case corresponds to the case in which the variables are considered imperfect substitutes, while the second one corresponds to the case in which the variables are regarded imperfect complements. Therefore, the choice of γ depends on whether it is assumed that the variables are substitutes or complements. If the variables are perfect substitutes, there is full compensation, and we obtain the intersection case; and if the variables are perfect complements, there is no compensation, and we get the union case (Silber & Yalonetzky, 2014; Rippin, 2013, 2017).

The choice of a particular relationship between the variables is not certainly so straightforward in practice (Espinoza-Delgado & Silber, 2018), as the variables "can be substitutes in the short run while being complementary and re-enforcing in the long run" (Thorbecke, 2008, p. 17), which has fundamental implications for the multidimensional poverty measurement over time, and there does not seem to be a clear empirical procedure to determine this relationship. Considering this issue, we assume in this paper 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, so we test the robustness of our main findings to these assumptions.

In line with the literature, the individual multi-dimensional poverty function must not only identify who is multi-dimensionally poor and who is not but also consider the multi-dimensional poverty breadth (Espinoza-Delgado & Silber, 2018; Silber & Yalonetzky, 2014). In this vein, we make the individual multidimensional poverty function depend on "the number of deprivations" and finally define it as the product of the identification function introduced previously and a function $g(x_i; z; w) = c_i$ that captures the multi-dimensional

poverty breadth.[10] Let $p_i(x_i; z; w)$ be the individual multi-dimensional poverty function, then it can be expressed as

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

2.3. The function that accounts for multidimensional poverty in the society

In the second stage of the framework, we derive a social multi-dimensional poverty function as the average of the individual multi-dimensional poverty functions; we end therefore up with a measure defined as (for more details, see, Rippin, 2013, 2017)

$$P_{CS}^\gamma(X; z; w) = \frac{1}{n}\sum_{i=1}^{n} c_i^{\gamma+1} \qquad (5)$$

Let q be the number of multi-dimensionally poor individuals; let $H = q/n$ be the multidimensional headcount ratio that measures the incidence of multidimensional poverty; let $A = \left[\sum_{i=1}^{q} c_i(x_i; z; w)\right]/q$ be the average of deprivations scores across the multi-dimensionally poor people that measures the poverty intensity (Alkire et al., 2015, p. 157), and let $GE_{\gamma+1}(c)$ be the generalized entropy inequality index among the multi-dimensionally poor individuals, Eq. (5) can also be defined as

$$P_{CS}^\gamma(X; z; w) = HA^{\gamma+1}\left\{1 + \left[(\gamma+1)^2 - (\gamma+1)\right]GE_{\gamma+1}(c)\right\} \qquad (6)$$

It should be noted that the resulting multi-dimensional poverty incidence is, in fact, the headcount of those individuals affected by deprivation in the society; therefore, it may be "too high to be useful" (Rippin, 2017, p. 43), particularly for targeting and prioritizing of poverty alleviation policies and programs. In this paper, we advocate first examining how the overall multi-dimensional poverty is distributed across the population, ranking individuals from the poorest to the richest, based on the individual multidimensional poverty functions, and focusing policies and programs on the bottom 40 percent of the population, the poorest of the poor, considering Target 10.1 of the SDGs: "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" (UN, 2015, 2017).

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[10] Note that we use the multidimensional poverty breadth suggested by Alkire and Foster (2011).

It is worthy of note that the M_0 measure proposed by Alkire and Foster (2011) is computed as the product of the incidence (H) and the intensity (A) of multidimensional poverty, so the Eq. 6 can also be expressed as

$$P_{CS}^{\gamma}(X; z; w) = M_0 A^{\gamma}\left\{1 + [(\gamma + 1)^2 - (\gamma + 1)]\, GE_{\gamma+1}(c)\right\} \qquad (7)$$

Accordingly, as noted by Espinoza-Delgado and Silber (2018, p. 12), the expression $A^{\gamma}\left\{1 + [(\gamma + 1)^2 - (\gamma + 1)]\, GE_{\gamma+1}(c)\right\}$ constitutes the substantive information that the M_0 multidimensional poverty measure overlooks when compared to the one to be used in this paper; the expression in curly brackets can be called the inequality component (Bérenger, 2017; Rippin, 2013, 2017). Note that this information may be especially important in the context of the SDGs, and its targets, and for gender inequality analysis (UN, 2015, 2017), as ignoring this information may lead to biased assessments of multidimensional poverty in the society.

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 identification 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 multidimensional 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, 2000a), can also be framed into the "Central Human Capabilities" suggested by Nussbaum (2003, p. 41) and the SDGs (UN, 2015). 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).

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).

Concerning the living standard dimension, it should be observed that we assume that the indicators under this dimension are non-rivals and non-excludable; in other words, these are considered 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 Agenda.

4.   Results

We first examine the overall progress in multidimensional 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 multidimensional poverty in this country, from 2001 to 2014, and the variations in relative terms, considering several values of γ.

The results in Table 2 suggest that overall multidimensional poverty in Nicaragua decreased between 2001 and 2014 (between 17.6% and 25.7%, depending on the value of γ adopted), and that the reduction was mainly driven by the progress achieved in the first sub-period (2001-2005) and in the third one (2009-2014) of the analysis; note that a relatively small decline (less than 2%) is observed between 2005 and 2009. Assuming a reduction of 17.6%, when γ takes a value of 0, multidimensional poverty in Nicaragua was lessened at a rate of 1.47% per year between 2001 and 2014, which means that it would take this country, *ceteris paribus*, more than 40 years to reduce multidimensional poverty by half. If we considered the annualized progress rate (2.35%) resulting from the most optimistic decline (25.7%), it would take Nicaragua, *ceteris paribus*, approximately three decades to halve multidimensional poverty.

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 γ								
	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 γ								
	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 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.

In line with the overarching concern of the 2030 Agenda, leaving no one behind (Klasen & Fleurbaey, 2018), we also investigate how the overall multidimensional poverty estimates are distributed across the population. To do this, in each case, we construct a concave curve that resembles 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, accumulating the average of multidimensional poverty per percentile, and plotting them on the base of these "100 observations" (for more details, see Espinoza-Delgado & Silber, 2018). The curve becomes horizontal at a point (percentile) that corresponds on the horizontal axis to the multidimensional headcount ratio (q/n); i.e., the multidimensional poverty incidence is summarized by the length of the non-horizontal section of the curve. The vertical height at which the curve becomes horizontal gives us the overall estimate of the multidimensional poverty index previously shown (see Panel I of Table 2); in other words, the overall multidimensional poverty is summarized by the height of the curve: the vertical intercept at 100th percentile. Figure 1 displays the resulting curves for 2001, 2005, 2009, and 2014, considering three values of γ (0.50, 1.00, and 1.50).[11]
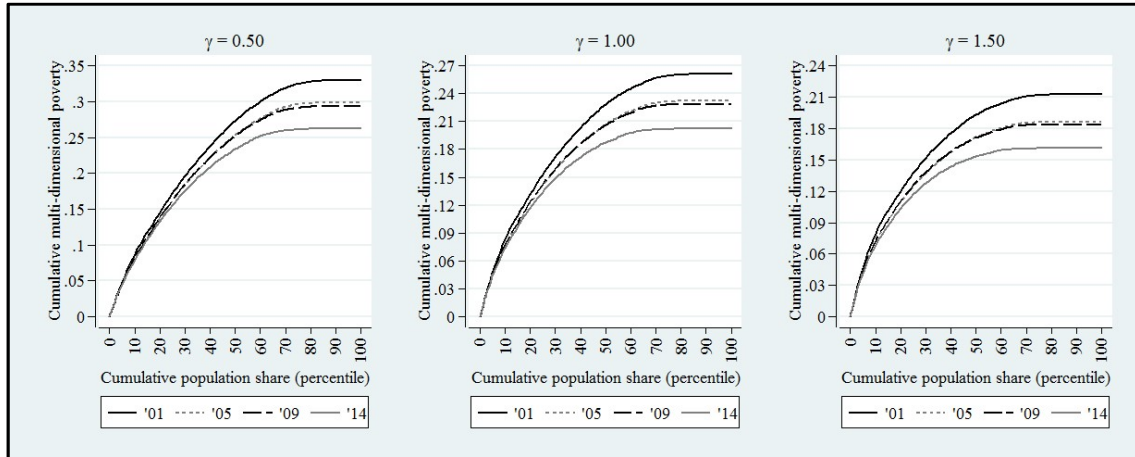
Fig. 1: Cumulative multi-dimensional poverty by population percentile, ordered from the poorest to the richest.
Source: Author's estimates based on 2001-EMNV, 2005-EMNV, 2009-EMNV, and 2014-EMNV.
Notes: In each case, the overall multidimensional poverty corresponds to the height of the curve; the incidence of multidimensional 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 approximated 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 multidimensional poverty in Nicaragua and of the progress made in the reduction of it between 2001 and 2014. Overall, it can be seen from the figure that, whatever the percentile considered, multidimensional

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[11] Similar curves are obtained when considering other values of γ, and the same conclusions can be drawn. Point estimates and their bootstrapped confidence intervals at 95% are available upon request from the author.

poverty in Nicaragua dropped between 2001 and 2014, but the progress observed seems not to be evenly achieved: the reduction in relative terms of multidimensional poverty of the poorest 20% appears not to be as substantial as the estimated overall decline, although this finding should be seen with some caution, because we are using cumulative distributions. If the three sub-periods are analyzed separately, we can observe a similar performance as the previous one (2001-2014) 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 noted from the figure that the 2009 curve intersects the 2005 curve once from above at around the 40th percentile, suggesting that the overall multidimensional poverty drop registered in this sub-period was only true from this percentile onward: in Nicaragua, the poorest of the poor became even poorer between 2005 and 2009.

As far as inequality is concerned, Figure 1 suggests that it increased between 2001 and 2014, comparing the curvatures of the corresponding curves, 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 multidimensional poverty) were less unequally distributed in 2001 than in 2014, which should be a concern for policy-makers as progress in multidimensional poverty reduction in Nicaragua seems to be leaving behind the poorest of the poor.

The above finding can be corroborated by looking at the results of Table 3, which exhibits the decomposition of the overall multidimensional poverty estimates into the three dimensions of poverty (incidence, intensity, and inequality), as well as the corresponding variations in relative terms and the bootstrapped standard errors. As Table 3 displays, the inequality among the multi-dimensionally poor individuals in Nicaragua increased substantially between 2001 and 2014 (between 24.8% and 31.4%, considering the different values of γ), despite the fact that in this country, the incidence and the intensity of multidimensional poverty declined in the same period. This result supports, therefore, the argument that an inequality-sensitive measure should be employed to properly monitor progress in multidimensional poverty reduction, as inequality might be a non-neutral issue and not a minor one over time, particularly in regions such as Latin American and the Caribbean (see, e.g., ECLAC, 2018).

Table 3: The three I's of multidimensional 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 γ							
			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 γ							
			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 multidimensional 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 multidimensional 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.

It can be seen from Table 3 that the estimated multidimensional poverty incidence in each year is very high (90.2% in 2001, 87.8% in 2005, 86.8% in 2009, and 83.4% in 2014), so it may not be useful for targeting and prioritizing poverty alleviation policies in Nicaragua; therefore, as discussed in Section 2, we suggest that the country focuses first on the poorest 40 percent and conducts a dashboard approach to social policy design, based on targets 1.2 and 10.1 of the SDGs (UN, 2015, 2017). In this vein, Table A.1 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 poorest 40 percent 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 decrease is, in relative terms, quite dissimilar across the indicators: for example, considering the estimates for the poorest 40 percent, the results show that between 2001 and 2014, Nicaragua made a good progress in reducing deprivation in electricity (-55.2%) and in assets (-28.5%), but it only registered a marginal progress in education (-2.3%) and in housing (-3.4%) during the same period.

Using the individual as the unit of identification also allows us to assess the progress in multidimensional poverty reduction by population sub-groups, for instance, children, adults, and elderly, as well as investigate intra-household inequalities. In this line, Table 3 exhibits the variations in relative terms of multidimensional poverty among children, adults, and elderly between 2001 and 2014, considering several values of γ.[12] The results indicate that in Nicaragua, the progress in multidimensional poverty in the period under analysis was not evenly achieved among these age sub-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, multidimensional 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 individuals that is being left behind.

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[12] The point estimates and the corresponding bootstrap estimates of the standard errors are shown in Table A.2 in Appendix A.

Table 4: 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***	-266***	-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 Agenda, "leaving no one behind" (Klasen & Fleurbaey, 2018), and targets 1.2 and 10.1 of the SDGs, in this paper, we stressed that the mainstream approach to the multidimensional poverty analysis in developing countries is deficient to properly monitor progress in multidimensional poverty reduction because it uses the household as the unit of identification, 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 proposed to depart somewhat from the mainstream approach and adopt a person-focused and inequality-sensitive framework that has been applied to the case of Nicaragua.

We found that in Nicaragua, multidimensional poverty decreased between 2001 and 2014, but inequality among the multi-dimensionally poor increased substantially in this period; that is, people's deprivation scores were less unequally distributed in 2001 than in 2014, suggesting that progress in multidimensional poverty reduction in Nicaragua seems to be leaving behind the poorest of the poor. Consequently, we found evidence to support the argument that an inequality-sensitive measure should be employed to properly monitor progress in multidimensional poverty reduction, as inequality might be a non-neutral issue and not a minor one over time and should not be thus be ignored in multidimensional poverty analyses.

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Appendix A

Table A.1: 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	93.3	-2.3***	60.7	48.7	-19.7***
	(0.2248)	(0.2754)		(0.3279)	(0.3260)	
Health	42.3	39.2	-7.3***	22.1	21.7	-1.4***
	(0.4318)	(0.5082)		(0.3012)	(0.2908)	
Housing	67.5	65.2	-3.4***	47.1	40.7	-13.6***
	(0.4192)	(0.5018)		(0.3155)	(0.2984)	
Water	68.8	56.9	-17.3***	41.3	35.0	-15.3***
	(0.3022)	(0.4038)		(0.1990)	(0.2504)	
Sanitation	72.0	66.3	-7.9***	54.6	44.5	-18.5***
	(0.4280)	(0.5145)		(0.3224)	(0.3265)	
Electricity	60.5	27.1	-55.2***	30.7	14.3	-53.6***
	(0.3339)	(0.4985)		(0.1964)	(0.2537)	
Energy	90.5	83.9	-7.3***	68.4	54.5	-20.3***
	(0.1933)	(0.1873)		(0.2346)	(0.1746)	
Assets	68.7	49.1	-28.5***	39.5	29.3	-25.9***
	(0.3858)	(0.5520)		(0.3073)	(0.3118)	

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.2: Level and variation in multidimensional 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 multidimensional 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.