Oxford Poverty & Human Development Initiative (OPHI)
Oxford Department of International Development
Queen Elizabeth House (QEH), University of Oxford

OPHI WORKING PAPER NO. 40

A Report on Mexican Multidimensional Poverty Measurement

James E. Foster*

October 2007

Abstract

This report addresses the challenges arising from a change in Mexico's official poverty methodology from an income-only basis to a multidimensional basis that includes education, access to health services, access to social security, shelter characteristics, access to basic services, access to food, and level of social cohesion. The *concept* of poverty underlying this report is drawn from Amartya Sen's capability approach. The specific multidimensional measurement framework used is that of Alkire and Foster (2007). Special emphasis is placed on the measure's *population decomposability* and *dimensional decomposability*. The new identification and aggregation methods are then applied to 2005 data provided by CONEVAL to illustrate the feasibility of the methodology and the kinds of results that one might obtain.

Keywords: Poverty Measurement, Multidimensional Poverty, Mexico, Capability Approach, Multidimensional Welfare, Human Development

JEL classification: I3, I32, O1

* The Elliot School of International Affairs, George Washington University, 1957 E Street, NW Suite 502, 20052, +1 202 994-8195, fosterje@gwu.edu and Oxford Poverty & Human Development Initiative (OPHI), Queen Elizabeth House (QEH), Oxford Department of International Development, 3 Mansfield Road, Oxford OX4 1SD, UK +44 1865 271915, james.foster@qeh.ox.ac.uk.

This study has been prepared within the OPHI theme on multidimensional poverty.

OPHI gratefully acknowledges support for its research and activities from the Government of Canada through the International Development Research Centre (IDRC) and the Canadian International Development Agency (CIDA), the Australian Agency for International Development (AusAID), and the United Kingdom Department for International Development (DFID).

ISSN 2040-8188 ISBN 978-1-907194-24-5

Acknowledgements

Research assistance was provided by Suman Seth. The author has benefited from conversations with the participants of the Conference on Multidimensional Poverty, held at Colmex during the late summer and early fall of 2007.

Acronyms

CONAPO	Consejo Nacional de Población (National Council of Population; Mexico)
CONEVAL	Consejo Nacional de Evaluación de la Política de Desarrollo Social (The National Council for Evaluation of Social Development Policy; Mexico)
FGT	Foster-Greer-Thorbecke
LGDS	Ley General de Desarrollo Social
SEDESOL	Secretaria de Dessarrollo Social (Social Development Secretariat; Mexico)

Contents

Abstract 3
Acknowledgements 4
I. Executive Summary 1
II. Theoretical Framework 2
A. The Concept of Poverty 4
B. The Framework for Measurement 5
III. Measurement Methodology 8
IV. Empirical Illustration 15
A. Data Sources and Definitions of Indicators and Variables 16
B. Results 19
V. References 34

The Oxford Poverty and Human Development Initiative (OPHI) is a research centre within the Oxford Department of International Development, Queen Elizabeth House, at the University of Oxford. Led by Sabina Alkire, OPHI aspires to build and advance a more systematic methodological and economic framework for reducing multidimensional poverty, grounded in people's experiences and values.

Oxford Poverty & Human Development Initiative (OPHI)
Oxford Department of International Development
Queen Elizabeth House (QEH), University of Oxford
3 Mansfield Road, Oxford OX1 3TB, UK
Tel. +44 (0)1865 271915 Fax +44 (0)1865 281801
ophi@qeh.ox.ac.uk http://ophi.qeh.ox.ac.uk/

I. Executive Summary

This report addresses the challenges arising from a change in Mexico's official poverty methodology from an income basis to a broader basis that includes education, access to health services, access to social security, shelter characteristics, access to basic services, access to food, and level of social cohesion. My main goal is to provide appropriate answers to questions arising from the identification (who is poor?) and aggregation (how much poverty is there?) steps in the multidimensional environment. I also explore the general issue of incorporating ordinal variables into a coherent measure of poverty – a significant departure from traditional assumptions of cardinal variables, and one that requires a fundamental reorientation of the measurement framework to accommodate the restrictions. Some discussion is provided concerning the specific summary variables and indices for each of the dimensions for poverty. I will argue that the introduction of a social cohesion variable into a multidimensional poverty measure is not advisable at this time. Finally, I present some preliminary poverty estimates based on the arbitrary, dimension-specific cutoffs provided by CONEVAL for this purpose and provide other estimates based on alternative cutoffs. The overriding goal of this proposal is to attack the key measurement issues head on and to find acceptable solutions that can be used by CONEVAL as well as the broader community of academic researchers.

This exercise is guided by the premise that the primary purpose for poverty measurement is to provide a continuous assessment of poverty in Mexico. Secondary purposes are to anchor studies that diagnose causes and suggest solutions for poverty in Mexico and to provide a possible indicator for targeting resources in the fight against poverty. The *concept* of poverty underlying this report is drawn from Amartya Sen's capability and functionings model of wellbeing, although it is consistent with a basic needs or a social exclusion perspective as well. The general *measurement* framework is based on Sen's methodology for poverty measurement. There are three steps: (1) selecting the space(s) for evaluation, (2) establishing cutoff(s) to identify the poor, and (3) finding an appropriate aggregation method to combine the data into an overall measure of poverty.

The specific measurement framework utilized is that of Alkire and Foster (2007), which is motivated by counting-based approaches that have appeared in the sociology literature as well as some economic studies. The identification of the poor is accomplished with the help of two types of cutoffs. First is the usual domain-specific poverty cutoff, with a person being deprived in that dimension if achievement falls below the cutoff. Second is a cross-dimensional cutoff that indicates the minimum range of deprivations necessary before a person is considered to be poor. Each dimension of wellbeing is given a weight, with all weights summing to one. A person who is deprived across several dimensions is considered poor if the associated sum of weights exceeds (or equals) the specified cutoff, and nonpoor if it is less. The main aggregation method used is an 'adjusted headcount ratio', which is the headcount ratio (or the percentage of the population identified as poor) times an average level of the (weighted) share of deprivations experienced by the poor. The methodology can be meaningfully applied to purely ordinal data and by definition is sensitive to the range of deprivations faced by a poor person.

The issue of weights is an important discussion point. Two alternatives are considered: The first is equal weighting, which is justified when there is no particular reason to weight one dimension more than another. Second is a nested constellation of weights, in which the weight is equally split between the income and non-income dimensions, and equal weighting is applied within the non-income dimensions as well. If an assumption that the variables are cardinally significant can be justified, the other main aggregation methods from Alkire and Foster can also be employed. These include the 'adjusted poverty gap' and the 'adjusted P_2 measure', or more generally the entire 'adjusted *FGT* measures' introduced therein.

The various axioms satisfied by these measures are discussed, and special emphasis is placed on *population decomposability* and *dimensional decomposability*. Population decomposability allows the level of poverty at the national level to be broken down into regional and local levels, and hence offers a consistent evaluation of local and national poverty. Dimensional decomposability links the overall level of multidimensional poverty to analogous indices of domain-specific deprivations. So, for example, the standard income poverty headcount ratio (or the *FGT* indices in general) can be functionally linked to the overall level of multidimensional poverty. This can have important benefits in relating the proposed methodology to the previously used income-based methodology, and it allows a clear and transparent understanding of how adding the non-income capabilities alters the assessment of poverty. With the particular weighting structure and dimensional cutoff identified below, there is an exceptionally clear interpretation of the multidimensional adjusted headcount measure as the average of the usual income-based headcount ratio (used for several years as the official poverty measure in Mexico) and a straightforward index of marginalization (in the style of CONAPO) for the poor population.

The new identification and aggregation methods are then applied to 2005 data provided by CONEVAL to illustrate the feasibility of the methodology and the kinds of results that one might obtain. The example begins with the (arbitrary) cutoffs provided for illustrative purposes by CONEVAL. Poverty levels are obtained for each of the measures discussed. The income cutoff selected by CONEVAL is but one of the three lines recommended by SEDESOL (the asset poverty line); consequently, a second income cutoff (namely the capabilities line) is also used. It is argued that social cohesion is an unusual variable to include in the poverty measurement exercise, and indeed it is verified that the specific indicator of low social cohesion provided by CONEVAL is *negatively* correlated with each of the other dimensions of deprivation. Including this variable can lower measured poverty. Consequently, a second round of results is provided which removes the indicator of social cohesion, leaving the remaining seven dimensions. It is the final methodology without the social cohesion variable that is recommended in this report.

II. Theoretical Framework

This section specifies the conceptual issues regarding the definition of poverty selected, as well as the theoretical framework behind it.

Purpose of measurement. As emphasized by Amartya Sen, the particular way of measuring a phenomenon should depend on the purpose to which the resulting measure will be used. In the case of poverty measurement, there are several conceivable purposes and applications for the resulting measures. I focus here on the two objectives that I think correspond most closely to the current policy exercise and mention a third that must also be considered.

Assessment. Poverty may be measured by a government to provide a continuous assessment of how its various policies are affecting the conditions of the poor. This is part and parcel of a government's quest to become accountable for its actions and to provide accurate information on a central social and economic problem. In keeping with this purpose, it is crucial that the measurement methodology in question be understandable as to its meaning and consistent and transparent in its application over time. There should be little room for hidden arbitrariness in its definition or application in order to minimize the perceived likelihood of manipulation; all the relevant choices should be reasonable and well documented. Any alteration to the methodology should only take place at regular intervals, such as every ten years, and this period should be fixed and announced ahead of time. The most common method of evaluating poverty for continuous assessment is to set a fixed poverty line in income space and calculate the percentage of a given population that is poor (as described below).

Diagnosis. Poverty can be measured to help uncover the causes and correlates of poverty in order to formulate policies to combat poverty. It is clear that this objective of poverty analysis will include more dimensions than income, either as part of the definition itself or as additional partial indices that can be econometrically linked with the original indicator of poverty. The central underlying premise is that poverty is related to many other social and economic variables, and that through an understanding of these relations and pathways one might be able to formulate superior policies to reduce the prevalence of poverty.

Targeting. In addition to the above purposes, a standard use for the poverty methodology is to enable the government to identify individuals or families as being in poverty and thereby focus services and policies directly upon them. This may take the form of locating services in areas where the level of poverty is high, as in the case of SEDESOL's milk distribution program in Mexico. It may be the way that potential recipients of cash benefits are considered eligible for cash transfers, as with the supplementary benefits line in the U.K. Or a multiple of the poverty line might be used to determine eligibility for a program, as in the State Children's Health Insurance Program (*SCHIP*) in the U.S.

When public policies are layered upon a particular poverty methodology, then additional issues come into play. The data upon which the methodology is based should not be subject to spurious swings. It should not be able to be easily manipulated due to being based on unverifiable self-reports. When allocation policies are linked to an official poverty measure, this has the good effect of economizing on the costs of reaching the actual poor using social services. However, it also means that the setting or redesigning of the poverty methodology can have serious budgetary implications and hence may constrain the methodologies to a subset of politically acceptable measures. The costs and benefits of using an official methodology for targeting should be evaluated before this is done.

Definition of poverty. Poverty is a state in which a person does not have access to sufficient resources to achieve a minimum level of living. To implement this general definition of poverty in real world situations, several choices must be made.

Space. First, a space in which to evaluate poverty must be selected. This space may focus on 'resources' – as is the case with income – or the 'level of living' – which data on expenditure or consumption tries to capture. It may also be a multidimensional space with elements of both resources and achieved levels of living, such as income, health and education.

Cutoff. Second, a minimum level of resources or level of living must be established in the case of a single dimensional variable. In multidimensional settings one must select a more nuanced methodology for determining the 'minimum'. One approach – the modified income approach – aggregates across the dimensions to obtain a single variable, and a cutoff is established in this space as in the standard income environment. A second approach sets a relevant cutoff in each dimension of evaluation but then must deal with the issue of what to do with the multiplicity of cutoffs in order to identify who is poor. For example, if a person falls below a cutoff in a single dimension, is that person poor? Or must a person fall below in all dimensions?

Aggregation. The evaluation of poverty also includes a third step, by which the various data across the population (and especially the poor population) are aggregated into an overall measure of poverty. In the process of doing this, however, it is important to ensure that the underlying data have the measurement properties that would support the particular aggregation method chosen. For example, if a variable in question has sufficient cardinality properties, one can evaluate the depth of poverty using a gap type measure; however, if a variable is purely ordinal, then the aggregate shortfall of a person (or its square) is not a meaningful indicator. For multidimensional exercises, problems with comparability across dimensions may prevent the researcher from meaningfully aggregating variables to obtain a single 'income variable' upon which poverty might be based.

A. The Concept of Poverty

The selection of a specific poverty measurement technology should be guided in part by an overall concept of poverty, which provides a context or model for understanding how poverty is related to the observable data.

Poverty as income shortfall. The first conceptual framework is in fact the one that is most commonly used, in part because of the ready availability, consistency and cardinality of the necessary data. The environment typically taken to be the standard economic setting is one in which an individual (or family) is viewed as having assets that it can sell in the market, and which in turn determine the available consumption bundles the agent can afford. The 'minimum' is often based on a consumption bundle, whose monetary value determines a poverty line, or an even smaller bundle such as food products, whose value – appropriately scaled up according to budget share – determines the minimum level of income necessary to achieve this food bundle (and the ancillary goods). In other studies, arbitrary cutoffs, such as $1 a day, are used in order to illustrate the magnitude of the particular poverty problem. Once a poverty line is set, it can be altered over time according to the rate of inflation, with longer-term updates conducted at set intervals to account for the impact of changing living standards on the poverty standard.

Poverty as lack of basic needs. The basic needs approach concentrates on the fulfillment of certain fundamental needs, such as food, clothing and shelter; essential services such as education and health; and various other political and social activities and freedoms. According to Francis Stewart (1985), the basic needs approach argues 'what the poor need is not money incomes alone, but essential goods and services to give everyone the opportunity to lead full lives'. The basic goods and services are not valued for themselves but rather instrumentally as a means to improve peoples' lives. The list of basic needs and the cutoffs must be codetermined by the people themselves and their government and not simply imposed from the outside. The approach is concerned with the absolute deprivations suffered by the poor, rather than the relative positions of people or groups in society.

Poverty as exclusion. The concept of social exclusion originated in industrialized countries to describe the forms of deprivation and marginalization that arise when a country is rich and has welfare policies that are generous. The key notion is perhaps due to Peter Townsend, who defined deprivation as referring to people who 'are in effect excluded from ordinary living patterns, customs and activities'. The underlying concept is often interpreted as a dynamic process, whose end product is the exclusion of individuals or groups of individuals from full participation. Exclusion must be defined relative to the norms and standards of the given society; therefore, it is by definition a fully relative approach. One may be deprived across many dimensions; consequently, this approach to poverty is intrinsically multidimensional.

Poverty as capability failure. Sen (1992) has argued that social evaluation should be based on the extent of the freedoms that people have to further the objectives that they value. According to Sen, the proper evaluative space is that of 'functionings' or the 'beings and doings' that people care about, such as being well nourished, communing with friends, etc. While a person's achieved functionings are an important part of the evaluation, Sen argues that more is needed to get a complete view of wellbeing. In particular, what other options were available, but were not chosen? The term 'capability' or 'capability set' provides information on the array of functionings that a person could achieve. Therefore, the extent of one's capabilities indicates the extent of a person's freedom to achieve one's objectives, to lead the life that one would want to lead, etc. Poverty in this framework becomes 'capability failure', or the inability to choose the 'beings and doings' that are basic to human life. Poverty is the absolute inability to pursue one's desired objectives, but this will often be seen in relative terms in the spaces of income or commodities. The concept is inherently multidimensional.

Choice of concept – income. There is much to be said for the simplicity and transparency of an income-based poverty concept. While income is not primarily an end in itself, the fungibility of money suggests that it is an important input to virtually all the ends that *are* valued. Hence, even though it is a single variable, it has a powerful impact on many of the other dimensions that are usually associated with wellbeing and poverty. This is clearly a central reason why the most common concept of poverty used in empirical applications is income based. Indeed, if the present project did not require seven additional domains to be included as part of the definition of poverty, a plausible case could be made for continuing with the present income-based methodology and investigating how the other seven variables empirically interact with income poverty as part of the process of policy development. Even *given* the requirement that several other dimensions must be considered as part of the *definition* of the measure, there are good arguments for retaining an income-based definition as a separate partial index of poverty that is reported on a yearly basis.

Choice of concept – capability. The capability and functionings framework of Sen provides a rich theoretical framework for evaluating wellbeing; capability deprivation is a natural, coherent way to conceive of poverty (see for example Sen, 1985; Foster and Sen, 1997; or Alkire, 2002).

Problems in implementation. As noted by many observers, though, capabilities are complicated to both conceive of and to measure in practice. First, there is the problem of actual achievements versus the set of potential achievements. The capability approach requires the researcher to consider not only the choices that are actually chosen but the unselected options as well. If a revealed preference calculus were available for arbitrary sets of 'beings and doings', then we may be able to extract the appropriate information on sets from observed choices and other information (analogous to prices and budget sets in the market context). However, as of yet, there is no such calculus, and hence the first aspect of the capability approach that is lost in bringing theory to data is the set-valued nature of the relevant variables. Therefore applying the capability approach is typically based on achieved functionings and not *sets* of functionings.

Second, even measuring a given functioning is no easy task. If it is single dimensional, it is typically measured ordinally, rather than cardinally; while if a given functioning is inherently multidimensional, it may well be impossible to make comparisons across certain different 'levels' of the functioning. And this does not even address the potential problems with making meaningful overall comparisons *across* the various functionings under consideration (analogous to the 'interpersonal comparability' problem emphasized by Amartya Sen in *Collective Choice and Social Welfare*, 1970). Suffice it to say that the measurement issues surrounding the implementation of the capability approach are substantial indeed (Alkire, 2002). However, recent advances in multidimensional poverty measurement offer some hope for evaluating poverty using the capability approach (Alkire and Foster, 2007).

B. The Framework for Measurement

The general framework for measuring poverty is an elaboration of the standard one proposed by Sen (1976) in his well-known paper on the measurement of poverty. The three steps are as follows: (1) select the space or spaces in which poverty is to be evaluated, (2) Identify the poor with the help of a cutoff for each space, as well as a rule for deciding when a person is poor, and (3) aggregate the resulting data using some form of overall poverty index. Of course, this general framework for measuring poverty allows a great deal of leeway in selecting a specific measurement procedure. We now discuss a range of available multidimensional poverty measures that fall within the Sen framework.

Modified income framework. In this approach, the various dimensions of wellbeing that are being used as the basis of poverty measurement are aggregated into a single cardinal measure of wellbeing. Any cardinal, interdimensionally comparable spaces may be used. The resulting cardinal variable is then used as an income variable in the traditional approach to measuring income poverty. Identification is accomplished by imposing a cutoff in the modified income space, possibly related to individual cutoffs in each of the component spaces. Then a standard income poverty measure is applied, such as an *FGT* index. The resulting indices can be subject to the usual battery of axioms for income poverty measurement with respect to the new aggregate variable as the income variable, including: *Focus*, *anonymity*, *(income) monotonicity*, *transfer*, *subgroup consistency*, and *population decomposability*. Examples of multidimensional poverty measures based on an aggregate variable are found in Tsui (2003).

Bourguignon-Chakravarty framework. The framework of Bourguignon and Chakravarty (2003) takes a multidimensional space per se as its basis for evaluating poverty. A cutoff is located within each space to identify when an individual is poor in that dimension. Their main analysis covers the case of two dimensions that are cardinal in nature and can be compared across dimensions; however, the general approach also covers the multidimensional case. Identification can take two extreme forms. First, the union approach defines a person to be poor in the multidimensional sense if the person falls below the cutoff in *some* dimension. Second, the intersection approach defines a person to be poor in the multidimensional sense if the person falls below the cutoff in *every* dimension. They also consider other ways of identifying the multidimensional poor that are equivalent to aggregating the variables (as with the modified income framework) into a single index and setting the line in the new aggregate space.

As for the aggregation stage, they discuss at length the relationship between the variables and what this implies for the form of the multidimensional poverty measure. Two components may be substitutes, in which case an increase in one variable lowers the marginal impact that changing the other variable has on poverty. The two may also be complements, in which case an increase in one variable raises the marginal impact that changing the other variable has on poverty. The indices presented focus on the intersection approach and the two-variable case, and they provide a straightforward generalization of the *FGT* class, namely, they calculate the normalized shortfall in each dimension, raise it to a power greater than or equal to zero, weight it and sum it across the dimensions. The resulting class of measures satisfies a number of reasonable axioms that are analogs of the single dimensional requirements in the multidimensional case.

Alkire-Foster framework. Alkire and Foster (2007) also consider a fundamentally multidimensional basis for evaluating poverty, with pre-determined cutoffs in each dimension $j = 1,\ldots,n$. Their first contribution is to consider an alternative intermediate approach to identifying the poor. They begin with the illustrative, simple case where all dimensions are accorded equal weight (e.g., see Mayer and Jencks, 1989). Motivated by the counting approaches prevalent in the sociological literature (see for example Gordon, et al. 2003 and Mack and Lansley, 1985, as cited in Boltvinik 1998), they define a person to be multidimensionally poor if $y_j < z_j$ for at least k many j's, where k is some integer from 1 to n. If $k = 1$ then they obtain the union approach to identification; if $k = n$ then this becomes the intersection approach. Using an intermediate k then yields an intermediary approach to identification.

Having provided a procedure for identifying the poor, they turn to a discussion of possible methods of aggregation. They discuss at length the case of the headcount ratio, or the percentage of the population that has been identified as being poor. One very important benefit of this measure is that it can operate in an environment where each of the dimensions is strictly ordinal, or even when the variable is simply zero-one. They then critique the simple headcount as being insensitive to increases in the scope of poverty pointing out that if a person who has been identified as being poor becomes deprived in an additional dimension, the measured level of poverty is unchanged. Consequently, the measure violates what might be called *dimension monotonicity*. They then propose a simple *adjusted headcount ratio*, which is the headcount ratio times the *average deprivation rate* among the poor, where the latter term is the number of deprivations suffered by a poor person divided by the total number of possible deprivations. This measure *does* satisfy dimension monotonicity and several other axioms for multidimensional poverty measures (including population decomposability) while being defined for any number of dimensions, whether ordinal or cardinal variables. Consequently, it is especially useful in measuring poverty as capability deprivation.

They then show how, under an assumption of cardinal variables, the approach may be extended to all the *FGT* indices to obtain the dimension-adjusted family of *FGT* multidimensional poverty measures. They also note that the general approach can be applied to any income poverty measure to obtain an adjusted version suited to the multidimensional setting. One last generalization that is particularly relevant for the present problem considers the case where the weighting structure across dimensions is not symmetric, which I will argue is applicable to the present case. For example, if income were accorded a weight of one half and the remaining capability dimensions shared equally in the remaining one half, the resulting measurement methodology could provide a useful transitional benchmark between income poverty and capability poverty that would truly augment the information utilized at the identification stage and at the aggregation stage.

Choice of framework – measurement issues. The key difference between the present effort and the previous official poverty methodology of Mexico is the introduction of additional information on capabilities beyond the usual income basis. However, without elaborating on the specific dimensions (this will be discussed at some length below) we can be fairly certain that the additional underlying variables are not all cardinal nor is there a natural metric which would allow comparability across dimensions. If so, then this has immediate implications for the choice of measurement framework.

First of all, it rules out a modified income framework by which an aggregate wellbeing indicator is obtained at the individual level and then used as the variable in a poverty measure. To be sure, one could attempt to force the issue through an aggregation process analogous to the Human Development Index (*HDI*) in which each variable is normalized and then comparability of units is simply asserted without any particular underlying justification. The modified income poverty approach could then be applied to the resulting aggregate, with a cutoff being established in the aggregate income space and a headcount or other index being use to summarize the level of poverty. However, the resulting index would be subject to numerous critiques not the least of which is that the measure and its ordering are not independent of monotonic transformations of its ordinal variables, thus violating a fundamental axiom of formal measurement theory (see Roberts, 1979). A key requirement of any measurement methodology is that the resulting measure should be appropriate to the underlying informational basis, which in the present case includes ordinal variables that have no inherent unit of measurement nor are comparable across the various dimensions.

The general Bourguignon-Chakravarty framework is likewise based on intercomparable, cardinal variables; indeed, their central discussion of whether the various dimensions are substitutes and complements is fundamentally reliant upon these assumptions. Hence, many of their interesting insights and measures may not be directly applicable to the present context. One aggregate measure that *can* be applied in their framework is the headcount ratio, or the percentage of the overall population that is identified as poor. However, the two kinds of identification steps included in their paper – namely union and intersection definitions – are unduly extreme, especially in the present case where there are several underlying dimensions of wellbeing. Indeed, the number of persons identified as poor is typically much too small when the intersection approach is used, but much too large when the union definition is applied. Consequently, we must turn to an alternative framework.

Choice of framework – counting methods. The Alkire-Foster framework has a counting-based method of identifying the poor that is intermediate between the extremes of the union or intersection approaches. It incorporates the counting approach into the aggregation stage to obtain a measure of poverty that is sensitive to the number or range of deprivations a person experiences. When one or more individual variables are ordinal and when the dimensional variables are not naturally comparable – both of which are likely to be true in the present case – the Alkire-Foster framework can be used to construct poverty measures that accommodate these restrictions and yet satisfy useful properties. When the dimensional variables are cardinal, the framework provides a straightforward methodology for incorporating information on the depth and distribution of deprivations into the resulting multidimensional poverty measure. It is therefore selected as the framework for poverty measurement used in this proposal.

III. Measurement Methodology

This section describes in detail the proposed methodology for measuring multidimensional poverty in Mexico. It verifies that the methodology can be applied to the eight dimensions defined in the LGDS and provides examples to show how one might construct the overall indicator from the different dimensions. Additionally, this section notes that the proposed methodology is comparable over time and can be applied at the individual, household, municipality, state, and national level. I begin by providing the basic notation and definitions that will be employed and then turn to the identification and aggregation steps underlying the measure. All of the initial discussion abstracts from the specific non-income capabilities considered, which are discussed in greater detail below. Since the approach presented here is applicable to virtually any configuration of variables representing the other capabilities, this order of discussion is entirely appropriate.

Notation and basic definitions. We begin with a matrix x of data, in which the m rows correspond to the various capabilities and the n columns correspond to the individuals under consideration. The typical element x_{ij} of x is therefore the associated level of capability i for person j. For notational simplicity, we will assume that dimension $i = 1$ is income, while dimensions $i = 2$ through m are the non-income capabilities, and sometimes use the notation y and c instead of x, where y is the first row of x containing the income distribution, while c is the matrix describing the distribution of the non-income capabilities found in the last seven rows of x. We assume that there is a (column) vector π of dimension-specific poverty lines, where π_i is the cutoff for dimension i. Anyone who achieves π_i or above is not deprived in this dimension; whereas, any person j satisfying $x_{ij} < \pi_i$ is deprived in dimension i. A multidimensional poverty measure is a function M associating a level of aggregate poverty $M(x)$ to every data matrix x given a cutoff vector π and perhaps other parameters as yet unspecified.

Transforming the data. For data that are cardinal in nature, it is useful to construct the normalized shortfall g_{ij} which is defined as $g_{ij} = 0$ whenever $x_{ij} \geq \pi_i$, and $g_{ij} = (\pi_i - x_{ij})/\pi_i$ otherwise. The resulting matrix g would provide cardinal information on the depth of the various deprivations experienced by each person in the population, with a depth of 0 indicating that the person is not deprived. When the variables are not all cardinally meaningful, the Alkire-Foster methodology relies on an alternative matrix h defined by $h_{ij} = 0$ whenever $x_{ij} \geq \pi_i$, and $h_{ij} = 1$ otherwise. Rather than indicating the depth of each deprivation, h reports whether or not person j is deprived in dimension i. This process of converting an ordinal variable into a dichotomous variable is a key strategy for dealing with ordinality and is commonly invoked in the health inequality literature, in indices of marginality and in certain poverty measures.

Identification. The basic Alkire-Foster approach to measuring multidimensional poverty identifies a person j as being poor by counting the number of dimensions for which $x_{ij} < \pi_i$ (i.e., counting the number of deprivations) and then checking whether this number is equal to or exceeds a certain cutoff number, say four out of eight dimensions. Notice that this implicitly assumes that each of the dimensions should receive equal weighting, which can be taken as a natural starting point for analyses of this type. The equal-weighting case is a focal point for multidimensional analysis when there are no compelling reasons to consider one capability to be more important than another.

One can often provide reasonably convincing arguments for according one or several dimensions greater than equal weight. Income, in particular, has a special position in the measurement of poverty, given its fungibility and its key role in facilitating other capabilities (see also Nolan and Wheelan, 1996). Indeed, this was the position implicitly taken by the previous technical committee for poverty measurement in Mexico, who recommended a standard based *entirely* on income – as is the norm in most countries. I argue below that a weight on income that is higher than the equal-weight case, but lower than the full-weight case, represents a reasonable compromise between a traditional 'economic' view of poverty and a more inclusive multidimensional view.

Consider the following general framework that allows the weights to differ across dimensions. In symbols, let w be an m dimensional (row) vector of positive weights summing to one, where $w_i > 0$ is the weight associated with dimension i, and let ω be an overall cutoff level satisfying $0 < \omega \leq 1$. Now matrix-multiply the $1\times m$ row vector w and the $m\times n$ matrix h. The j^{th} entry d_j of the resulting row vector $d = wh$ indicates the extent of person j's deprivations, measured from zero to one; it is obtained by adding the weights across all dimensions in which j is deprived, and may be viewed as the share of (weighted) deprivations experienced by j. If the deprivation indicator d_j satisfies $d_j \geq \omega$, then person j is identified as being poor; otherwise, j is not poor. Notice that for the case of $m = 8$ dimensions, the specification $w_i = 1/8$ for $i = 1,\ldots,8$, and $\omega = 50\%$ would correspond exactly to the case considered above where each of eight dimensions is accorded equal weight. Alternatively, the specification $w_1 = 1/2$, $w_2 = \ldots = w_8 = 1/14$, and $\omega = 50\%$, is an example in which the overall weight is split 50-50 between income and non-income capabilities, and then the weighting within the set of non-income capabilities is split equally. This case will be the subject of further discussion below.

Censoring the nonpoor. In the multidimensional environment, the nonpoor may very well be deprived in a several dimensions; however, according to the above criterion, the extent of their deprivation would not be sufficient for them to be identified as poor. Consequently, once the poor population has been identified, a logical next step is to suppress the data of the nonpoor to focus on the poor. Define the matrix h^* by $h^*_{ij} = 0$ if $d_j < \omega$, while $h^*_{ij} = h_{ij}$ if $d_j \geq \omega$. This new matrix provides a picture of all the deprivations that are experienced by the poor but censors out the information pertaining to a nonpoor person j by replacing the j^{th} column vector with a vector of zeroes. Notice that this censoring process (and hence h^*) depends crucially on the specific weights w and cutoff level ω being used. Define the censored deprivation vector d^* by $d^* = wh^*$. Clearly $d^*_j = d_j$ if person j is poor, while $d_j = 0$ for all nonpoor j. For every poor person j, the value d^*_j lies between ω and 1 and is the share of (weighted) deprivations experienced by the poor person.

The headcount ratio H. Having identified the set of the poor in this multidimensional environment using π, w and ω, we can denote the associated number of the poor (or, equivalently, the number of nonzero entries in d^*) by q, and let $H = q/n$ be the resulting headcount ratio, indicating the percentage of the overall population that is poor according to our weighted counting criteria. In terms of the matrix h^*, the headcount ratio is the number of columns in h^* that have at least one positive entry, divided by the total number of columns; in terms of d^*, it is the number of nonzero entries in d^* divided by the total number of entries. It is clear that H is telling us something important about poverty in the data – the percentage of the people who are poor – and thus it is a useful *partial* index of poverty in the sense of Foster and Sen (1997) that satisfies many of the basic properties of a multidimensional poverty measure. However, one can argue that it falls short as an overall measure in that it ignores the 'extent' of the deprivations of the poor – now measured *across* dimensions rather than *within* a given dimension. So for example, if a poor person who was not deprived in dimension i suddenly became deprived in i, there would be no impact at all on H. In this sense we say that H violates *dimensional monotonicity* – a natural axiom discussed in Alkire and Foster (2007). This provides a rationale for the following measure.

Adjusted headcount ratio D_0. The headcount ratio can be transformed into a more satisfactory multidimensional measure of poverty by taking into account additional information that is available on the conditions of the poor, namely, the deprivation values d^*_j of the poor. For a given poor person j, the (weighted) deprivation share d^*_j is a measure of the extent or range of poverty of person j. Let A denote the average deprivation share among the poor. Given that the entries in d^* for the nonpoor are zero, we may express $A = \Sigma_j d^*_j / q$. This is a useful measure of how poor on average the poor are in terms of the range of deprivations they are experiencing. Put differently, where u is the column vector having n many 1's, it follows that $A = (wh^* u)/q$

$= \Sigma_i \Sigma_j w_i h^*_{ij} / q$; in other words, A is the weighted sum of the entries in h^* where the entry h^*_{ij} has the weight w_i/q and where $\Sigma_i \Sigma_j w_i/q = 1$. Consider the following poverty measure, which combines information on the prevalence of poverty in the population and average extent of a poor person's deprivation.

Definition. The *(dimension) adjusted headcount measure* M_0 is defined by $M_0 = HA$.

The adjusted headcount ratio is thus the product of the headcount ratio and the average deprivation share of the poor. It also easy to show that $M_0 = \mu(d^*)$, or the mean of the censored deprivation vector. Indeed, $H = q/N$, while $A = \Sigma_i d^*_i / q$, hence their product is $\mu(d^*) = \Sigma_i d^*_i / n$. For example, if the first two persons in a population of four persons were poor, and their deprivation shares were 0.9 and 0.7, respectively, then the adjusted headcount measure would be $M_0 = HA = (0.8)(0.5) = 0.4$. Alternatively, the censored deprivation vector would be $d^* = (0.9,0.7,0,0)$ and hence $M_0 = \mu(d^*) = 0.4$. The adjusted headcount M_0 can also be expressed as a weighted mean of the entries in the matrix h^*, where the entry h^*_{ij} has the weight w_i/n; in other words $M_0 = \mu(h^*;w) = (wh^* u)/n$. The measure M_0 ranges in value from zero to one.

Similarities to the FGT measure P_1. There is an obvious analogy between the adjusted headcount and the well known the per capita poverty gap measure, $P_1 = HI$, found in the income poverty literature. The per capita poverty gap also supplements the headcount ratio with information on the average level of poverty experienced by the poor. But the supplementary information is the income gap ratio I, which measures how far the average poor person's income falls below the poverty line. Note, however, that I and hence HI depend on the cardinal information available in the income variable case. In an ordinal environment, we are unable to make use of cardinal measures of depth of poverty, and instead can supplement H by A, which takes into account the range and configurations of deprivations the average poor person experiences. This analogy is suggested in the approach of Gordon, et al. (2003).

Axioms satisfied by the measure. The measure satisfies a *focus* axiom, which requires the measure to be insensitive to increases in x_{ij} for any nonpoor person j and for any poor person j not deprived in capability i. It satisfies *anonymity*, which requires the value to be unchanged when two persons' vectors of capabilities are switched. It satisfies *replication invariance*, which requires that if each person were replicated a fixed number of times, the poverty level would be unchanged. In other words, the measure is a per capita indicator of poverty, which allows coherent comparisons across different-sized populations. It satisfies *weak monotonicity*, which requires the measured level of poverty to be weakly decreasing in each x_{ij}. This means that poverty cannot rise when any poor person's capabilities are enhanced. And it satisfies *dimensional monotonicity*, which requires poverty to strictly rise if a poor person j experiences a decrement in some capability i that makes j deprived in i.

Population decomposability. Following Foster and Shorrocks (1990), the requirements of subgroup consistency and population decomposability have become standard for measures of poverty. Intuitively speaking, a poverty measure satisfies subgroup consistency if regional changes in poverty are appropriately reflected in the national poverty figures. In symbols, let x, x', v and v' be data matrices across the m dimensions such that x has the same population size as x' while v has the same population size as v'. Then M satisfies *subgroup consistency* if $M(x,v) > M(x',v')$ whenever $M(x) > M(x')$ and $M(v) = M(v')$. By repeated application, this generalizes to the case where both subgroup poverty levels increase, or to any number of subgroups that partition of the population. This intuitive requirement follows from another property dealing with population subgroups. Let x and v be any two data matrices across the m dimensions, and let n_x and n_v be their respective population sizes. Then M satisfies *population decomposability* if

$$M(x,v) = \frac{n_x}{n_x + n_v} M(x) + \frac{n_v}{n_x + n_v} M(v).$$

In other words, overall poverty is just a weighted average of subgroup poverty, where the weights are subgroup population shares. It is easy to see that any population-decomposable measure is also subgroup consistent and, by repeated application, the property can be extended to any number of subgroups. M_0 satisfies both of these properties, which follows immediately from the fact that it is a weighted mean of the d^* vector. Therefore M_0 can be used in targeting antipoverty programs at the local/municipal, state, or other regional level. Indeed, the measure can provide consistent assessments of multidimensional poverty for any level of aggregation – from regional and state down to the household and individual levels.

Dimensional decomposition. As noted above, M_0 is the weighted mean of the censored deprivation matrix h^*, with weights on the elements of the i^{th} row h_i^* of h^* being w_i/n, and hence

$$M_0 = \Sigma_i \Sigma_j h_{ij}^* w_i / n = \Sigma_i w_i \Sigma_j h_{ij}^* / n = \Sigma_i w_i H_i$$

where $H_i = \Sigma_j h_{ij}^*/n$ is the headcount ratio for capability i in h^*, or the population frequency with which people are both deprived of capability i and are poor. Notice that since h^* excludes the data of any nonpoor individual, H_i is in general not the overall incidence of the deprivation – it is the percentage of the population that is both poor and deprived of capability i. This formula offers a decomposition of M_0 by dimensions and thus can provide insights on the sources of poverty as measured by M_0. For example, the contribution of deprivations in capability i to overall poverty can be measured by

$C_i = w_i H_i / M_0$, where clearly each capability's contribution is nonnegative ($C_i \geq 0$ for all i) and from the decomposition formula they sum to one ($\Sigma_i C_i = 1$).

Invariance. By converting each variable to a dichotomous indicator, where one indicates the person is deprived and zero indicates that the person achieves the cutoff level of the capability, we have produced a measure whose values are robust to independent monotonic transformations of each underlying variable (and cutoff). Thus if the first variable is doubled, while the second is replace by its cube, and so forth, the resulting level of poverty would be unchanged. This form of invariance ensures that our measure can technically deal with ordinal variables and ones for which there may be no a priori basis of comparison across dimensions.

Adjusted FGT measures. The majority of multidimensional poverty measures that have been proposed recently require cardinal and interdimensionally comparable variables. This is also the case for the other measures considered by Alkire and Foster (2007), namely, the *adjusted FGT measure* (apart from the adjusted headcount) including the *adjusted gap measure* and the *adjusted* P_2 *measure*. We will briefly define this broader class of multidimensional measures.

Adjusted gap measure. Recall the matrix g of normalized shortfalls whose typical entry g_{ij} is defined as $g_{ij} = 0$ whenever $x_{ij} \geq \pi_i$, and $g_{ij} = (\pi_i - x_{ij})/\pi_i$ otherwise. This matrix provides information on the depth of all the deprivations occurring in a given society, whether experienced by a poor person or a nonpoor person. Now consider the associated censored matrix g^* defined by $g^*_{ij} = 0$ if $d_j < \omega$, while $g^*_{ij} = g_{ij}$ if $d_j \geq \omega$; in other words, g^* only includes the deprivations of the poor (or those whose deprivation indicator d_j satisfies $d_j \geq \omega$). In order to supplement the information of M_0 in the case where the underlying variables are cardinal, we can make use of the extra information on depth available in the g^* matrix. Note that $(wg^*u) = \Sigma_i \Sigma_j wg^*_{ij}$ is the sum of weighted shortfalls across all poor persons and all dimensions, while $(wh^*u) = \Sigma_i \Sigma_j w_i h^*_{ij}$ gives the total weighted number of deprivations across all poor persons and all dimensions. Therefore $G = (wg^*u)/(wh^*u) = \Sigma_i \Sigma_j wg^*_{ij} / \Sigma_i \Sigma_j w_i h^*_{ij}$ is the average depth of deprivation across all the cases of deprivation experienced by the poor. Consider the following poverty measure, which combines information on the prevalence of poverty in the population, the average range of a poor person's deprivation, and the average depth.

Definition. The *adjusted poverty gap* M_1 is defined by $M_1 = HAG$.

The adjusted poverty gap measure is thus the product of the headcount ratio, the average deprivation share of the poor, and the average depth. It also easy to show that M_1 can also be expressed as a weighted mean of the entries in the matrix g^*, where the entry g^*_{ij} has the weight w_i/n; in other words $M_1 = \mu(g^*;w) = (wg^*u)/n$. Indeed, $H = q/n$ and $A = (wh^*u)/q$, while $G = (wg^*u)/(wh^*u)$; hence their product is $\mu(g^*;w) = (wg^*u)/n$.

The measure M_1 ranges in value from 0 to 1. Notice that in addition to the properties satisfied by M_0, the adjusted poverty gap satisfies *monotonicity*, which requires the measured level of poverty to rise when x_{ij} falls, given that person j is a poor person who is deprived in dimension i.

Adjusted P_2 measure. Consider the matrix s of squared normalized shortfalls whose typical entry s_{ij} is defined by $s_{ij} = (g_{ij})^2$. In other words defined as $s_{ij} = 0$ whenever $x_{ij} \geq \pi_i$, and $s_{ij} = (\pi_i - x_{ij})^2/\pi_i^2$ otherwise. This matrix provides information on the severity of all the deprivations occurring in a given society, whether experienced by a poor person or a nonpoor person, as given by the square of the normalized shortfalls. Now consider the associated censored matrix s^* defined by $s^*_{ij} = (g^*_{ij})^2$. Clearly s^* includes only information on the deprivations of the poor. Rather than using the matrix g^* to supplement the information of M_0 (as was done in M_1), we can use the s^* matrix. Note that $(ws^*u) = \Sigma_i \Sigma_j w_i s^*_{ij}$ is the sum of weighted squared shortfalls across all poor persons and all dimensions, while $(wh^*u) = \Sigma_i \Sigma_j w_i h^*_{ij}$ gives the total weighted number of deprivations across all poor persons and all dimensions. Therefore $S = (ws^*u)/(wh^*u) = \Sigma_i \Sigma_j w_i s^*_{ij} / \Sigma_i \Sigma_j w_i h^*_{ij}$ is the average severity of deprivations across all the cases of deprivation experienced by the poor. Consider the following poverty measure, which combines information on the prevalence of poverty in the population, the average range of a poor person's deprivation, and the average severity.

Definition. The *adjusted FGT measure, denoted* M_2, is defined by $M_2 = HAS$.

The adjusted *FGT* measure is thus the product of the headcount ratio, the average deprivation share of the poor, and the average severity. M_2 can also be expressed as a weighted mean of the entries in the matrix s^*, where the entry s^*_{ij} has the weight w_i/n; in other words $M_2 = \mu(s^*;w) = (ws^*u)/n$. Indeed, $H = q/n$ and $A = (wh^*u)/q$, while $S = (ws^*u)/(wh^*u)$; hence their product is $\mu(s^*;w) = (ws^*u)/n$. The measure M_2 also ranges in value from zero to one. Notice that in addition to the properties satisfied by M_1, the adjusted poverty gap satisfies a multidimensional *transfer property*, as defined in Alkire and Foster (2007), and hence is sensitive to the inequality with which deprivations are distributed among the poor, and not just their average level. It is easy to extend the measures M_0, M_1, and M_2, to obtain the entire class M_α (for $\alpha \geq 0$) of multidimensional poverty measures associated with the unidimensional class P_α developed by Foster, Greer and Thorbecke (1984), and this is done in Alkire and Foster (2007).

Choice of weights. The general approach allows a multitude of ways of comparing and weighing the contribution of each deprivation to overall poverty. Each collection of weights w is easily understood and communicated, and this in turn can help facilitate a reflective deliberation about what the weights ought to be. At the end of the process, a single constellation of weights should be selected in order to implement the general approach (although this should be backed up with robustness analysis). I now turn to the central issue of weights, which is ever-present in discussions of multidimensional measurement. Note that this question (of weights across dimensions) has not been fully resolved in theory or practice – and it may never be. The goal of the following is to provide an intuitive and perhaps helpful discussion of some of the related issues in order to arrive at a reasonable initial weighting structure.

Two focal points. In the present context, there are two obvious focal points for the vector of weights. First is the weighting structure $w^e = (1/m,\ldots,1/m)$ which gives equal weight to all capabilities. Selecting this structure can be viewed as a positive assertion that the m dimensions are coequal ends and means for development, and hence no single capability should be unduly emphasized. Alternatively, it may be viewed as a negative statement concerning the present level of knowledge on multidimensional comparisons, i.e., equal weights are selected since 'we have no reliable basis for doing [otherwise]' (Mayer and Jencks, 1989). In other words, while the instrumental or intrinsic importance of the different variables may vary substantially, the evidence at this time is not conclusive and therefore an equal weighting structure is (at least provisionally) justified.

Second, one can follow a traditional economic approach and put full weight $w^1 = (1,0,\ldots,0)$ on income. As noted above, this is the implicit weighting structure behind most official poverty standards in common use, and the assumption underlying the previous income-based, official poverty methodology in Mexico. Many arguments have been advanced in favor of an income-based (or nearly income-based) approach, including theoretical arguments drawn from traditional welfare economics, practical issues of data quality, measurement problems when ordinal variables are used, etc. In any case, there is no doubt that income growth plays an especially important role in the development process; and if so, then it should be accorded greater weight.[1]

A compromise position. For purposes of illustration, I confine attention to weighting structures that are weighted averages of w^e and w^1. The question then becomes: How much weight should be given to income relative to the other capabilities? I noted above several reasons for placing higher weight on income, including normative justifications and issues of data quality. To these one could add: (1) the key role income plays in overcoming deprivations in other dimensions, (2) the salience that income has for policymakers, academics, and citizens in discussions of poverty, (3) the wide use of the income-based methodology in evaluations of poverty, and (4) its historical use in the previous official methodology. On the other hand, viewing poverty as capability deprivation would force one away from a purely income-based position. A weight of one on income alone misses out on important ancillary information that can be useful in tracking poverty as capability deprivation and diagnosing its origins. Moreover, given the General Law of Social Development, there is clear evidence of political will to make the move to include other relevant dimensions of poverty, and this would push us away from the extreme income-based position to a compromise position.

The illustrations below will focus on the weighting structure w^o which places half the weight on income and half on the other, non-income capabilities – equally split across the seven dimensions. This is an example of what might be called a 'nested' weighting structure, in which the dimensions are first

[1] Even if one is sure that full weight on income is not right, it does not follow that w^1 is worse than any particular alternative vector w. Using a weighting structure that overemphasizes other, less important dimensions may in fact be far more wrong-headed than simply giving income full weight.

separated into certain metacategories (the two here being income and other capabilities) with each receiving equal weight and then the capabilities within each category are accorded equal weight (income receives the full one-half weighting as the only member of its category, while the other capabilities split their one-half weighting equally). Notice that w^0 is indeed a weighted average of the two basic weighting structures, $w^0 = \alpha w^e + (1-\alpha)w^1$; however, it is not the midpoint obtained when $\alpha = ½$. Instead, somewhat more weight is being placed on the equal weighted structure w^e than on the income-based structure w^1.

Which dimensional cutoff ω? The illustrative examples presented below will report multidimensional poverty levels for several measures of poverty and for the weighting structures w^e and w^0. It will also provide information on unidimensional poverty associated with the 'income-only' weighting structure w^1. In order to implement the multidimensional measures, a dimensional cutoff ω must be selected. I will give poverty estimates for a range of potential values for the dimensional cutoff ω but will focus on the intermediate level of $\omega^o = 50\%$.

Under the equal weighting structure w^e, this amounts to requiring a person to be deprived in four out of the eight dimensions in order to be considered poor. Lowering ω eventually lowers the number of dimensions needed to be poor, while raising it raises the number required.

Under the nested weighting structure w^0, a dimensional cutoff of $\omega^o = 50\%$ implies that the set of poor persons includes all persons who are income deprived, irrespective of their non-income capability levels, and all persons who are not deprived in income but are deprived in the remaining m-1 dimensions. How does this picture change as ω is altered? With a lower cutoff of $\omega < 50\%$, the set of poor persons still includes all income deprived persons (since the weight on income deprivation is greater than the cutoff); and eventually, the second group of income sufficient but capability deprived persons tends to become larger as the number of non-income deprivations required to be poor falls. With a higher cutoff $\omega >$ 50%, some of the income-deprived persons (those who are not deprived in any other dimension) will no longer be poor; and the second group of persons who are not income deprived will contain no poor persons at all. The poor are now those who are deprive in income and in enough of the other dimensions to reach the higher cutoff ω. In what follows, I will focus on the measure adjusted headcount ratio obtained when w^o is the weighting structure and ω^o is the dimensional cutoff, but will also explore what happens when these parameters are altered.

A helpful formula. Now utilizing the specific weights w^0 in M_0, we see that

$$M_0 = \Sigma_i w_i^o H_i = ½ H_1 + ½ \Sigma^m_{i=2} H_i /(m\text{-}1)$$

$$= ½ H_1 + ½ M_c$$

where $M_c = \Sigma^m_{i=2} H_i /(m\text{-}1)$ takes a form analogous to a 'marginalization index' across the non-income dimensions 2 through m-1, but ignoring the deprivations of the nonpoor. Therefore, the adjusted headcount ration is just the average of H_1, or the share of the population that is both poor and deprived in the income dimension, and M_c, the marginalization index. Given w^0 it is clear that whenever the dimensional cutoff ω satisfies $\omega \leq \omega^0 = 50\%$, then anyone how is deprived in income is poor overall. Consequently, we have $H_1 = H_y$, the traditional income-based headcount ratio, and therefore

$$M_0 = ½ H_y + ½ M_c.$$

This is a remarkably intuitive formula, which views the new measure as the average value of the previous official measure based purely on income and the new index of marginalization that captures the information provided by the non-income dimensions. Any change in M_0 can be broken down into the change in the traditional and widely reported income-based poverty measure H_y and the change in the new marginalization index over the non-income dimensions M_c. The new measure M_0 builds upon the previous official measure of poverty H_y in a natural way that is easy to understand and explain to policymakers. A similar formula could be constructed for the adjusted poverty gap M_1 and the adjusted *FGT* measure M_2, linking the new multidimensional measures to the traditional *FGT* measures over income.

Critique of the measure. Before illustrating how the new multidimensional methodology can be applied, we provide some potential criticisms of the approach.

First, while the measure M_0 has the advantage of being able to be applied to ordinal data, it does so at a cost of ignoring the depth and severity of poverty. It is based on a dichotomization that gives a value of one to all persons below the cutoff and a value of zero for all persons achieving the cutoff. This, of course, entails a large potential loss of information, and like the traditional headcount ratio, it generates a ranking that relies heavily on the particular cutoffs employed. In particular, the identification method regards a person who is deprived in enough dimensions to be poor, even if the depth of poverty in each dimension is very small; while a person who is deeply deprived in a few dimensions may not be identified as being poor. This lack of tradeoff at the identification stage is a central part of the methodology.

Second, I have not provided a normative formula linking the new measures of multidimensional poverty to wellbeing, per se. Of course, the general normative framework is the capabilities approach of Sen, in which poverty is seen as capability deprivation. However, the specific way that one variable interacts with another and influences wellbeing is not known and hence has not been incorporated into the measures. In particular, there is no attempt to account for substitution possibilities across dimensions or complementarities (although the identification method can be viewed as accounting for complementarities by requiring a minimum range of deprivations before it calls a person poor). Likewise, a person who is very rich in several of the dimensions could still be identified as poor if deprived in enough dimensions. One cannot apply the excess from these dimensions to lift a person above the cutoff in another dimension.

Third, the use of M_α for $\alpha > 0$ requires the variables to be cardinally significant, an assumption that is less likely to be satisfied by the non-income capability variables than for the income variable. Moreover, the use of mixing zero-one variables with continuous variables can lead to misleading results for these measures, since the contribution of zero-one variables will tend to rise with α. Of course, these criticisms are not applicable to M_0.

Fourth, there will inevitably be some arbitrariness in the selection of weights and/or the dimensional cutoff.

IV. Empirical Illustration

The above section has outlined a methodology for evaluating multidimensional poverty. In this section I show that the methodology can be employed using existing data to obtain estimates of multidimensional poverty in Mexico. Note that I have not undertaken a sophisticated analysis of poverty in Mexico, either overall or by subgroup. I have ignored issues of sample structure and whether the data are representative for the subgroup in question. I have not employed the population weights provided with the data. Instead, I have concentrated on demonstrating that the technology can be fruitfully used to address the kinds of issues mentioned in the Terms of Reference. I begin with a brief discussion of each indicator and variable.

A. Data Sources and Definitions of Indicators and Variables

All data are derived from the sources provided by CONEVAL for this project. As result of a suggestion by David Gordon at the second meeting, it was agreed that CONEVAL would also provide cutoffs for each of the dimensions for the purpose of facilitating comparisons of the various approaches. An extensive discussion of the sources and definitions of the variables is not necessary. Instead, I will review the definitions, variables, and cutoffs provided by CONEVAL for each dimension and will provide a brief evaluation of each along with potential directions for improvement or alterations.

1. Income. The income variable provided is per-capita household income, or the total income of a household divided by the number of persons in the household. This variable is a reasonable reflection of the resources available to an individual in a given household but ignores the economies available to persons living together in households as well as the different needs of households of different configurations (e.g., all adults vs. one adult and several children). There are many approaches to addressing this shortcoming. The way this is done in the U.S. is to set a different poverty line for each and every household configuration. The more standard way is to use an equivalence scale to convert a household income level and configuration into an 'equivalent' income for each household member. How is the equivalence scale to be constructed? The natural tendency for economists is to undertake an empirical analysis to find appropriate conversion factors. However, this approach is not necessarily the best option, since it is less transparent, depends on the specific year of data in question, and changes from year to year, creating further noise for the poverty analyst to have to account for when evaluating poverty trends. Instead, the norm for analyses of this kind appears to be to adopt a simple, fixed equivalence scale that is unchanging over time and space.[2] I would encourage CONEVAL to consider adopting such an approach, since per capita income is certainly providing biased estimates of poverty levels among larger families with children as compared to small families with adults.

As for the cutoff, CONEVAL provided the *PL3* 'patrimony' poverty lines (differentiated by urban and rural regions) to be used in the illustration. An alternative cutoff is the *PL2* 'capabilities' line that was the most common basis of the official figures reported during the last several years. For analyzing the income dimension, we have considered both the patrimony and capabilities poverty lines. Each contains a separate cutoff for urban and rural regions. For the patrimony approach, the urban poverty line is 1,586.54 pesos and for rural areas the poverty line is 1,060.34 pesos. Under the capability approach, the urban poverty line is 969.84 pesos, and for rural areas the poverty line is 690.87 pesos (CONEVAL, 2007, Cuadro 2, p. 6).

2. Education. The education variables suggested are based on years of schooling for both the adult and child population. For the population between 6 to 14 years old, the educational gap of an individual is defined as a function of the numbers of years they are behind the normative number of schooling years corresponding to their age. For the population between 15 and 29 years old, the normative value of schooling years is nine years, according to the requirement in the relevant Mexican law. For the population 30 or more years old, the normative value is six years.

This seems to be a reasonable first approach to obtaining an indicator for education. The use of different norms for adults of different ages is, on one hand, a fair reflection of the changes that are occurring in this society. On the other hand, it appears to be replacing 'what is' with 'what ought to be',

2 The discussion of equivalence scales in Citro and Michael (1995) is most informative. See also Foster (1998).

which reduces the potential information value from this dimension. If a given adult has only a 6th grade education, this will have real effects on that adult's ability to function in current society, and these effects are not likely to be different whether the person is 29 or 39 years old.

The attempt to include children currently in school is indeed important, but perhaps as a predictor of what is to come rather than as an indicator of what is. Even so, a child who is currently behind by one year is not necessarily going to end up below the norm by one year; this depends on what subsequently happens over the course of the child's education.

So, who is educationally deprived? It seems to me that an alternative and more transparent possibility would be to set up a fixed-year standard across all adults and to use the deprivation level of the parents as a best estimate of the future deprivation of the children. How educationally deprived are they? To be sure, the number of years of schooling is a cardinally significant variable, and consequently the number of years of schooling below some fixed norm, or even the normalized shortfall, can be meaningfully calculated. However, 'years of schooling' is a pretty poor indicator of underlying education. The link between schooling and education is likely to be very different across persons and across grade level. Even if more schooling is assumed to lead to higher levels of education, and this function is the same across people, an extra year of schooling may have a differential impact depending on how much schooling an individual has. There is no assurance that schooling is the appropriate cardinal representation for education. Instead, schooling should be taken to be, at best, one of many possible cardinalizations of educational achievement and, hence, under this interpretation, it would not be appropriate to apply gap-type measures to this variable. For illustration purposes we follow the definitions suggested by CONEVAL and apply the gap-based measures as if the variable were cardinally significant.

3. Space availability and quality of the dwelling. This dimension is represented by two variables as specified in the General Law of Social Development: number of persons living per bedroom and the materials used to build the dwelling. According to the suggested cutoffs, a family will be counted as poor if: (1) there are more than two persons living per bedroom, or (2) the dwelling floors are made of soil, or (3) the dwelling has walls made of throwaway material, or (4) the dwelling has a roof made of throwaway material. Clearly, this variable is trying to gauge the adequacy of the living space for a household, first in terms of a norm on the number of persons living together in a bedroom and second in terms of the material from which the house is made. The first of these is clearly a very crude indicator, as it does not take into account the size of the bedrooms, nor whether the living space is intended to house many persons (as with a school dormitory), nor whether the family has a preference for living close together. (I note that for many years my three children had a large common bedroom). A measure of living area would likely be a better indicator of this aspect of housing adequacy. The building materials would seem to me to be a better signal of poverty, but even then there is an issue of whether the materials used are being used because of a significant lack of resources or because of the culture and acceptable practice in a given region or group.

4. Basic dwelling-related services. The next category is related to the above category in that the features are related to the services that are associated with the house where the family lives. Four factors are used to determine deprivation in basic dwelling related services, namely, availability of electricity, water, sewage, and a toilet. A family is called poor in terms of basic dwelling-related services if electricity is not available in their house, there is no public water service inside the house, or the drainage of the dwelling does not go to the public sewage network. I found this to be an unusual category as the deprivation of a family in housing services may well depend on whether these services are generally provided in the locality or region. An urban area, for example, is likely to have different levels of availability of public service than a rural area, reflecting the very different needs of a crowded metropolitan environment vs. a house on a beach or in a traditional rural area. At the same time, it is surprising to have two separate variables associated with the quality of housing services. With two variables devoted to this aspect of life, it receives twice the weight of other key capabilities, such as education. CONEVAL should evaluate whether the dwelling variables should be consolidated into a single variable.

5. Access to food. There are several possible ways of gauging whether a family has adequate access to food. The most obvious is to assume that any family with adequate access to food would achieve an adequate diet and then to observe the eating or expenditure patterns of the family. We did not have access to this data and instead used an alternative approach suggested by CONEVAL which evaluates whether a family would have adequate monetary resources that would allow them to purchase what families near the patrimony poverty line in fact purchase. This appears to be related to income poverty at a lower cutoff, and if so, the effect of averaging this with the income poverty measure at a higher poverty line is to place greater weight on lower incomes.

6. Access to health services. The question of whether a person or family has access to health services is a complicated mix of the availability of the services of a doctor, hospital, or clinic within a reasonable distance, and the resources necessary to pay for such services (assuming they are not freely provided). The variable offered by CONEVAL for the purpose of the exercise is constructed as follows: Any household that is not poor according to the patrimony poverty line is assumed to have adequate access to health services. I am not certain how good an assumption this is. Among households with incomes below that cutoff, deprivation in this variable is determined as follows. For the working population, the worker is not deprived in this dimension if he or she has 'as a labor benefit, access to medical services from *IMSS*, *ISSSTE*, *ISSSTE* estatal, *PEMEX*, Army, Navy, universities, private medical services or insurance for medical expenses'. For persons who are not employed, the person is not deprived if 'the individual is retired or pensioner' or if the person resides in a household where the head is not deprived in this dimension. As noted by CONEVAL, this assumes that when a household head has access to healthcare, all nonworking members of that household also have access, an assumption that is very strong and is only being made 'for the purpose of this exercise'. It would seem to me that additional information must be obtained directly on access to healthcare, if it is indeed the appropriate variable to be evaluated.

I found it surprising that the variable used in assessing multidimensional poverty is access to healthcare. To be sure, access to healthcare is one of several ways of improving the health of the population (although it is not likely the most important, given recent studies that show a much lower impact of medical care on health than is usually presumed). Other policies to improve health include public health efforts, or even ensuring adequate educational achievements (given the strong empirical link between education and health). However, I would argue that the correct variable to be placed in a multidimensional measure of poverty is health status, not access to healthcare, since it is the low health status of a person that is conceptually linked to multidimensional poverty. I would recommend that CONEVAL review this specification.

7. Access to social security. The variable recommended by CONEVAL for the purpose of the exercise is constructed as follows: Any household that is not poor according to the patrimony poverty line is assumed to have adequate access to social security. Among households with incomes below that cutoff, deprivation in this variable is determined as follows: For the working population, the worker is not deprived in this dimension if he or she has 'as a labor benefit, access to social security from *IMSS*, *ISSSTE*, *ISSSTE* estatal, *PEMEX*, Army, or Navy'. For persons who are not employed, the person is not deprived if 'the individual is retired or pensioner' or if the person resides in a household where the head is not deprived in this dimension. As before, this assumes that when a household head has access to social security, all nonworking members of that household also have access. I am unclear how access to private pension plans is related to this variable. In addition, it is quite obvious that this variable will correlated with the health access variable given above, which begs the question of whether there might be redundancy in including both of these variables in the measure. Put differently, should they be combined into a single varable that would receive a weight equal to the remaining (nonincome) capabilities and not twice the weight of the others? This question should be considered by CONEVAL.

8. Social cohesion. This is a variable seemingly definable only for groups of people. The variable recommended by CONEVAL for the purpose of the exercise is based on the crime rate (per thousand population in a municipality). The indicator of social cohesion is the reciprocal of the crime rate. The cutoff in this dimension is a relative one: the median observation. One immediate question is whether through higher reporting of crimes in more affluent areas, the observed level of social cohesion may be excessively biased upwards for poorer areas. Indeed, one might a priori expect an indicator of social cohesion to be higher among poorer groups who are materially poor but rich in (strong tie) relationships. As is well known, though, being rich in such relationships may actually have a negative impact on other dimensions of wellbeing. In principle there should be no discernable relationship between social cohesion and positive outcomes. And according to a colleague and expert on the topic, there is no generally acceptable, implementable indicator of social cohesion. A second problem is that, because it is a group variable, it cannot begin to play the role it was intended to play – to provide information on the extent to which the links between people might benefit an otherwise poor person. Measures of social capital are a possible way forward, but they too are not well formulated to indicate the positive impact of linkages one has on the capabilities of the person. Instead, a new formulation focusing on the quality of the persons in an individual's network might be needed. One such framework of evaluation is developed in Foster and Handy (2007) with the name 'external capabilities'. For example, a person who is not literate himself may well have access to a literate person in the household or extended family, which provides him with access to literacy skill when needed.

I think it is premature to try to incorporate a social cohesion variable into the official measure of multidimensional poverty; much more investigation is needed. I am currently part of a project sponsored by the Latin America and Caribbean section of the UNDP studying this problem. We will evaluate whether polarization indices could provide a useful group-based measure of social cohesion; and we will explore how the external capabilities approach can be implemented empirically as an individual-level variable. The project leader at the UNDP wished to convey to CONEVAL that he would be interested in partnering with CONEVAL to address this important issue.

B. Results

We now turn to the illustrative results obtained using the multidimensional poverty methodology with Mexican data.

Table 1: FGT Levels of Deprivation within Dimensions

Dimension	P_0	P_1	P_2
Income	0.42	0.17	0.09
Education	0.57	0.19	0.10
Health	0.37	0.37	0.37
Social Security	0.59	0.59	0.59
Dwelling	0.53	0.15	0.06
Services	0.36	0.10	0.04

Food	0.53	0.22	0.12
Cohesion	0.82	0.48	0.32

Table 1 provides the levels of the unidimensional *FGT* measures (P_0, P_1, and P_2) for each of the eight dimensions. The first entry in the first column corresponds to the standard income poverty headcount rate and, indeed, the estimated level of about 42 per cent for the patrimony cutoff is very close to the estimates found by CONEVAL for 2004 and 2006 (CONEVAL, 2007). If instead the capabilities cutoff were employed one would expect a figure of about 23 per cent, according to the same source. The social cohesion deprivation rate is so high as to call into question its usefulness in helping to identifying the poor. Note that the two dimensions 'health' and 'social security' are zero-one variables, and hence the headcount provided is simply the percentage of the population that does not have access to the programs listed in the definition of the variable. Since there is no gradation in each of these variables, the deprivation gap (P_1) and *FGT* (P_2) are identical to the headcount ratio. In contrast, these three measures have entirely different levels for each of the other variables; the value falls when one accounts for the depth and the severity of deprivation. This will have implications for the associated multidimensional poverty measures. Indeed, as we shall see below, the two dimensions of health and social security will account for a disproportionately high share of multidimensional poverty as measured by the adjusted gap or the adjusted *FGT* measure. While mixing zero-one and continuous variables may be appropriate for the headcount ratio H and adjusted headcount measure M_0, it is not clear whether this makes sense for the measures M_1 and M_2.

Table 2: Poverty Levels with Equal Weight System Including Social Cohesion

	Patrimony Cutoff for Income				Capability Cutoff for Income			
ω Cutoff (%)	Head Count	Adjusted Head Count	Adjusted Poverty Gap	Adjusted FGT	Head Count	Adjusted Head Count	Adjusted Poverty Gap	Adjusted FGT
0	0.99	0.52	0.28	0.21	0.99	0.50	0.27	0.21
10	0.99	0.52	0.28	0.21	0.99	0.50	0.27	0.21
20	0.88	0.51	0.28	0.21	0.88	0.48	0.26	0.20
30	0.71	0.47	0.25	0.19	0.70	0.44	0.24	0.18
40	0.56	0.41	0.22	0.17	0.54	0.38	0.21	0.16
50	**0.44**	**0.35**	**0.19**	**0.15**	**0.39**	**0.31**	**0.17**	**0.13**
60	0.44	0.35	0.19	0.15	0.39	0.31	0.17	0.13
70	0.33	0.28	0.16	0.12	0.27	0.23	0.13	0.10
80	0.21	0.19	0.11	0.09	0.17	0.15	0.09	0.07
90	0.08	0.08	0.04	0.03	0.06	0.06	0.03	0.02
100	0.08	0.08	0.04	0.03	0.06	0.06	0.03	0.02

Table 2 provides estimates of multidimensional poverty using the equal weighting vector w^e = (1/8,…,1/8) and the measures H, M_0, M_1, and M_2. To indicate the sensitivity of the estimates to the dimensional cutoff, we have provided poverty estimates for a range of values of ω. Moving from the patrimony to the capabilities income poverty line obviously leads to a lower multidimensional poverty level. However, because income has the same weight as any other dimension, the impact is not particularly large.

Now look specifically at the case of ω = 50%, as highlighted in the table and extracted below:

	Patrimony Cutoff				Capability Cutoff			
ω	H	M_0	M_1	M_2	H	M_0	M_1	M_2
50	**0.44**	**0.35**	**0.19**	**0.15**	**0.39**	**0.31**	**0.17**	**0.13**

When the patrimony cutoff is used for the income variable, we see that about 44 per cent of the population is deprived in four or more dimensions. The headcount measure H, though, does not make a distinction between having four, five, six, seven, or eight deprivations. Once a person is considered to be multidimensionally poor, the headcount ratio essentially assumes that the person is deprived in all dimensions. The adjusted headcount M_0, on the other hand, carefully accounts for the number of deprivations, using the average share A of deprivations experienced by the poor. In the present case A = 80%, and consequently $M_0 = HA$ has a value that is 80% of H. If A were in fact 100%, then M_0 would simply be H. If A were 70% then M_0 would have an even lower value. Clearly, M_0 reflects both the prevalence of the poor and the range of deprivations they experience. Note also that M_0 can be interpreted as the number of deprivations among the poor divided by mn, the maximum number of deprivations that could conceivably arise in the population.

The adjusted poverty gap measure M_1 includes information on the depth of deprivations, as represented by G, the average normalized gap among all the deprivations experienced by the poor (and excluding all cases where a poor person is not deprived). In the present situation, G is approximately 57%; in other words, when a poor person is deprived, the expected depth of a deprivation is about 57% of that dimension's cutoff. The resulting adjusted poverty gap measure M_1 is thus obtained by multiplying M_0 by 57%. If G had in fact been 100%, then M_1 would have the same value as M_0. But M_1, unlike M_0, can differentiate between situations where the poor have large shortfalls on average or have shortfalls that are quite small. This is a distinct advantage; however, note that the use of M_1 requires a cardinal representation to be selected for each variable in such a way that alternative cardinalizations (altering the implied poverty ranking) are definitively ruled out. In practice this is a difficult requirement to satisfy, since it involves both a cardinalization of each variable as well as a calibration across dimensions. A second potential difficulty in moving from M_0 and M_1 is that zero-one variables (if they are being used) will receive greater weight than the more continuous variables. The normalized shortfall for a zero-one variable is identical to its incidence; the normalized shortfall of a continuous variable is typically well below its incidence. Therefore, in the present case, the contribution of the health and social security variables is likely to be over emphasized in M_1; in M_0 all variables have been converted to zero-one variables and there is no bias. Finally, there is an alternative interpretation of M_1 available: It is the sum of all the normalized shortfalls among the poor, divided by the maximum value that the sum of the normalized gaps could take across the population, or mn.

The adjusted FGT measure M_2 uses alternative additional information to augment the information in M_0: namely the average *squared* normalized shortfall S. Since the shortfalls are between zero and one, squaring them will lead to a lower number than the shortfalls themselves, and hence S is generally less than G. In the present case, S has a value of about 42% (which is less than the 57% found above for G) and hence M_2 is correspondingly lower in value. If the average squared shortfall S had been 100% (so that G would be 100% as well), then M_2 would simply be equal to M_0 (and M_1 as well). However, M_2 uses a convex function of the normalized gap (namely the square) to discount the smaller shortfalls.

This also makes the poverty measure sensitive to the distribution of the deprivations. If all individual shortfalls were close to the average shortfall G, then this would be reflected in a smaller value for S (and hence M_2) as compared to a case where there are many larger shortfalls and smaller shortfalls (with the same average shortfall G). Of course, when there are variables that can only take on zero-one values, this impact is dampened, and the values of S and G are closer together. This may be what is happening in the present case, due to the nature of the health and social security variables. Note that M_2 like M_1 relies heavily on an assumption of cardinality and interdimensional comparability of the underlying variables. And another interpretation of M_2 is available: it is the sum of all the squared normalized shortfalls among the poor, divided by the maximum value that the sum of the squared normalized shortfalls could take across the population, or mn.

Table 3: Poverty Levels with Nested Weight System Including Social Cohesion

	Patrimony Cutoff for Income				Capability Cutoff for Income			
ω Cutoff (%)	Head Count	Adjusted Head Count	Adjusted Poverty Gap	Adjusted FGT	Head Count	Adjusted Head Count	Adjusted Poverty Gap	Adjusted FGT
0	0.99	0.48	0.24	0.16	0.99	0.38	0.19	0.14
10	0.88	0.47	0.23	0.16	0.88	0.37	0.19	0.13
20	0.71	0.45	0.22	0.15	0.70	0.35	0.17	0.12
30	0.48	0.39	0.19	0.13	0.40	0.27	0.13	0.09
40	0.44	0.38	0.18	0.12	0.30	0.24	0.12	0.08
50	**0.42**	**0.37**	**0.18**	**0.12**	**0.22**	**0.20**	**0.10**	**0.07**
60	0.42	0.37	0.18	0.12	0.22	0.20	0.10	0.07
70	0.41	0.36	0.18	0.12	0.22	0.20	0.10	0.06
80	0.31	0.29	0.15	0.10	0.19	0.18	0.09	0.06
90	0.21	0.20	0.11	0.08	0.15	0.14	0.07	0.05
100	0.08	0.08	0.04	0.03	0.06	0.06	0.03	0.02

Table 3 uses the alternative weight structure $w' = (1/2, 1/14, \ldots, 1/14)$, which first splits the weight between income and the other capabilities, then uses equal weights among the nonincome capabilities. Once again, a range of dimensional cutoffs and aggregation methods are employed. Let us look at the figures for the 50 per cent cutoff (reproduced here for convenience).

	Patrimony Cutoff				**Capability Cutoff**			
ω	**H**	**M_0**	**M_1**	**M_2**	**H**	**M_0**	**M_1**	**M_2**
50	**0.42**	**0.37**	**0.18**	**0.12**	**0.22**	**0.20**	**0.10**	**0.07**

The incidence of poverty with the patrimony cutoff is 42 per cent, which is just below the level obtained using equal weights. Interestingly, though, the differential weighting yields a higher adjusted headcount ratio M_0 of 0.37; the differential weighting causes the average share of deprivations A to rise to about 88%. The average gap G and average squared gap S fall to about 49% and 33%, respectively, resulting in lower values for M_1 and M_2. These smaller figures are likely picking up the fact that there is now less weight on the zero-one variables of health and social security. Now, with income having half the total weight in the identification and aggregation steps, we would expect the figures for the capabilities cutoff to be lower than with the equal weights case. Indeed, the overall incidence H is now just over 22%; with a lower cutoff in the income dimension, far fewer persons are identified as being poor. The average deprivation share A, however, rises to about 91%; hence, M_0 is reasonably close to H.

Table 4: Correlation Matrix

Attributes	**Income**	**Education**	**Health**	**Social Security**	**Dwelling**	**Other Services**	**Food**	**Cohesion**
Income	1.00							
Education	0.37	1.00						
Health	0.90	0.38	1.00					
Social Security	0.31	0.28	0.43	1.00				
Dwelling	0.43	0.34	0.40	0.20	1.00			
Other Services	0.30	0.31	0.31	0.27	0.36	1.00		
Food	0.44	0.28	0.40	0.12	0.32	0.16	1.00	
Cohesion	-0.17	-0.19	-0.20	-0.20	-0.16	-0.20	-0.11	1.00

Table 4 evaluates the population correlation between all pairs of deprivations. Notice the very high correlation between being deprived in terms of income and being deprived in terms of access to health services. Other notably high correlations are seen between deprivation in income and access to food, deprivation in access to health services and access to social security, and the two variables linked to dwellings. On the other hand, the specific variable representing social cohesion appears to behave perversely, in that deprivation in social cohesion is negatively related to every other deprivation. Is this unexpected? It may be reasonable to expect criminal activity to be reported more frequently in nonpoor areas, due to different reporting proclivities by the poor vs. the nonpoor. Or in fact there may be a natural tendency for certain forms of criminal activity to be more common in nonpoor areas than poor areas. There is no reason to expect reported criminal activity to be reflective of actual criminal activity, nor any reason to think that criminal activity is a particularly good indicator of social cohesion, even if measured correctly. Moreover, there is good reason to expect closer ties among poorer people; however, these forms of connections may not be the type that would be especially beneficial to the poor. Given the lack of justification for the specific variable, the limited confidence in its value for poverty measurement, and the difficulty of finding an appropriate replacement as an indicator of social cohesion, I will redo the analysis leaving out this variable.

Table 5: Poverty Levels with Equal Weight System Excluding Social Cohesion

	Patrimony Cutoff for Income				Capability Cutoff for Income			
ω Cutoff (%)	**Head Count**	**Adjusted Head Count**	**Adjusted Poverty Gap**	**Adjusted FGT**	**Head Count**	**Adjusted Head Count**	**Adjusted Poverty Gap**	**Adjusted FGT**
0	0.89	0.48	0.26	0.20	0.89	0.45	0.24	0.19
10	0.89	0.48	0.26	0.20	0.89	0.45	0.24	0.19
20	0.73	0.46	0.24	0.19	0.72	0.43	0.23	0.18
30	0.58	0.41	0.22	0.17	0.56	0.38	0.21	0.16
40	0.58	0.41	0.22	0.17	0.56	0.38	0.21	0.16
50	**0.46**	**0.36**	**0.20**	**0.16**	**0.42**	**0.32**	**0.18**	**0.14**
60	0.35	0.30	0.17	0.13	0.29	0.25	0.15	0.11
70	0.35	0.30	0.17	0.13	0.29	0.25	0.15	0.11
80	0.24	0.22	0.13	0.10	0.19	0.18	0.11	0.08
90	0.13	0.13	0.08	0.06	0.10	0.10	0.06	0.05
100	0.13	0.13	0.08	0.06	0.10	0.10	0.06	0.05

Table 6: Poverty Levels with Nested Weight System Excluding Social Cohesion

	Patrimony Cutoff for Income				Capability Cutoff for Income			
ω Cutoff (%)	**Head Count**	**Adjusted Head Count**	**Adjusted Poverty Gap**	**Adjusted FGT**	**Head Count**	**Adjusted Head Count**	**Adjusted Poverty Gap**	**Adjusted FGT**
0	0.89	0.46	0.22	0.15	0.89	0.36	0.18	0.13
10	0.73	0.44	0.21	0.15	0.72	0.34	0.17	0.12
20	0.59	0.42	0.20	0.14	0.56	0.32	0.16	0.11
30	0.49	0.40	0.19	0.13	0.42	0.28	0.14	0.10
40	0.44	0.38	0.19	0.13	0.32	0.25	0.12	0.09

50	**0.42**	**0.37**	**0.18**	**0.12**	**0.22**	**0.21**	**0.10**	**0.07**
60	0.41	**0.36**	**0.18**	**0.12**	0.22	0.21	0.10	0.07
70	0.38	0.35	0.17	0.12	0.22	0.20	0.10	0.07
80	0.33	0.30	0.16	0.11	0.20	0.19	0.09	0.06
90	0.24	0.23	0.13	0.09	0.17	0.16	0.08	0.06
100	0.13	0.13	0.07	0.05	0.10	0.10	0.05	0.04

Table 5 reports what happens when we use w^e and remove social cohesion from consideration as a dimension of poverty (so that each weight is now 1/7 rather than 1/8). The higher poverty values indicate the contrary effect that the social cohesion variable was having on the measured levels of poverty. This can also be seen in Table 6, where we return to the w^0 constellation of weights and delete the social cohesion variable – so that half of the weight is on income and the remaining weight is equally split among the six additional capabilities.

Table 7: Decomposition by Rural and Urban Area

Area	Population	Adjusted Head Count		Adjusted Poverty Gap		Adjusted FGT	
Urban	14208	0.27	45%	0.12	40%	0.08	39%
Rural	8966	0.52	55%	0.28	60%	0.20	61%
Total	**23174**	**0.36**	**100%**	**0.18**	**100%**	**0.12**	**100%**

One of the most important practical properties a measure of poverty can satisfy is population decomposability. As each member of the class of adjusted *FGT* indices satisfies subgroup decomposability, each may be used for evaluating regional poverty levels for targeting and other purposes. Table 7 provides one illustration of this where poverty is decomposed by rural and urban areas for a cutoff of $\boldsymbol{\omega}$ = 60% and the w^0 weights. The overall levels of poverty in Table 7 are identical to the three bold entries in the $\boldsymbol{\omega}$ = 60% row of Table 6. Clearly, Table 7 paints a picture of greater poverty in rural regions than urban; though the population is smaller, rural areas have a greater percentage contribution to overall poverty than urban areas.

Table 8: Dimensional Decomposition: Percentage Contribution by Each Dimension

Attributes	Adjusted Head Count	Adjusted Gap	Adjusted FGT
Income	56.9%	47.9%	38.9%
Education	6.4%	4.7%	3.8%
Health	7.3%	14.9%	22.0%

Social Security	6.3%	12.9%	19.1%
Dwelling	6.4%	4.2%	2.9%
Services (Utilities)	4.3%	2.8%	2.0%
Food	6.4%	6.0%	5.2%
Cohesion	6.1%	6.7%	6.2%

A second form of decomposability satisfied by the adjusted *FGT* measures is dimensional decomposability, which allows the contribution of each dimension to overall poverty to be calculated. This has been done in Table 8, once again for the case of ω = 60% and the w^{ρ} weights (with social cohesion included). In the first column, we see that the contribution of deprivations in income to the adjusted headcount is about 57 per cent, with the remaining dimensions sharing the rest. However, as we move to the adjusted gap and *FGT* measures, the impact of the zero-one variables of health and social security disproportionately rise. This suggests that there might be some difficulty in mixing zero-one variables with continuous variables when applying the latter two measures.

We noted above that given the nested weighting structure w^0 and a cutoff ω satisfying $\omega \leq \omega^0 = 50\%$, the adjusted headcount is the average of the income poverty, as measured by the traditional headcount ratio, and non-income deprivation, as measured by a special form of marginalization index ($M_0 = ½ H_y + ½ M_c$). Consequently, the new measure is partly based on H_y, which was the previous official poverty measure, and on the new marginalization measure M_c, which incorporates information about the extent of non-income deprivations among the poor.

Table 9: Decomposition by Income Headcount and Marginalization

Dimensional Cutoff = 0.50

States	Adjusted Headcount M_0	Rank	Income Headcount H_y	Rank	Marginalization M_c	Rank
Baja California Sur	0.124	1	0.15	1	0.098	1
Baja California	0.161	2	0.187	2	0.134	3
Distrito Federal	0.168	3	0.21	3	0.126	2
Nuevo León	0.188	4	0.221	4	0.156	4
Colima	0.219	5	0.267	5	0.17	5
Nayarit	0.26	6	0.302	6	0.219	6
Sonora	0.274	7	0.325	7	0.223	7
Querétaro de Arteaga	0.298	8	0.342	8	0.255	10
Aguascalientes	0.305	9	0.385	13	0.225	8
Quintana Roo	0.306	10	0.345	9	0.268	11
Chihuahua	0.31	11	0.349	10	0.27	12
Morelos	0.312	12	0.35	11	0.274	13
Coahuila de Zaragoza	0.324	13	0.399	14	0.249	9

Tamaulipas	0.328	14	0.379	12	0.276	14
Sinaloa	0.346	15	0.405	15	0.288	16
Estado de México	0.35	16	0.419	18	0.28	15
Jalisco	0.35	17	0.405	16	0.295	18
Guanajuato	0.356	18	0.418	17	0.295	17
Zacatecas	0.381	19	0.455	20	0.306	19
Tabasco	0.397	20	0.448	19	0.345	22
Yucatán	0.41	21	0.459	21	0.361	24
Durango	0.412	22	0.49	24	0.334	20
Michoacán de Ocampo	0.415	23	0.475	22	0.355	23
Tlaxcala	0.423	24	0.509	26	0.337	21
San Luis Potosí	0.429	25	0.475	23	0.382	25
Veracruz de Ignacio de la Llave	0.459	26	0.504	25	0.413	27
Puebla	0.464	27	0.521	28	0.407	26
Campeche	0.47	28	0.515	27	0.426	29
Hidalgo	0.475	29	0.531	29	0.42	28
Oaxaca	0.599	30	0.637	30	0.561	31
Chiapas	0.604	31	0.66	31	0.547	30
Guerrero	0.644	32	0.69	32	0.598	32

Table 9 provides an application of this decomposition using state data and the weighting structure w^0 and the dimensional cutoff ω^0 = 50% discussed above.[3] The first column gives the name of the state, listed in order from lowest to highest level of M_0. Column 2 contains the adjusted headcount ratio for the state and column three indicates the relative rank, where the state with the lowest level is given rank one. The next column lists the usual income poverty headcount ratio H_y, followed by the respective rank. Then the marginalization index M_c is given, followed by the rank for this partial index. The first aspect of interest in the table is the very strong association between the three indicators M_0, H_y, and M_c. Indeed, the numerical ranks are identical for M_0 and the income headcount ratio for 14 of the 32 states (primarily at the highest and lowest ranks). However, there are several notable cases where ranks are quite different. For example, Aguascalientes, has the 13th lowest income headcount ratio, but the 8th lowest in marginalization of the poor, leading to an overall rank of 9th in the adjusted headcount measure of poverty.

Table 10: Decomposition by Income Headcount and Marginalization

Dimensional Cutoff = 0.40

States	Adjusted Headcount M_0	Rank	Income Headcount H_y	Rank	Marginal-ization M_c	Rank

3 Again, I am ignoring whether the data are representative at the state level. This is simply an illustration of how the methodology might be applied if the data were available.

Baja California Sur	0.13	1	0.15	1	0.111	1
Distrito Federal	0.169	2	0.21	3	0.127	2
Baja California	0.173	3	0.187	2	0.159	3
Nuevo León	0.192	4	0.221	4	0.164	4
Colima	0.223	5	0.267	5	0.179	5
Nayarit	0.27	6	0.302	6	0.237	7
Sonora	0.282	7	0.325	7	0.238	8
Aguascalientes	0.308	8	0.385	13	0.231	6
Querétaro de Arteaga	0.309	9	0.342	8	0.277	10
Quintana Roo	0.315	10	0.345	9	0.285	11
Morelos	0.328	11	0.35	11	0.307	17
Coahuila de Zaragoza	0.329	12	0.399	14	0.259	9
Chihuahua	0.332	13	0.349	10	0.314	18
Tamaulipas	0.339	14	0.379	12	0.299	14
Sinaloa	0.347	15	0.405	15	0.289	13
Estado de México	0.353	16	0.419	18	0.287	12
Jalisco	0.356	17	0.405	16	0.307	16
Guanajuato	0.36	18	0.418	17	0.302	15
Zacatecas	0.392	19	0.455	20	0.328	19
Tabasco	0.403	20	0.448	19	0.358	22
Yucatán	0.417	21	0.459	21	0.374	23
Durango	0.421	22	0.49	24	0.352	21
Tlaxcala	0.426	23	0.509	26	0.343	20
Michoacán de Ocampo	0.427	24	0.475	22	0.38	24
San Luis Potosí	0.435	25	0.475	23	0.395	25
Veracruz de Ignacio de la Llave	0.468	26	0.504	25	0.432	28
Puebla	0.472	27	0.521	28	0.424	26
Hidalgo	0.48	28	0.531	29	0.43	27

Campeche	0.482	29	0.515	27	0.449	29
Oaxaca	0.607	30	0.637	30	0.578	31
Chiapas	0.611	31	0.66	31	0.561	30
Guerrero	0.653	32	0.69	32	0.617	32

Table 10 undertakes the same analysis, but uses a lower cutoff of ω = 40%. This has the effect of increasing the number of persons identified as poor, with all of the additional poor people being income sufficient, but non-income capability deprived. In Table 9, every poor person was either deprived in income or in all of the non-income capabilities. Lowering the dimensional cutoff from 50 per cent to 40 per cent permits a person who is deprived in five of the six non-income dimensions to be considered poor. Hence, this increases the number of the poor, as well as the value of the index of marginalization for the poor, but leaves the income headcount unchanged. A new, higher adjusted headcount level is given in column 2. Column 4 (the income headcount ratio) is unchanged, while column 6 (the marginalization index) has risen – in some cases dramatically. The change in cutoff has led to several changes in the rankings of the states according to the adjusted headcount ratio. For example, the Distrito Federal saw very little change in its level of M_c as a result of the change in cutoff; apparently, there are few people in the D.F. who are deprived in exactly five non-income dimensions. In contrast, the marginalization index for the poor in Baja California increased significantly and this in turn raised the overall adjusted headcount level to above that of the D.F. Chihuahua likewise rose dramatically in terms of the marginalization index, moving from the 12th best to the 18th best for this index, and thus going from 11th to 13th overall in terms of M_0.

Table 11: Decomposition by Income Deprivation and Marginalization

Dimensional Cutoff = 0.60

States	Adjusted Headcount M_0	Rank	Income Depriv. H_1	Rank	Marginal-ization M_c	Rank
Baja California Sur	0.117	1	0.138	1	0.097	1
Nuevo León	0.152	2	0.173	2	0.132	3
Baja California	0.161	3	0.197	4	0.125	2
Distrito Federal	0.172	4	0.192	3	0.152	4
Colima	0.213	5	0.257	5	0.169	5
Nayarit	0.252	6	0.287	6	0.217	6
Quintana Roo	0.267	7	0.312	7	0.222	8
Sonora	0.286	8	0.352	12	0.221	7
Morelos	0.296	9	0.338	9	0.254	10
Chihuahua	0.3	10	0.333	8	0.266	11
Querétaro de Arteaga	0.306	11	0.368	13	0.244	9
Aguascalientes	0.307	12	0.344	11	0.269	12
Coahuila de Zaragoza	0.308	13	0.343	10	0.273	13
Tamaulipas	0.326	14	0.376	14	0.275	14

Jalisco	0.338	15	0.4	17	0.277	15
Sinaloa	0.343	16	0.399	16	0.287	16
Guanajuato	0.344	17	0.395	15	0.294	18
Estado de México	0.348	18	0.403	18	0.293	17
Zacatecas	0.37	19	0.435	19	0.305	19
San Luis Potosí	0.39	20	0.437	20	0.343	22
Tabasco	0.402	21	0.472	24	0.332	20
Durango	0.406	22	0.453	21	0.36	24
Michoacán de Ocampo	0.411	23	0.467	23	0.354	23
Yucatán	0.413	24	0.491	25	0.334	21
Tlaxcala	0.422	25	0.464	22	0.38	25
Puebla	0.454	26	0.496	26	0.412	27
Veracruz de Ignacio de la Llave	0.457	27	0.509	27	0.405	26
Campeche	0.469	28	0.519	29	0.418	28
Hidalgo	0.47	29	0.515	28	0.426	29
Chiapas	0.596	30	0.631	30	0.56	31
Oaxaca	0.6	31	0.654	31	0.546	30
Guerrero	0.639	32	0.681	32	0.597	32

Table 11 increases the cutoff to $\omega = 60\%$, which has the effect of requiring a person to be deprived both in income and at least one other dimension in order to be identified as poor. Unlike the above two cases, it is no longer true that everyone who is income deprived is poor; consequently, the percentage of the population both income deprived and poor, namely H_1, is strictly less than the income headcount ratio H_y. In keeping with the dimensional decomposition, it is H_1 and not H_y that is listed in column 4. Moreover, as it is no longer possible to be poor purely on the basis of non-income deprivations, M_c is only measuring deprivations among the income deprived. The relevant decomposition is $M_0 = ½ H_1 + ½ M_c$, which is the formula explored in Table 11.

Notice that when $\omega = 60\%$ the values of M_0 and the constituent indices H_1, and M_c are all lower as compared to the cases where ω is 50% or 40%. The higher cutoff ensures there are fewer poor people and hence fewer positive entries are found in h^*. Consequently, the adjusted headcount must fall as well. However, the changes are not uniform across all states, and so the overall ranking of states by M_0 is altered by changing the cutoff. For example, as a result of changing the dimensional cutoff from $\omega = 50\%$ to $\omega = 60\%$, Nuevo León goes from the 4th to the 2nd spot in the ranking of least-poor states. It appears that many of the persons who were previously counted among the poor were purely income poor, because the incidence of income deprivation has fallen dramatically. In addition, there appears to have been a significant number of persons who were deprived in all non-income dimensions, since M_c falls dramatically when this group is excluded from the poor. This explains the improved position of this state.

Table 12: Statewise Poverty and Partial Indices

Dimensional Cutoff = 0.40

State	Head Count (Rank)	Adjusted Head Count (Rank)	Adjusted Gap (Rank)	Adjusted FGT (Rank)	A	G	S
Baja California Sur	0.165 (1)	0.130 (1)	0.052 (1)	0.034 (1)	0.79	0.40	0.26
Distrito Federal	0.212 (2)	0.169 (2)	0.065 (2)	0.042 (2)	0.80	0.39	0.25
Baja California	0.216 (3)	0.173 (3)	0.069 (3)	0.045 (3)	0.80	0.40	0.26
Nuevo León	0.230 (4)	0.192 (4)	0.086 (4)	0.057 (4)	0.83	0.45	0.30
Colima	0.278 (5)	0.223 (5)	0.089 (5)	0.059 (5)	0.80	0.40	0.26
Nayarit	0.324 (6)	0.270 (6)	0.127 (7)	0.088 (9)	0.83	0.47	0.33
Sonora	0.343 (7)	0.282 (7)	0.123 (6)	0.080 (6)	0.82	0.44	0.28
Quintana Roo	0.365 (8)	0.315 (10)	0.149 (11)	0.103 (13)	0.86	0.47	0.33
Querétaro de Arteaga	0.368 (9)	0.309 (9)	0.148 (10)	0.102 (11)	0.84	0.48	0.33
Morelos	0.390 (10)	0.328 (11)	0.150 (12)	0.101 (10)	0.84	0.46	0.31
Aguascalientes	0.393 (11)	0.308 (8)	0.130 (8)	0.084 (7)	0.78	0.42	0.27
Chihuahua	0.402 (12)	0.332 (13)	0.164 (16)	0.113 (17)	0.82	0.49	0.34
Tamaulipas	0.407 (13)	0.339 (14)	0.154 (13)	0.102 (12)	0.83	0.45	0.30
Sinaloa	0.407 (14)	0.347 (15)	0.165 (17)	0.112 (16)	0.85	0.47	0.32
Coahuila de Zaragoza	0.412 (15)	0.329 (12)	0.137 (9)	0.088 (8)	0.80	0.42	0.27
Jalisco	0.419 (16)	0.356 (17)	0.175 (18)	0.123 (19)	0.85	0.49	0.35
Guanajuato	0.426 (17)	0.360 (18)	0.163 (15)	0.108 (15)	0.84	0.45	0.30
Estado de México	0.427 (18)	0.353 (16)	0.157 (14)	0.105 (14)	0.83	0.45	0.30
Tabasco	0.464 (19)	0.403 (20)	0.192 (21)	0.130 (21)	0.87	0.48	0.32
Yucatán	0.475 (20)	0.416 (21)	0.185 (20)	0.125 (20)	0.88	0.44	0.30
Zacatecas	0.481 (21)	0.392 (19)	0.181 (19)	0.121 (18)	0.81	0.46	0.31
San Luis Potosí	0.490 (22)	0.435 (25)	0.238 (27)	0.171 (28)	0.89	0.55	0.39
Michoacán de Ocampo	0.505 (23)	0.427 (24)	0.212 (24)	0.146 (24)	0.85	0.50	0.34
Durango	0.512 (24)	0.421 (22)	0.209 (23)	0.143 (23)	0.82	0.50	0.34

Tlaxcala	0.517 (25)	0.426 (23)	0.195 (22)	0.132 (22)	0.82	0.46	0.31
Veracruz de Ignacio de la Llave	0.528 (26)	0.468 (26)	0.239 (28)	0.165 (27)	0.89	0.51	0.35
Puebla	0.542 (27)	0.472 (27)	0.237 (26)	0.164 (26)	0.87	0.50	0.35
Campeche	0.542 (28)	0.482 (29)	0.232 (25)	0.156 (25)	0.89	0.48	0.32
Hidalgo	0.542 (29)	0.480 (28)	0.260 (29)	0.188 (29)	0.89	0.54	0.39
Oaxaca	0.657 (30)	0.607 (30)	0.341 (30)	0.246 (30)	0.92	0.56	0.40
Chiapas	0.677 (31)	0.611 (31)	0.353 (31)	0.258 (31)	0.90	0.58	0.42
Guerrero	0.713 (32)	0.653 (32)	0.392 (32)	0.291 (32)	0.92	0.60	0.45

Each of the adjusted *FGT* multidimensional poverty indices is derived from a combination of the following partial indices: the headcount ratio H, the average deprivation share A, the average gap G, and the average squared gap S. Table 12 expands on the information available in Table 10 (where $\omega = 60\%$) to illustrate how these partial indices interact to determine the adjusted *FGT* indices and their associated rankings across states. The overall multidimensional headcount ratio is presented in the first data column, along with the rank (which is in consecutive order because states are ordered using H). Next, the level H is multiplied by the partial index A to obtain the adjusted headcount ratio M_0. Due to the variation in the average deprivation share across states, the ranking for M_0 is somewhat different to the ranking for H. For example, Aguascalientes is ranked 11th according to the headcount ratio, but it has the lowest average deprivation share across all states, and hence it has a much better rank according to the adjusted headcount ratio (8th). The next column gives the adjusted poverty gap M_1, which is obtained by multiplying M_0 by the partial index G. It is the differences in the levels of average shortfalls across the states that causes the ranks to be different between M_0 and M_1. For example, Coahuila de Zaragoza has a very low level of average gap G, and consequently its rank for M_1 (9th) is much better than its rank in terms of M_0, which is given in the final column of the table. Some states are characterized by especially severe deprivations or by unequally distributed deprivations, in which case the average squared gap S will be particularly large and the rank in terms of M_2 will be correspondingly worse. For example, Jalisco has a particularly high level of S, which is the reason that its rank in terms of M_2 (19th) is worse than its rank in terms of M_0 (17th).

Table 13: Poverty Levels with Nested Weight System Excluding Social Cohesion, Health, and Social Security

(Compare with Patrimony values in Table 5)

	Patrimony Cutoff for Income			
ω Cutoff (%)	**Head Count**	**Adjusted Head Count**	**Adjusted Poverty Gap**	**Adjusted FGT**
0	0.83	0.46	0.17	0.09
10	0.83	0.46	0.17	0.09

20	0.65	0.44	0.16	0.09
30	0.53	0.41	0.15	0.08
40	0.45	0.38	0.15	0.08
50	**0.41**	**0.36**	**0.14**	**0.08**
60	0.41	0.36	0.14	0.08
70	0.37	0.33	0.13	0.07
80	0.28	0.27	0.11	0.06
90	0.14	0.14	0.07	0.04
100	0.14	0.14	0.07	0.04

Finally, we briefly return to the question of zero-one variables in Table 13. Recall that as a result of the zero-one nature of the access to healthcare variable and the access to social security variable, there was some question as to the appropriateness of using these variables with the multidimensional poverty measures M_1 and M_2. In Table 13, these two variables (and the social cohesion variable) have been removed from the analysis. Now compare this to the first columns in Table 5. Clearly, there is a much greater gradient in the measured poverty levels in moving from M_0 to M_1 and then to M_2, and this is much more similar to the usual relationship between the values of the unidimensional measures P_0, P_1, and P_2. For example, compare both tables for the dimensional cutoff $\omega = 50\%$. Dropping the extra two dimensions leaves M_0 at the same level as before; however, M_1 is lower and M_2 is much lower than before. Indeed, the gradient is not dissimilar to the the gradient obtained for P_0, P_1, and P_2 in Table 1 for the income variable and the other less discrete variables. This suggests that the healthcare access and social security variables are responsible for inflating the values of M_1 and M_2 due to their zero-one nature.

V. References

Alkire, S. (2002), *Valuing Freedoms*, Oxford University Press, Oxford.
Alkire, S. and Foster J.E. (2007), 'Counting and Multidimensional Poverty Measures', mimeo, Oxford University.
Atkinson, A.B. (2003), 'Multidimensional Deprivation: Contrasting Social Welfare and Counting Approaches', *Journal of Economic Inequality*, 1:1.
Boltvinik, J. (1998), 'Poverty Measurement Methods – An Overview', Poverty Elimination Programme, UNDP.
Brandolini, A. and D'Alessio, G. (1998), 'Measuring Well-Being in the Functioning Space' mimeo, Banco d'Italia Reseach Department.
Bourguignon F. and Chakravarty S.R. (2003), 'The Measurement of Multidimensional Poverty', *Journal of Economic Inequality*, 1, 25-49.
Citro, C. F., and Michael, R. T. (1995), *Measuring Poverty: A New Approach*, Washington, DC: National Academy Press.
CONEVAL (2007), 'Nota Técnica sobre la Aplicación de la Metodología para la Medición de la Pobreza por Ingresos y Pruebas de Hipótesis 2006', Nota Técnica 001/2007, July 2007, Mexico City, Mexico.
Foster, J.E. (1998), 'Absolute versus Relative Poverty,' *American Economic Review*, Papers and Proceedings, Volume 88, May, pp. 335–341.
Foster, J.E., Greer, J., and Thorbecke, E. (1984), 'A Class of Decomposable Poverty Measures', *Econometrica*, 52, 761–765.
Foster, J.E. and Handy, C. (2007), 'External Capabilities,' Mimeo, Vanderbilt University.
Foster, J.E. and Sen, A. (1997), '*On Economic Inequality*: After a Quarter Century', Annex to Enlarged Edition of *On Economic Inequality* by A. Sen, Clarendon Press, Oxford.
Gordon, D., Nandy, S., Pantazis, C., Pemberton, S., and Townsend, P. (2003), 'The Distribution of Child Poverty in the Developing World', University of Bristol.
Mack, J. and Lansley, S. (1985), *Poor Britain*, George Allen & Unwin, London.
Nolan, B. and Whelan, C.T. (1996), *Resources, Deprivation and Poverty*, Clarendon Press, Oxford.
Roberts, F.S. (1979), *Measurement Theory, with Applications to Decisionmaking, Utility, and the Social Sciences*, Addison-Wesley, Reading, MA.
Sen, A.K. (1970), *Collective Choice and Social Welfare*, San Francisco, Holden-Day.
Sen, A.K. (1976), 'Poverty: An Ordinal Approach to Measurement', *Econometrica*, 44:2.
Sen, A.K. (1985), *Commodities and Capabilities*, Amsterdam, Elsevier.
Sen, A.K. (1992), *Inequality Reexamined*, Cambridge, MA, Harvard University Press.
Stewart, F. (1985), *Planning to Meet Basic Needs*, Macmillan.
Thorbecke, E. (2005), 'Multi-dimensional Poverty: Conceptual and Measurement Issues', mimeo, Cornell University.
Townsend, R. (1979), *Poverty in the United Kingdom*, Harmondsworth, Penguin.
Tsui, K.Y. (2002), 'Multidimensional poverty indices', *Social Choice and Welfare*,19, 69–93.