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Estimating Utility-Consistent Poverty Lines with Applications to Egypt and Mozambique

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I. Introduction

Poverty reduction has become one of the primary objectives of development assistance, and changes in poverty have become the dominant yardsticks by which development assistance and accompanying government action are measured. The stakes are high. In many poor countries, failure to reduce measured poverty levels over the medium term, either nationally or in significant subregions, would very likely catalyze widespread calls for major policy reform as well as country program reviews by donor organizations, including a reassessment of the overall level of assistance. In this environment, reasonably precise measures of poverty levels across space and changes in poverty levels through time are essential.

Poverty measurement is a complex and contentious subject with a large literature. This article concentrates on methods for setting consumption-based absolute poverty lines.[1] Poverty lines serve not only as a dividing line between

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[1] Further, we focus uniquely on utility-based approaches to poverty analysis. Sen's (1985) concept of functioning potentially provides an alternative philosophical grounding to the estimation of absolute poverty lines. Although utility consistency can be interpreted as one of the relevant functionings in Sen's framework (Ravallion and Lokshin 2005), this and other alternatives are not considered here.

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the poor and nonpoor but also as cost-of-living indexes, permitting interpersonal welfare comparisons when the cost of acquiring basic needs varies over time or space (Ravallion 1998). Demand systems estimation constitutes a direct approach to setting poverty lines; however, formidable practical barriers have limited application of this approach.[2] Instead, two major approaches to setting poverty lines are commonly used: the food-energy-intake approach (Dandekar and Rath 1971; Greer and Thorbecke 1985, 1986) and the cost-of-basic-needs (CBN) approach (Ravallion 1994, 1998; Ravallion and Bidani 1994; Ravallion and Sen 1996; Wodon 1997). We focus on the CBN approach, which estimates the cost of acquiring explicit basic consumption bundles.

Early applications of the CBN approach constructed poverty lines on the basis of a single national consumption bundle, evaluated at region-specific prices. In many instances—for example, if relative prices of basic commodities vary by region (or through time) and preferences permit substitution—the use of a single consumption bundle may yield inconsistent poverty comparisons (Tarp et al. 2002). To address this issue, recent literature accommodates region-specific bundles as well as region-specific prices when setting CBN poverty lines (Tarp et al. 2002; Gibson and Rozelle 2003; Mukherjee and Benson 2003; MPF/IFPRI/PU 2004; Datt and Jolliffe 2005; Ravallion and Lokshin 2006). In addition to potentially addressing the consistency problems arising from use of a single bundle, multiple bundles also enhance specificity by helping to ensure that the reference consumption bundle in a region is relevant to poor consumers in that region.

However, as is well known, the use of multiple bundles does not automatically resolve the issue of consistency. In particular, how does one ensure that each of the region-specific CBN consumption bundles provides the same level of utility? Gibson and Rozelle (1999) suggest application of revealed preference tests in an analysis of data from Papua New Guinea. Subsequently, revealed preference tests have also been applied to data from Egypt (this article), Mozambique (MPF/IFPRI/PU [2004], for two separate household surveys), and Russia (Ravallion and Lokshin 2006). As will be discussed in greater detail in the next section, satisfaction of revealed preference conditions is the exception rather than the rule. Ravallion and Lokshin (2006) propose a scalar adjustment process to reconcile the bundles with revealed preference theory but note that there is no guarantee that such a scalar adjustment exists; indeed, it does not exist for the Russian data in their study.

[2] Dorosh, del Ninno, and Sahn (1994) estimate poverty rates via demand systems estimation. Meyerhoefer, Ranney, and Sahn (2005) provide an overview of the issues associated with demand systems estimation and propose a new approach when panel data are available.

In short, poverty analysts face a quandary particularly in developing country environments where relative prices, and hence consumption patterns, can vary significantly through time or space. Use of a single bundle is often unsatisfactory from the perspective of both consistency and specificity. The obvious solution is to develop multiple bundles. However, attempts to develop multiple bundles using current best practices typically result in bundles that are demonstrably utility inconsistent, thus violating the fundamental premise that poverty lines should represent the same level of welfare.

In this article, we introduce an information-theoretic approach for estimating utility-consistent poverty lines and provide examples of the approach using survey data from Egypt and Mozambique. The method makes full use of the information available on consumption patterns from the survey data, while at the same time ensuring that the poverty line bundles are consistent with revealed preference conditions. The approach is feasible, even when the scalar correction proposed by Ravallion and Lokshin (2006) does not exist, and thus provides a general approach to ensuring the consistency of poverty comparisons across population subgroups or over time.

The article is organized as follows. Section II outlines the theoretical underpinnings of poverty lines, using the framework of constrained utility maximization. Section III presents a method, based on information theory, for reconciling CBN poverty lines with revealed preference conditions. Section IV briefly describes the methods used to estimate CBN poverty lines in Egypt and Mozambique and evaluates the utility consistency of the poverty lines. Section V presents adjusted poverty lines that are utility consistent. This section also discusses the extent of changes in measured poverty when the utility-consistent poverty lines are employed. Section VI summarizes and provides concluding remarks.

II. Poverty Lines and Utility Consistency

Poverty lines may reflect notions of either absolute poverty or relative poverty. The well-known dollar-a-day (adjusted for purchasing power parity) poverty line is an example of the former, while the European Union's benchmark of 60% of national median income is an example of the latter. Although many of the arguments and methods presented in this article apply to both types of poverty lines, the focus here is on absolute poverty. The concept of absolute poverty posits that there is a minimum acceptable standard of living below which one is considered poor and above which one is considered nonpoor. Furthermore, unlike basic needs vectors that define poverty on the basis of attainment of specific needs (e.g., food, housing, education), poverty lines measure, in monetary terms, the level of resources required to meet basic needs.

When comparing levels of absolute poverty between subgroups of a population, it is essential that the reference standard of living is fixed over the domain (spatial or temporal) of the comparison (Ravallion 1994, 1998). Ravallion and Bidani (1994) refer to this property as consistency: two individuals at the same welfare level should be considered equally poor. Another desirable characteristic of poverty lines is termed specificity, meaning that the poverty line should reflect local perceptions of what constitutes poverty (Ravallion and Bidani 1994).

Poverty lines are sometimes justifiably criticized as arbitrary dividing lines that transform the continuum of individual welfare into unrealistically discrete states of poor and nonpoor (Deaton 1997; Sahn 2001). Yet poverty lines have another important role as price or cost-of-living indexes, specific to low-income groups, that permit interpersonal welfare comparisons (Ravallion 1998). Stochastic dominance methods, which make poverty and welfare comparisons over a wide range of plausible poverty lines, can give a more complete picture than that obtained from a single set of poverty lines (Atkinson 1987). Yet, stochastic dominance analysis requires that the same welfare metric is used for comparing populations or subgroups. This is typically accomplished by mapping nominal consumption to real consumption using indexes derived from poverty lines, also known as the welfare ratio (Blackorby and Donaldson 1987).

The theory underlying absolute poverty lines is grounded in welfare economics and constrained utility maximization. In this context, the fixed standard of living represented by the poverty line is viewed as a level of utility associated with the minimally acceptable standard of living. We follow the approach of Ravallion (1998) and Ravallion and Lokshin (2006), which considers household i in subgroup j. The household has a vector of household characteristics x_{ij}, and household preferences are represented by a utility function $u_j(q_{ij}, x_{ij})$. The household chooses a consumption vector q_{ij} that maximizes utility given its characteristics and preferences. The household's expenditure function is written $e_j(p_{ij}, x_{ij}, u)$ and is defined as the minimum cost of achieving utility u in subgroup j given prices p_{ij} and household characteristics x_{ij}. The expenditure function permits mapping welfare from utility terms to a money metric. Specifically, the set of utility-consistent poverty lines associated with attaining the minimum acceptable standard of living, indicated by utility u_z may be written as

$$z_{ij}^{u} = e_j(p_{ij}, x_{ij}, u_z) \qquad \forall\ i, j. \tag{1}$$

As explained in Ravallion and Lokshin (2006), CBN poverty lines can be viewed as the expenditure needed to acquire a specific bundle of goods and an "ideal" utility-consistent poverty line can be written as

$$z_{ij}^{u} = p_{ij} q_{ij}(p_{ij}, x_{ij}, u_z). \tag{2}$$

The CBN poverty lines will be utility consistent if the underlying bundles of goods are on the Hicksian utility-compensated demand functions and hence yield the same level of utility u_z. Unfortunately, there are significant practical difficulties to ensuring that multiple bundles yield the same or even approximately the same level of utility. The theory of revealed preferences provides a framework for countering these difficulties.

The theory of revealed preferences applies the restrictions on rational consumer behavior postulated in microeconomic theory without imposing any specific form for preferences on individual behavior. Revealed preference restrictions rely on the assumption that consumers prefer consuming more rather than less (nonsatiation; Varian 1992). To begin, assume identical consumers who prefer more to less and whose preferences are defined on I ($i \in I$) commodities with each consumer living in a distinct spatial domain, r, among the set of spatial domains R ($r \in R$). We instruct these consumers to spend the minimum necessary in order to attain the same arbitrary level of utility. Prices potentially differ across spatial domains. Under these conditions, the following revealed preference conditions will hold:

$$\sum_i p_{ir} q_{ir'} \geq \sum_i p_{ir} q_{ir} \qquad \forall\ r, r', \tag{3}$$

where r' represents an alias index for the set of spatial domains R ($r, r' \in R$) and the variables p and q represent prices and quantities, respectively.

The logic behind this set of restrictions is as follows. For a given spatial domain r, the representative consumer in r has the opportunity to choose any bundle that delivers the required utility level. As this consumer is rational and prefers more to less, she will choose a cost-minimizing bundle, q_r. By cost minimization, the cost of any other bundle that delivers the same level of utility, evaluated at prices p_r, must be at least as much as the cost-minimizing bundle. Since, by assumption, the selected bundle in each spatial domain delivers the same utility level, condition (3) must hold for all possible pairs of spatial domains.

The application of conditions, such as those outlined in equation (3), to a group of bundles designed to represent the standard of living associated with a poverty line for particular spatial domains or particular points in time is both straightforward and highly attractive. From theory, we know that identical preferences are a sufficient condition for revealed preferences to hold.

However, the reverse condition is less strong. As Ravallion and Lokshin (2006) point out, the revealed preference conditions in equation (3) are necessary but not sufficient conditions for identical preferences. It is possible that the representative consumers mentioned above could have different preferences, yet all revealed preference conditions could still be satisfied. Rather than identical preferences, satisfaction of revealed preference conditions indicates the existence of a coherent preference set that rationalizes the observed behavior (Varian 1992).

The literature contains relatively few examples of revealed preference tests applied to poverty line bundles. The limited information available indicates that failures of revealed preference conditions occur more often than not. For example, an analysis by Ravallion and Lokshin (2006) divides Russia into 23 spatial domains with a separate bundle developed for each domain. This results in 506 (23×22) revealed preference conditions. These conditions fail nearly half the time. Only six of the 253 distinct pairs of bundles are mutually consistent, meaning that the revealed preference conditions are satisfied both when the two bundles, A and B, are evaluated at region B's prices and when the same bundles are evaluated at region A's prices. A strong temperature gradient between southern and northern Russia potentially influences the revealed preference results. However, confining the calculations to similar temperature zones does not resolve the problem. Gibson and Rozelle (1999) experience similar difficulties in Papua New Guinea. The original bundles developed for Mozambique and Egypt that are presented in Section IV also frequently violate revealed preference conditions and generate relatively few mutually consistent pairs.

III. Entropy Estimation

When confronted with failure of revealed preference conditions despite every effort at careful construction of the bundles, we posit that the poverty analyst has, in fact, reached a familiar juncture in experimental science. The analyst has used all available information to construct the bundles, yet the bundles fail to meet the minimum conditions necessary for making valid welfare comparisons. As all information has already been incorporated into the construction of the original bundles, no additional information exists, by definition, on which to base adjustment of the bundles in order to conform to revealed preference conditions.

This situation is regularly encountered in diverse areas of inquiry. Consider the following examples. (i) Despite careful collection of all available data after a year of economic activity, the national accountant is invariably confronted with a situation in which the raw data fail to respect basic macroeconomic identities. (ii) Having carefully collected data on the motion of particles, the physicist notes that these data do not completely respect accepted rules of motion. (iii) A crime lab receives a photo of the license plate of a car fleeing the scene of a robbery. Unfortunately, the image is blurry and the license plate cannot be read.

In all of these cases, the signal, despite the best attempts at observation, is noisy and fails to conform to what is required to be true. National accounts must respect basic macroeconomic identities. In order to make credible inferences, the physicist's data must conform to basic laws of motion. The license plate photo does not conform to what must be true about the license plate in question (e.g., the shape is rectangular with particular dimensions, the letters and numbers written on the plate are in block form, etc.). In all of these cases, relevant additional information would, without doubt, be useful. However, information is, at least for practical purposes, finite. At some point, the analyst is forced to obtain a coherent picture from the available information. The maximum entropy approach represents an information-theoretic approach to accomplishing this objective. As stated by physicists Buck and MacAulay (1991, ix), "the intention is to give a way of extracting the most convincing conclusions implied by given data and any prior knowledge of the circumstance."

Entropy approaches to estimation are motivated by information theory and the work of Shannon (1948), who defined a function to measure the uncertainty, or entropy, of a collection of events, and Jaynes (1957a, 1957b), who proposed maximizing that function subject to appropriate consistency relations, such as moment conditions. The maximum entropy (ME) principle and its sister formulation, minimum cross-entropy (CE), are now used in a wide variety of fields to estimate and make inferences when information is incomplete, highly scattered, or inconsistent (Kapur and Kesavan 1992). The basic philosophy of entropy estimation is to use all available information and no more.

In economics, the ME principle has been successfully applied to a range of estimation problems when limited data or computational complexity hinder traditional estimation approaches. Theil (1967) provides an early investigation of information theory in economics. Mittelhammer, Judge, and Miller (2000) provide a recent textbook treatment that is focused more tightly on the ME principle and its relationships with more traditional estimation criteria such as maximum likelihood. A special issue of the *Journal of Econometrics* edited by Golan (2002) focused on cutting-edge applications of the entropy principle.

In general, information in an estimation problem using the entropy principle comes in two forms: (1) theoretical or empirical information about the system that imposes constraints on the values that the various parameters to be estimated can take and (2) prior knowledge of likely parameter values. In the first form, the information is applied by specifying constraint equations in the estimation procedure. In the second, the information is applied by specifying a discrete prior distribution and estimating parameters by minimizing the entropy distance between the estimated and prior distributions—the minimum CE approach. The prior distribution does not have to be symmetric, and weights on each point in the prior distribution can vary. If the weights in the prior distribution are equal (e.g., the prior distribution is uniform), then the CE and ME approaches are equivalent.

In the application considered here, the revealed preference conditions represent the primary theoretical information that imposes constraints on the composition of the poverty line bundles. Data from household surveys, analyzed using the CBN approach, provide prior information on the composition of the poverty line bundles. Further information, such as minimum caloric requirements, can be imposed. An example of the basic approach for obtaining utility-consistent bundles is illustrated by the following constrained minimization problem:

$$\min_{q_{ir}, s_{ir}^{\text{ent}}} \sum_r \sum_i s_{ir}^{\text{ent}} \ln\left(\frac{s_{ir}^{\text{ent}}}{s_{ir}^{\text{orig}}}\right) \tag{4}$$

subject to

$$\sum_i p_{ir} q_{ir'} \geq \sum_i p_{ir} q_{ir} \qquad \forall\ r, r' \qquad r \neq r' \tag{4a}$$

$$s_{ir}^{\text{ent}} \sum_{i'} p_{i'r} q_{i'r} = p_{ir} q_{ir} \qquad \forall\ i, r \tag{4b}$$

$$\sum_i \text{calpg}_i q_{i1} = \text{cal} \tag{4c}$$

$$s_{ir}^{\text{ent}} \geq 0, \qquad s_{ir}^{\text{ent}} \leq 1, \qquad q_{ir} \geq 0 \qquad \forall\ i, r, \tag{4d}$$

where notation is carried forward from condition (3), which has now become constraint (4a). New or revised notation is as follows: s_{ir}^{ent} is budget shares of the entropy-adjusted bundle, s_{ir}^{orig} is budget shares of the original bundle, calpg_i is calories per quantity unit for each commodity i, cal is calorie requirement for all bundles, r, r' is an index of location in space or time, and i' is an alias index for i.

Equation (4) is the minimum CE objective.[3] The problem treats the expenditure shares from the original bundle as providing prior information on consumption patterns in the particular region or point in time. Prior information in the minimum CE framework classically comes in the form of probabilities associated with a discrete distribution. In the problem at hand, the expenditure shares are viewed as the probability that an arbitrarily small quantity of currency will be devoted to the purchase of good i. The objective minimizes the entropy distance between the adjusted and original budget shares. To satisfy the revealed preference constraints, the composition of the bundle—and consequently, the values of the budget shares—may need to be altered.

In brief, the approach imposes revealed preference conditions on the poverty bundles. From economic theory, we know that imposition of revealed preference conditions implies that the estimated bundles are consistent with at least one set of rational preferences. From information theory, we know that the approach preserves, to the greatest degree possible, the information content in the original budget shares, while satisfying the imposed constraints. These are desirable properties. Consistency with some arbitrary unknown preference set would appear to be a minimum condition for making utility-based welfare comparisons. The approach achieves this minimum and no more.

It is important to emphasize that the proposed procedure is the last step in developing CBN bundles and is only applied when the original bundles fail to satisfy conditions of utility consistency. Similar to the national accountant, the physicist, and the crime lab scientist mentioned above, the poverty analyst will apply the procedure only when all available information to draw poverty lines has been employed, yet the bundles remain utility inconsistent. It is also important to emphasize that, as an extension of the CBN method, other concerns related to the CBN method, such as constancy of preferences, quality of constituent goods in the bundle across regions, and other measurement issues, still apply.

Three further points merit mention. First, the objective (eq. [4]) is strictly convex. If all constraints were linear, the optimal solution would be a unique global minimum. However, as constraint equation (4b) is nonlinear, the feasible set is not guaranteed to be compact. Hence, the possibility of local optima must be admitted unless a proof of uniqueness, within the relevant range of the solution set, can be devised. Pending a proof, standard numerical methods

[3] In our empirical approach, if the original share, s_{ir}^{orig}, was equal to zero, then the adjusted share was set equal to zero. In the limit, $x \ln(x/x) = 0$ as x approaches zero. Numerically, these terms were simply dropped from the objective.

associated with nonlinear estimation (such as alternative starting values for variables and alternative algorithms for finding optimal solutions) should be employed to avoid local optima. In our empirical experience, the approach reliably converges to a unique optimum.

Second, note that equations (4a) and (4b) are both relative constraints that could hold for an infinite number of bundles. In order to determine a solution, at least one normalization equation is required. In the formulation above, equation (4c) constrains the calorie content of the bundle from region 1 to an arbitrary value. There are many alternatives. For example, one could constrain the nominal value of the poverty line in region 1 to be equal to the initial value. In practice, the choice of a single normalization equation is not likely to be an issue. Because of the traditional rooting of CBN poverty lines in calorie requirements, analysts are likely to impose calorie requirements in each region, rather than just one region. We return to this issue in the next section.

Finally, we note that, for the minimization problem presented in equation (4), the minimum possible value for the objective function is zero (Golan, Judge, and Miller 1996). This occurs when the adjusted shares (s_{ir}^{ent}) equal the original shares (s_{ir}^{orig}). Consequently, the approach also has the property that the scalar correction approach suggested by Ravallion and Lokshin (2006) will be the solution to the minimization problem in equation (4), if feasible, as it leaves the original budget shares intact (assuming the same single equation normalization procedure).

IV. Poverty Lines in Egypt and Mozambique

This section describes the household survey data from Egypt and Mozambique that are used in the empirical application of estimating utility-consistent poverty lines. It also outlines the approach used to estimate the original region-specific CBN poverty lines and provides tests showing violations of revealed preference conditions for the food poverty lines in both countries.

Data

The Egypt data are from the Integrated Household Survey (IHS) that was conducted from March through May 1997. It is a multipurpose household and community survey in the same vein as the World Bank's Living Standards Measurement Study (LSMS) surveys, including detailed information about household consumption of purchased and home-produced goods. The survey was carried out by the International Food Policy Research Institute in coordination with the Ministry of Agriculture and Land Reclamation and the Ministry of Trade and Supply. A two-stage stratified cluster sample design was used to select 2,500 sample households from 125 primary sampling units. Additional details about the survey and its characteristics are available in Datt, Jolliffe, and Sharma (2001).

The Mozambique data are drawn from the 1996–97 and 2002–3 rounds of the national household living standards survey (Inquérito aos Agregados Familiares sobre as Condições de Vida, or IAF96 and IAF02). These are nationally representative cross-sectional surveys conducted by the National Statistics Institute, also in the spirit of the LSMS surveys, and included detailed household consumption modules. A three-stage stratified cluster sample design was used for these surveys, with a sample of 8,250 households in IAF96 and 8,700 households in IAF02. Further details about IAF96 are presented in Simler et al. (2003), and additional information about IAF02 is available in MPF/IFPRI/PU (2004).

Setting CBN Poverty Lines

Egypt and Mozambique were chosen for the present analysis in part because very similar methods were used to estimate CBN region-specific poverty lines in each country. Each was divided into regions on the basis of similarities and differences in prices for basic commodities and consumption patterns among the poor. Adequacy of sample size in each region was also a consideration. In both countries, separate poverty lines were estimated for rural and urban areas within each region. In total, five poverty line regions were specified in Egypt and 13 in Mozambique, with the same delineation of regions used for both rounds of the Mozambique surveys. In each poverty line region, a basket of food products that satisfied basic calorie needs (WHO 1985) was identified using information on the age and sex composition of the household and the recorded consumption patterns of poorer households. The cost of this basket, valued at prices prevailing within each region, is the food poverty line in each region.[4] A nonfood poverty line was obtained for each region by calculating the share of food expenditures for households whose total food and nonfood consumption per capita was near the food poverty line. The total poverty line is obtained as the sum of the food and the nonfood poverty lines.

The original food, nonfood, and total poverty lines for Egypt are shown in table 1. They show that the cost of basic needs is highest in the metropolitan region and generally higher in urban areas than in rural areas, with the nonfood poverty lines accounting for most of the difference between regions.

[4] As pointed out by a referee, the food poverty line is often calculated as the cost of a calorie multiplied by the calorie requirement. This calorie is a "composite calorie" that is calculated from the observed consumption patterns of the poor. It is thus straightforward to extract the physical quantities and outlay for each item in the food bundle.

TABLE 1
ORIGINAL FOOD, NONFOOD, AND TOTAL POVERTY LINES IN EGYPT, 1997

	Poverty Line		
Region	Food	Nonfood	Total
Metropolitan	50.18	79.01	129.19
Lower urban	45.94	55.78	101.72
Lower rural	44.29	41.09	85.38
Upper urban	45.19	56.17	101.36
Upper rural	40.36	42.45	82.81

Source. Datt et al. (2001).
Note. Data are monthly per capita figures in Egyptian pounds.

In Mozambique, two methods were employed to obtain the food poverty line in 2002–3. The first method simply updated the food poverty line by calculating the cost of obtaining the same bundles as 1996–97 but at 2002–3 prices. The inherent appeal of this approach is that it seems reasonable to assume that the same bundle will provide the same utility (assuming no change in preferences), thus satisfying the consistency criterion. However, the survey data also showed considerable changes in the relative prices of basic foods between IAF96 and IAF02 and that poor consumers had adjusted their consumption patterns in response to the change in relative food prices. Ignoring these substitution effects tends to overstate the level of poverty lines and poverty rates.

The second method of updating the poverty lines for Mozambique was to create new food bundles based solely on consumption behavior of poor households in the 2002–3 survey. This method used the same procedure for constructing the poverty lines that was used in IAF96 and the Egypt IHS. As expected, the poverty lines were considerably lower than those obtained by repricing the IAF96 bundles because they incorporated substitution effects.

Food poverty lines for 1996–97 and 2002–3 in Mozambique are presented in table 2. We focus on the food poverty lines in this case both for reasons of space and because the tests for revealed preference consistency that follow are limited to the CBN food bundles. Several patterns are noteworthy. First, in nominal terms, the cost of the 1996–97 CBN food bundle doubled in most regions. Second, the interregional variability of food poverty lines is much greater than that observed in Egypt. As in Egypt, the rural food poverty lines tend to be lower than the urban food poverty lines. Like Egypt, there is also a north-south component to the levels of food poverty lines, with food poverty lines tending to increase as one nears the capital city (the regions in tables 1 and 2 are both ordered roughly from north to south). Third, when evaluated at 2002–3 prices, in most cases the bundles constructed from actual consumption behavior of the poor in 2002–3 cost less than the 1996–97 bundles,

TABLE 2
ORIGINAL FOOD POVERTY LINES IN MOZAMBIQUE, 1996–97 AND 2002–3

		2002–3	
Region	1996–97	Method 1	Method 2
Niassa and Cabo Delgado—rural	3,011	6,246	4,756
Niassa and Cabo Delgado—urban	3,687	7,857	7,717
Nampula—rural	2,742	5,277	2,752
Nampula—urban	3,642	8,275	3,749
Sofala and Zambézia—rural	3,719	5,175	3,548
Sofala and Zambézia—urban	5,370	7,483	5,902
Manica and Tete—rural	3,845	6,838	6,937
Manica and Tete—urban	5,548	11,176	9,656
Gaza and Inhambane—rural	4,971	6,858	5,438
Gaza and Inhambane—urban	5,714	7,461	6,613
Maputo Province—rural	5,418	11,801	12,584
Maputo Province—urban	6,047	11,898	13,741
Maputo City	6,192	12,224	13,211

Source. MPF/IFPRI/PU (2004).
Note. Data are daily per capita figures in Mozambican meticais. Method 1 data are 1996–97 bundles at 2002–3 prices; method 2 data are 2002–3 bundles at 2002–3 prices.

which is consistent with the substitution behavior noted earlier. This is most pronounced in Nampula. These differences stem from an across-the-board tendency to direct consumption toward less expensive products, including some products from the 1996–97 basket disappearing from the 2002–3 basket and some new products appearing in the basket in 2002–3 that were not present in 1996–97. Exceptions to this pattern, in Maputo Province and Maputo City, for example, correspond to failures in temporal revealed preference conditions, the issue to which we now turn.

Revealed Preference Tests

As noted earlier, in Egypt and Mozambique it is only the food poverty line bundles that have explicit information on goods, quantities, and prices. The nonfood poverty line bundles are determined from the nonfood budget shares, and their composition is not explicit. Thus, our tests for consistency with revealed preferences are limited to the food poverty lines, implicitly assuming that preferences are weakly separable over food items and other commodities. This assumption is common. Detailed information on nonfood items in the poverty line bundles is rare, especially in low-income countries. With adequate data, it is straightforward to extend these tests to situations in which the specific items and quantities underlying the nonfood poverty lines are available.

Starting with Egypt, table 3 shows the quantity index matrix for the food poverty lines in the five regions. The rows represent the region-specific quantities (bundles), and the columns represent the region-specific prices. For row i and column j, the off-diagonal elements indicate the cost of acquiring region

TABLE 3
REVEALED PREFERENCE TESTS FOR FOOD POVERTY LINES IN EGYPT, 1997

Region-Specific Bundles	Region-Specific Prices				
	Metropolitan	Lower Urban	Lower Rural	Upper Urban	Upper Rural
Metropolitan	1	1.003	1.022	1.021	1.151
Lower urban	1.018	1	1.030	1.041	1.163
Lower rural	1.061	.990	1	1.036	1.150
Upper urban	1.076	1.026	1.059	1	1.167
Upper rural	.977	.891	.918	.888	1

Source. Authors' calculations from Egypt 1997 Integrated Household Survey.
Note. Values less than one indicate failure of a revealed preference condition.

i's food poverty line bundle in region *j*, relative to the cost of acquiring region *j*'s own bundle.[5] The diagonal elements are equal to unity by definition. Violations of revealed preference conditions are indicated by off-diagonal elements less than unity. For example, at the prices prevailing in the lower urban region, consumers could have obtained the upper rural's food bundle while only spending 89% of what they would spend on their own food poverty line bundle. That they instead consume their own bundle indicates that the lower urban food bundle is preferred to the upper rural bundle, and the food poverty lines are not utility consistent. Of the 20 possible revealed preference comparisons in Egypt's five regions, 15 are consistent with revealed preferences. However, only five out of a possible 10 pairs are mutually consistent. In particular, the upper rural bundle appears to be inferior to all of the other bundles, as shown by the quantity index matrix.

The quantity index matrix for Mozambique's 2002–3 food poverty lines, focusing exclusively on spatial revealed preference conditions, is presented in table 4. Note that these are the food poverty lines calculated using method 2, which is based on prices and consumption behavior observed in 2002–3. These revealed preference tests pass only slightly better than half the time and with only nine mutually consistent pairs out of 78 possible. Note in particular that failures are consistently observed for Nampula rural, indicating a low-quality bundle in that domain. Consistent failures are also observed in Manica, Tete, and Maputo, indicating relatively high-quality bundles in those spatial domains.

In summary, estimated CBN food poverty lines in both countries are inconsistent with the theory of revealed preferences and are therefore not utility consistent. In each country, there is one region in which the poverty line food

[5] In both Egypt and Mozambique, we occasionally encountered situations in which price data were not available in region *j* for a commodity that appears in region *i*'s bundle. This can occur when the commodity in question is rarely consumed or traded in region *j*. In these cases we used the maximum price for that commodity among the regions that had price data for the commodity.

TABLE 4

SPATIAL REVEALED PREFERENCE TESTS FOR FOOD POVERTY LINES IN MOZAMBIQUE, 2002–3

	Region-Specific Prices												
Region-Specific Bundles	Rural Niassa and Cabo Delgado	Urban Niassa and Cabo Delgado	Rural Nampula	Urban Nampula	Rural Sofala and Zambézia	Urban Sofala and Zambézia	Rural Tete and Manica	Urban Tete and Manica	Rural Inhambane and Gaza	Urban Inhambane and Gaza	Rural Maputo Province	Urban Maputo Province	Maputo City
Niassa and Cabo Delgado—rural	1	.829	1.450	1.193	1.129	.952	.794	.655	1.026	.945	.519	.614	.756
Niassa and Cabo Delgado—urban	1.241	1	1.636	1.464	1.387	1.118	.925	.787	1.304	1.206	.699	.758	.780
Nampula—rural	.736	.579	1	.976	.819	.799	.438	.258	.865	.535	.278	.351	.537
Nampula—urban	1.026	.758	1.287	1	.862	.886	.645	.617	1.070	.821	.414	.570	.560
Sofala and Zambézia—rural	.965	.799	1.331	1.173	1	.925	.687	.527	.927	.768	.452	.512	.691
Sofala and Zambézia—urban	1.205	.959	1.532	1.429	1.253	1	.891	.725	1.164	1.030	.644	.595	.711
Manica and Tete—rural	1.423	1.136	1.723	1.923	1.435	1.312	1	.992	1.767	1.551	.988	1.114	.860
Manica and Tete—urban	1.627	1.272	2.052	1.888	1.707	1.510	1.133	1	1.671	1.532	.971	.948	.891
Gaza and Inhambane—rural	.937	.753	1.231	1.071	1.008	.949	.661	.513	1	.897	.814	.637	.679
Gaza and Inhambane—urban	1.070	.872	1.433	1.346	1.213	1.144	.804	.665	1.188	1	.780	.675	.715
Maputo Province—rural	1.493	1.337	2.063	2.042	1.797	1.606	1.051	.987	1.777	1.576	1	1.002	1.046
Maputo Province—urban	1.715	1.422	2.129	2.175	2.109	1.965	1.320	1.173	2.011	1.751	1.103	1	1.037
Maputo City	1.654	1.377	2.054	2.090	2.014	1.941	1.286	1.158	1.980	1.729	1.073	.966	1

Source. Authors' calculations from 1996–97 and 2002–3 Mozambique Inquérito aos Agregados Familiares sobre as Condições de Vida.
Note. Values less than one indicate failure of a revealed preference condition.

bundle appears to be inferior (superior) to that of all other regions. In these regions, the poverty lines represent a lower (higher) standard of living than the other regions, and poverty comparisons based on these poverty lines will understate (overstate) poverty in the regions with inferior (superior) bundles. Other violations of revealed preference conditions evident in tables 3 and 4 would lead to similar inconsistencies in poverty comparisons and affect the poverty profiles. In addition, for the Mozambican case, table 2 shows that some of the 2002–3 bundles fail temporal revealed preference conditions relative to the 1996–97 bundles, leading to inconsistent poverty comparisons through time. In the next section, we attempt to resolve these inconsistencies.

V. Obtaining Utility-Consistent Poverty Line Bundles and Poverty Comparisons

Before resorting to entropy estimation, we consider the scalar adjustment to the bundles described by Ravallion and Lokshin (2006). Recall that there is no guarantee that a scalar adjustment exists. A necessary condition for the existence of a set of scalar adjustments that will satisfy the revealed preference tests is that the products of all mirror-image off-diagonal pairs in the quantity index matrix are greater than or equal to unity, or $Q_{ij}Q_{ji} > 1$ for all mirror-opposite (i, j). Applying this rule to table 3, we see that this necessary condition is satisfied for Egypt's food poverty lines. Applying the same rule to the Mozambique Q matrix in table 4 reveals that the necessary condition for existence of such a scalar adjustment is not satisfied, similar to Ravallion and Lokshin's (2006) finding in Russia.

With respect to the scalar adjustment for Egypt, two issues remain. First, the scalar adjustments are not unique, so some guidance is required for selecting one set of scalar adjustments from a potentially large number of feasible candidates. This is exactly the normalization equation issue discussed with respect to equation set (4). Recall that, when the same single normalization equation is employed, the scalar adjustment method and the proposed entropy estimator converge to the same solution. Second, the scalar quantity adjustments imply changes in the caloric content of at least some of the food bundles, which were initially pegged to average calorie requirements in each region. Although altering the caloric content of the food bundles provides a means (in the case of Egypt) of achieving consistency with revealed preferences, it also negates a basic premise of the food poverty line bundles, which is that each provides exactly the average calorie requirements given the demographic composition of the region.

In short, there are severe limitations to the scalar adjustment approach. Importantly, the approach is frequently infeasible. And, when it is feasible, it is not really desirable as achieving revealed preference consistency requires caloric content inconsistent with the demographic composition of the region. In contrast, the proposed entropy approach is more general than the scalar adjustment approach. In addition, as indicated in the discussion of equation set (4), arbitrary levels of calories for each region can be targeted.

Obtaining Consistent Food Poverty Bundles via the Entropy Estimator

The exigencies of the specific cases require some specific adaptations to the simple generic estimator presented in equation set (4). For example, the Mozambique case study incorporates both intertemporal and spatial revealed preference conditions. That is, not only must the 2002–3 food poverty line bundle for region *i* cost no more than the food poverty line bundles from any region *j* (all evaluated at region *i*'s price vector), but it must also cost no more than the food poverty line bundle for region *i* that applied in the earlier period, 1996–97 (and vice versa). To obtain utility-consistent food bundles in the Mozambican case, we solve the following constrained minimization problem:

$$\min_{q_{ir}^{02},\, s_{ir}^{\text{ent}}} \sum_r \sum_i s_{ir}^{\text{ent}} \ln\left(\frac{s_{ir}^{\text{ent}}}{s_{ir}^{\text{orig}}}\right) \tag{5}$$

subject to

$$\sum_i p_{ir}^{02} q_{ir'}^{02} \geq \sum_i p_{ir}^{02} q_{ir}^{02} \qquad \forall\ r, r' \qquad r \neq r' \tag{5a}$$

$$\sum_i p_{ir}^{02} q_{ir}^{96} \geq \sum_i p_{ir}^{02} q_{ir}^{02} \qquad \forall\ r \tag{5b}$$

$$\sum_i p_{ir}^{96} q_{ir}^{02} \geq \sum_i p_{ir}^{96} q_{ir}^{96} \qquad \forall\ r \tag{5c}$$

$$s_{ir}^{\text{ent}} \sum_{i'} p_{i'r} q_{i'r} = p_{ir} q_{ir} \qquad \forall\ i, r \tag{5d}$$

$$\sum_i \text{calpg}_i q_{ir} = \text{cal} \qquad \forall\ r \tag{5e}$$

$$s_{ir}^{\text{ent}} \geq 0, \qquad s_{ir}^{\text{ent}} \leq 1, \qquad q_{ir} \geq 0 \qquad \forall\ i, r, \tag{5f}$$

where the basic notation is carried forward from equation set (4) with some revisions. The price and quantity variables now have superscripts corresponding to the year of the survey. Additional notation is as follows: s_{ir}^{ent} is budget shares of the entropy-adjusted bundle from 2002–3, s_{ir}^{orig} is budget shares of the original bundle from 2002–3, r, r' is an index of spatial domains (regions), and i, i' is an index of commodities.

Two points are worth noting. First, constraint (5e) requires that the bundles in each region yield the same level of calories. In other words, revealed preference consistent bundles are estimated under the assumption of constant demographic composition and, hence, constant calorie requirements, across all regions. To obtain the final bundles used for poverty measurement, these estimated bundles are rescaled to reflect differences in demographic composition and, hence, calorie requirements by region. As mentioned in the discussion of equation (4), the rooting of each region's bundles in calorie requirements is not strictly necessary for the estimation of utility-consistent bundles but follows current standard practice in the estimation of CBN bundles.

Second, practical considerations indicate that it is advisable to exclude Maputo Province and Maputo City (regions 11, 12, and 13) from the revealed preference conditions that compare bundles across space. This choice is motivated primarily by the large differences in the mode of living that exist in Maputo. In particular, cash income and cash requirements are much more important in Maputo than in other regions. Also, opportunities to earn cash are more readily available. As a result, people in Maputo City—including those from lower-income households—more frequently work outside the home and more frequently purchase services, such as prepared food or milled grain, than do people in other regions where these services are overwhelmingly produced within the home. The method employed to measure consumption counts all expenditures made outside the home but often ignores services produced and consumed at home, such as food preparation.[6]

This characteristic of the data helps to explain the nearly complete failure of revealed preference conditions in the Maputo columns of table 4. The failures might not be nearly so monolithic if the value of home-produced services implicit in the bundles from other regions were included using Maputo shadow values on labor. As the data do not permit estimation of this value, we chose instead to exclude Maputo from the spatial revealed preference conditions (the temporal conditions are imposed). This choice is also consistent with the

[6] This bias in consumption surveys is essentially the same as the bias in the national accounts, which exists in all countries. Home-produced/consumed goods, such as agricultural products, are valued while home-produced services, such as cooking and cleaning, are not.

analysis from 1996–97 in which revealed preference conditions for Maputo also failed badly.

Revealed preference comparisons for the entropy-adjusted food poverty lines for Mozambique are shown in table 5. All elements are now greater than or equal to unity, thus satisfying revealed preferences, as required by the constraints in the estimation procedure. Note that several of the off-diagonal elements are exactly equal to unity, meaning that consumers in region *i* can acquire region *j*'s food poverty line bundle for exactly the same cost as region *i*'s bundle. This occurs when one or more of the constraints are binding.

Table 5 also illustrates the percentage change in the value of the food poverty line brought about by the entropy-adjustment procedure. Some adjustment occurs in every region. Regions with more consistent revealed preference failures tend to experience a greater degree of adjustment. The poverty line is adjusted upward in four out of five rural zones. The most dramatic adjustment occurs in rural Nampula, which had failed all row-wise revealed preference tests, indicating a low-quality bundle.

Although the Egypt food poverty lines meet the necessary conditions for the existence of a scalar adjustment to satisfy revealed preference constraints, the entropy estimator can also be used to find utility-consistent food bundles. An advantage to using the entropy estimator is that, by including constraint (5e), revealed preference consistent bundles can be attained under the assumption of constant demographic composition across regions. When applying the entropy estimator to the Egyptian data, constraint (5b) and (5c) are dropped because intertemporal consistency is not an issue, and equation (5a) refers to quantities and prices in 1997, the year of data collection for Egypt. Table 6 presents revealed preference comparisons for the entropy-adjusted food poverty lines for Egypt and illustrates the percentage change in the adjusted food poverty line from the value showed in table 1.

Poverty Comparisons

How much do the changes in poverty lines affect poverty profiles? Using the same procedure for the original poverty lines described in Section IV, we estimated revised nonfood poverty lines to complement the utility-consistent food poverty lines estimated via the entropy method and scaled to reflect differential calorie requirements due to differences in the demographic composition of each region. The revised nonfood poverty lines differ from the original nonfood poverty line because the reference population used for computing the weighted average of the nonfood budget share changed because of the change in the food poverty lines. Poverty head-count estimates were cal-

TABLE 5

ENTROPY-ADJUSTED FOOD POVERTY LINES FOR MOZAMBIQUE, 2002–3: REVEALED PREFERENCE TESTS AND PERCENTAGE CHANGE

	Region-Specific Prices									
	Rural Niassa and Cabo Delgado	Urban Niassa and Cabo Delgado	Rural Nampula	Urban Nampula	Rural Sofala and Zambézia	Urban Sofala and Zambézia	Rural Tete and Manica	Urban Tete and Manica	Rural Inhambane and Gaza	Urban Inhambane and Gaza
Region-specific bundles:										
Niassa and Cabo Delgado—rural	1	1	1	1.060	1.065	1.013	1.090	1.060	1	1.075
Niassa and Cabo Delgado—urban	1.038	1	1	1.090	1.142	1	1.100	1.029	1.002	1.061
Nampula—rural	1.102	1.182	1	1.187	1.084	1.184	1	1	1.188	1.142
Nampula—urban	1.291	1.180	1.133	1	1	1.109	1.173	1.391	1.200	1.151
Sofala and Zambézia—rural	1.070	1.106	1.029	1.130	1	1.087	1.026	1	1	1
Sofala and Zambézia—urban	1.115	1.089	1	1.203	1.125	1	1.139	1.059	1.027	1.055
Manica and Tete—rural	1.120	1.358	1	1.778	1.006	1.257	1	1.372	1.709	1.488
Manica and Tete—urban	1.126	1	1.040	1.192	1.188	1.063	1.073	1	1.124	1.103
Gaza and Inhambane—rural	1.072	1.002	1	1.109	1.184	1.207	1.055	1	1	1.230
Gaza and Inhambane—urban	1.024	1	1	1.155	1.134	1.133	1.064	1	1.034	1
% change in food poverty line*	14.2	−2.3	62.5	29.5	17.1	11.7	−18.9	−26.0	21.6	9.8

Source. Author's calculations from Mozambique Inquérito aos Agregados Familiares sobre as Condições de Vida, 2002–3.

* Illustrates the percentage change in the value of the food poverty line due to adjustment relative to the value from table 2 (method 2).

TABLE 6
ENTROPY-ADJUSTED FOOD POVERTY LINES FOR EGYPT, 1997

Region-Specific Bundles	Region-Specific Prices				
	Metropolitan	Lower Urban	Lower Rural	Upper Urban	Upper Rural
Metropolitan	1	1.021	1.010	1.044	1.044
Lower urban	1.000	1	1.001	1.046	1.036
Lower rural	1.074	1.019	1	1.071	1.055
Upper urban	1.052	1.022	1.025	1	1.035
Upper rural	1.077	1.000	1.000	1.000	1
% change*	−1.2	−2.9	−.1	−3.4	8.9

Source. Authors' calculations from Egypt 1997 Integrated Household Survey.
* Illustrates the percentage change in the value of the food poverty line due to adjustment relative to the value from table 1.

TABLE 7
POVERTY HEAD-COUNT RATIO ESTIMATES FOR MOZAMBIQUE UNDER VARIOUS POVERTY LINES

Region or Province	1996–97	2002–3		
		Method 1	Method 2	Entropy-Adjusted Utility-Consistent Bundles
National	69.4	63.2	48.0	54.1
Urban	62.0	61.3	52.4	51.5
Rural	71.3	64.1	45.9	55.3
Niassa	70.6	61.2	45.6	52.1
Cabo Delgado	57.4	72.3	57.1	63.2
Nampula	68.9	68.1	30.5	52.6
Zambézia	68.1	58.6	35.1	44.6
Tete	82.3	71.6	70.8	59.8
Manica	62.6	60.2	58.5	43.6
Sofala	87.9	48.4	30.9	36.1
Inhambane	82.6	80.1	75.1	80.7
Gaza	64.6	58.6	47.1	60.1
Maputo Province	65.6	66.9	75.9	69.3
Maputo City	47.8	45.5	58.0	53.6

Source. Authors' calculations from 1996–97 and 2002–3 Mozambique Inquérito aos Agregados Familiares sobre as Condições de Vida.
Note. Method 1 data are 1996–97 bundles at 2002–3 prices; method 2 data are 2002–3 bundles at 2002–3 prices.

culated by comparing the new region-specific total poverty lines with nominal total household consumption per capita.

The Mozambique geographic poverty profile is shown in table 7. Estimates are shown for 1996–97 and for the three different approaches to estimating poverty lines for 2002–3. Comparison of the last two columns illustrates the effect of imposing revealed consistency conditions on the poverty line bundles estimated from the 2002–3 data. The most notable difference occurs in Nampula, whose poverty head count increases from 31% to 53% when utility consistency is imposed. Recall that rural Nampula's unadjusted food poverty lines failed all row-wise revealed preference tests in table 4 and therefore required considerable adjustment upward, which likewise increased the poverty

TABLE 8
POVERTY HEAD-COUNT RATIO ESTIMATES FOR EGYPT UNDER VARIOUS POVERTY LINES, 1997

	Original Poverty Lines	Entropy Adjusted (with Calorie Target)
National	26.5	26.4
Rural	29.1	30.3
Urban	23.1	21.2
Metropolitan	26.1	24.2
Lower urban	24.2	20.4
Lower rural	27.0	27.8
Upper urban	17.0	17.0
Upper rural	31.7	33.6

Source. Authors' calculations from Egypt 1997 Integrated Household Survey.

rates. Another notable difference is the 13-percentage-point increase in the poverty head count in Gaza province.

Because Nampula is a populous province—about one in five Mozambicans live there—and because it is predominantly rural, the changes in rural Nampula's food poverty line bundle have a strong ripple effect to higher levels of aggregation. For example, the poverty ranking of rural and urban areas is reversed when utility consistency is imposed, largely as a result of the large increase in poverty in rural Nampula. The national head count is also affected and is 6 percentage points higher (54% vs. 48%) with the utility-consistent poverty lines, a very substantial change. Qualitatively similar results are obtained for the poverty gap (P_1) and squared poverty gap (P_2) measures (results available from authors on request). When compared with other indicators of welfare, such as asset ownership, the poverty comparisons using the utility-consistent poverty lines appear to be much more credible than the results using the utility-inconsistent poverty lines. This is true not only for Nampula and the comparison of rural and urban areas but also for other interprovincial comparisons (see MPF/IFPRI/PU [2004] for further discussion of these comparisons).

The comparable results for Egypt are shown in table 8. As with Mozambique, the most noticeable changes are in the region that had the most serious revealed preference violations in the original poverty line bundles, which in Egypt's case is upper rural. When utility-consistent poverty lines are used, the poverty head count in upper rural increases by 2 percentage points. Urban areas that initially had superior bundles, namely, metropolitan and lower urban, see their head-count estimates adjusted downward by 2 and 4 percentage points, respectively. Overall, the difference in the poverty rates between rural and urban areas grows from 6 to 9 percentage points, with no net change in measured poverty at the national level. As in Mozambique, the changes in the estimates of P_1 and P_2 follow the same pattern as the changes in the head-count ratio (results available from the authors).

VI. Conclusions and Future Research

With the focus of international development resources increasingly turned toward poverty reduction, the demand for reliable empirical estimates of poverty levels has grown dramatically. Governments and donors are particularly interested in making valid poverty comparisons across space and through time. In fluid developing-country environments, generating these comparisons is challenging.

We present an information-theoretic approach for estimating utility-consistent poverty lines, which builds on the poverty measurement approaches developed by Ravallion (1994, 1998) and Ravallion and Lokshin (2006). Information theory is increasingly applied to numerous conceptually similar problems in empirical science across a variety of disciplines, and the practical application of this particular information-theoretic approach is quite straightforward.

The proposed approach is applied to recent survey data from Egypt and Mozambique. Revealed preference tests show that the poverty lines estimated through conventional means fail to satisfy this basic consistency criterion. These are not unusual cases. Gibson and Rozelle (1999) and Ravallion and Lokshin (2006) found similar revealed preference violations. Poverty measures obtained from utility-consistent poverty lines frequently differ substantially from those obtained using current best practices. We argue that these measures are preferred from a theoretical poverty measurement perspective. Empirically, the utility-consistent poverty estimates also conform more closely with other available information on correlates of poverty, such as asset ownership. Finally, in both country cases, poverty lines based on traditional methods for estimating CBN bundles that are not utility consistent tended to overestimate poverty in urban areas and underestimate it in rural areas.

By permitting the development of region-specific (or temporally specific) bundles that are consistent with revealed preference conditions, the approach enhances both consistency and specificity of CBN bundles. Overall, we conclude that the proposed approach represents a useful addition to the poverty analyst's toolkit and enhances the attractiveness of the CBN approach for practical poverty measurement problems.

Nevertheless, the research agenda for accurate poverty measurement remains ample. Only two examples are considered. First, as illustrated in the empirical applications, CBN bundles are typically composed uniquely of homogenous commodities, particularly food, with nonfood expenditures on items that vary dramatically in quality represented as a share of total expenditure. This approach imposes implicit preference constraints on the poverty comparisons. These constraints are present for all CBN bundles that treat sets of nonfood items as an aggregate. The entropy approach developed above is fully capable of including nonfood items. This potentially enhances the attractiveness of developing complete food and nonfood bundles, although the measurement challenges remain formidable.

Second, welfare equivalency of purchased bundles may vary with the environment. For example, Ravallion and Lokshin (2006) point out that welfare equivalent purchased bundles might vary from the southern edge to the northern edge of Russia uniquely because of home-heating needs. In other words, bundles that are the same in both price and quantity, with the exception of the fuel content, may be considered welfare equivalent, even though these bundles would fail revealed preference conditions. This can be ascribed to the role of fuel as an intermediate in the production (within the household) of a reasonably comfortable ambient temperature inside the home, which is the final good. Differences in the (unobserved) price of producing this good by latitude, and not necessarily differences in preferences, underlie the cost differences in achieving welfare equivalency. Flexibly adapting revealed preference conditions to handle this and similar issues remains on the agenda.

References

Atkinson, Anthony B. 1987. "On the Measurement of Poverty." *Econometrica* 55: 749–64.

Blackorby, Charles, and David Donaldson. 1987. "Welfare Ratios and Distributionally Sensitive Cost-Benefit Analysis." *Journal of Public Economics* 34:265–90.

Buck, Brian, and Vincent A. MacAulay, eds. 1991. *Maximum Entropy in Action*. Oxford: Clarendon.

Dandekar, V. M., and Nilakantha Rath. 1971. *Poverty in India*. Pune: Indian School of Political Economy.

Datt, Gaurav, and Dean Jolliffe. 2005. "Poverty in Egypt: Modeling and Policy Simulations." *Economic Development and Cultural Change* 53:327–46.

Datt, Gaurav, Dean Jolliffe, and Manohar Sharma. 2001. "A Profile of Poverty in Egypt." *African Development Review* 13:202–37.

Deaton, Angus. 1997. *The Analysis of Household Surveys: A Microeconometric Approach to Development Policy*. Baltimore: Johns Hopkins University Press for the World Bank.

Dorosh, Paul, Carlo del Ninno, and David E. Sahn. 1994. "Food Aid and Poverty Alleviation in Mozambique: The Potential for Self-Targeting with Yellow Maize." Cornell Food and Nutrition Policy Program Working Paper no. 50, Cornell University.

Gibson, John, and Scott Rozelle. 1999. "Results of the Household Survey Component for the 1996 Poverty Assessment for Papua New Guinea." Discussion paper, Poverty and Human Resources Division, World Bank, Washington, DC.

———. 2003. "Poverty and Access to Roads in Papua New Guinea." *Economic Development and Cultural Change* 52:159–86.

Golan, Amos. 2002. "Information and Entropy Econometrics—an Editor's View." *Journal of Econometrics* 107:1–15.

Golan, Amos, George G. Judge, and Douglas Miller. 1996. *Maximum Entropy Econometrics: Robust Estimation with Limited Data*. New York: Wiley.

Greer, Joel, and Erik Thorbecke. 1985. "Food Poverty Profile Applied to Kenyan Smallholders." *Economic Development and Cultural Change* 35:115–41.

———. 1986. "A Methodology for Measuring Food Poverty Applied to Kenya." *Journal of Development Economics* 24:59–74.

Jaynes, Edwin T. 1957a. "Information Theory and Statistical Mechanics I." *Physics Review* 106:620–30.

———. 1957b. "Information Theory and Statistical Mechanics II." *Physics Review* 108:171–90.

Kapur, J. N., and H. K. Kesavan. 1992. *Entropy Optimization Principals with Applications*. Boston: Academic Press.

Meyerhoefer, Chad D., Christine K. Ranney, and David E. Sahn. 2005. "Consistent Estimation of Censored Demand Systems Using Panel Data." *American Journal of Agricultural Economics* 87:660–72.

Mittelhammer, Ron C., George G. Judge, and Douglas J. Miller. 2000. *Econometric Foundations*. Cambridge: Cambridge University Press.

MPF/IFPRI/PU (Mozambique Ministry of Planning and Finance/International Food Policy Research Institute/Purdue University). 2004. "Poverty and Well-Being in Mozambique: The Second National Assessment." Report, Ministry of Planning and Finance, Maputo.

Mukherjee, Sanjukta, and Todd Benson. 2003. "The Determinants of Poverty in Malawi, 1998." *World Development* 31:339–58.

Ravallion, Martin. 1994. *Poverty Comparisons*. Chur: Harwood.

———. 1998. "Poverty Lines in Theory and Practice." Living Standards Measurement Study Working Paper no. 133, World Bank, Washington, DC.

Ravallion, Martin, and Benu Bidani. 1994. "How Robust Is a Poverty Profile?" *World Bank Economic Review* 8:75–102.

Ravallion, Martin, and Michael Lokshin. 2005. "On the Consistency of Poverty Lines." In *Poverty, Inequality and Development: Essays in Honor of Erik Thorbecke*, ed. A. de Janvry and R. Kanbur. Norwell, MA: Kluwer.

———. 2006. "Testing Poverty Lines." *Review of Income and Wealth* 52:399–421.

Ravallion, Martin, and Binayak Sen. 1996. "When Method Matters: Monitoring Poverty in Bangladesh." *Economic Development and Cultural Change* 44:761–92.

Sahn, David E. 2001. "Poverty Profile without Poverty Lines: Romania, 1994 to 1997." Cornell Food and Nutrition Policy Program Working Paper no. 118, Cornell University.

Sen, Amartya K. 1985. *Commodities and Capabilities*. Amsterdam: North Holland.

Shannon, Claude E. 1948. "A Mathematical Theory of Communication." *Bell System Technical Journal* 27:379–423.

Simler, Kenneth R., Sanjukta Mukherjee, Gabriel Dava, and Gaurav Datt. 2003. *Rebuilding after War: Micro-Level Determinants of Poverty Reduction in Mozambique*. IFPRI Research Report no. 132, International Food Policy Research Institute, Washington, DC.

Tarp, Finn, Kenneth R. Simler, Cristina Matusse, Rasmus Heltberg, and Gabriel Dava. 2002. "The Robustness of Poverty Profiles Reconsidered." *Economic Development and Cultural Change* 51:77–108.

Theil, Henri. 1967. *Economics and Information Theory*. Amsterdam: North Holland.

Varian, Hal R. 1992. *Microeconomic Analysis*. 3rd ed. New York: Norton.

Wodon, Quentin. 1997. "Food Energy Intake and Cost of Basic Needs: Measuring Poverty in Bangladesh." *Journal of Development Studies* 34:66–101.

WHO (World Health Organization). 1985. *Energy and Protein Requirements*. Technical Report Series 724. Geneva: WHO.