An Alternative Approach to Defining and Assessing Poverty Thresholds

James R. Blaylock and David M. Smallwood

This paper introduces a new method for defining poverty lines based on an individual's self-evaluation of the household's present situation. The proposed method focuses on the minimum household income necessary to purchase food supplies evaluated by society to be barely adequate. The method is especially useful for evaluating and comparing poverty thresholds derived from different methods. It is also valuable for comparing the official U.S. poverty guidelines across households of different sizes. The approach can be extended to include estimation of thresholds differentiated by various household characteristics and comparison of thresholds across these characteristics.

Key words: minimum household income, poverty, self-evaluation, threshold.

Poverty thresholds or guidelines are usually defined as income levels below which a household is classified as poor. A number of federal programs, including Head Start, national school lunches, and food stamps, use poverty guidelines as an eligibility criterion for program participation. In the United States, the measurement of poverty thresholds has remained virtually the same since they were first developed by Orshansky in the 1960s. Orshansky, using data from the U.S. Department of Agriculture's (USDA) 1955 Household Food Consumption Survey, observed that the average household of three or more persons spent approximately one-third of their after-tax income for food. The estimated cost of the USDA's 1961 economy food plan (a minimum food basket meeting then currently recommended dietary allowances) was then multiplied by three to derive poverty lines. The resulting thresholds, varying by size of household, the age and sex of the household head, and whether or not it was a farm or nonfarm household, were recognized in 1969 by the Office of Management and Budget as the official U.S. poverty guidelines. The official thresholds have undergone only minor definitional changes in the interim and are adjusted annually by the consumer price index (CPI).[1] In effect, these thresholds define as poor any household whose after-tax income is not sufficient to purchase a minimally adequate diet, assuming one-third of income is spent on food.

As noted by Wetzler and others, the Orshansky approach attempts to make a comparison of welfare which is based on an opinion of physical food needs rather than on the actual market behavior of households. One way to circumvent this criticism is to base the concept of poverty lines on observed Engel functions. This method, termed the "Food Poverty Line" (FPL) approach, has been illustrated, for example, by Love and Oja.

The above approaches have several characteristics in common. First, both methods require that a maximum food-spending-to-income ratio be provided from an exogenous source before a poverty threshold can be established. Second, it is interesting that both methods focus on the proportion of income spent on food as a measure of the general welfare of households. The basic underlying assumption is, of course, that households who spend equal fractions of their income on food are, on the average, equally well off.

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[1] For example, the distinction between farm and nonfarm households was dropped in 1981.

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A unique approach to defining poverty lines has been proposed by Goedhart et al. with extensions given in van Pragg, Spit, and van de Stadt. The underlying premise of this so-called Leyden method is that individuals themselves are the best judge of their own situations. Essentially, the method is based on a household's self-evaluation of alternative income levels via an "Income Evaluation Question" (IEQ). The IEQ asks respondents to list various income levels that they would regard as very bad, bad, very insufficient, etc. Using the answers to this question and data on the respondent's actual after-tax income, poverty thresholds can be developed which correspond to certain welfare levels. The major advantage of this method is that the subjective evaluation of poverty levels is made by individuals in society rather than government officials. The major drawback is centered on the issue of whether or not an individual is capable of ascertaining an income level which would be, for example, barely sufficient for the respondent's family. Furthermore, an individual's current income is probably a major factor influencing his/her responses to the IEQ.

In this paper, a different approach to defining and estimating poverty lines is proposed. This method is related to the Leyden approach in that it is based on an individual's self-evaluation of his household's present situation. However, the self-evaluation is not of alternative income levels per se but of the adequacy of home food supplies in terms of the quantities and kinds of food desired.[2] This approach has advantages over the Leyden, FPL, and Orshansky methods. First, it is probably easier for an individual to assess the adequacy of his current at-home food supplies than it is to give hypothetical income levels necessary to achieve a certain level of satisfaction. Second, individuals can probably evaluate their food supplies more easily than government officials or experts can cite income levels or maximum food spending to income ratios that are barely sufficient for households to purchase a predetermined level of food supplies. Last, as the proposed approach is related to food adequacy, it has common ground with the method currently used to establish poverty thresholds. Clearly, however, all of these methods are subjective.

Like the Orshansky, FPL, and Leyden methods, the proposed procedure does not contain endogenous criteria for the selection of a unique poverty line. The proposed method focuses on the minimum household income necessary to purchase food supplies which are evaluated in society as barely adequate. Consequently, a set of poverty lines (i.e., income levels) can be developed which are direct measures of welfare (with respect to food) as opposed to the indirect measures represented by the FPL and Orshansky approaches. One immediate and important use of the proposed method is to provide information to policy makers about the likelihood that households at or below the official poverty thresholds have an adequate/inadequate food supply.

The following section briefly outlines the calculation of food poverty lines and develops the proposed method. The third section contains a simple empirical example and draws comparisons between poverty lines estimated from alternative methods. The paper concludes with a brief summary and conclusions.

Poverty Lines

The food ratio is defined as E_f/y where E_f denotes food expenditures and y represents after-tax household income. Engel's law states that this ratio declines as income increases. On the other hand, as household welfare increases with income, the food ratio can be viewed as a proxy for household welfare. Given a critical food ratio, θ, the food poverty line, $y^*(\theta)$, is derived from the following relation

$$E_f(y^*, HS)/y^* = \theta \tag{1}$$

where food expenditures are a function of income and household size (other household characteristics or adult equivalent scales could be incorporated, but for the purposes of this paper the models are kept intentionally simple). The policy control variable in the FPL method is θ, the critical food ratio. The FPL approach assumes that a household is poor if the ratio of food expenditures to income is greater than a specified proportion, θ. Using Engel's law and holding household size constant, the lower the critical food ratio the higher the minimum income level necessary for a household to be above the poverty threshold.

[2] The definition of diet adequacy in the Orshansky method relates to a nutritionally adequate food supply, while the definition using our method relates to sufficient quantities and the kinds of foods desired.

An Engel curve that is logarithmic in expenditures, income, and household size can be written as

$$\ln(E_f) = \alpha_0 + \alpha_1 \ln(HS_i) + \alpha_2 \ln(y). \tag{2}$$

Combining equations (1) and (2) yields the level of income (i.e., poverty threshold) that is necessary for a given size household to have the necessary purchasing power to be at the critical food spending ratio θ:

$$\ln(y^*) = [\alpha_0 + \alpha_1 \ln(HS_i) - \ln(\theta)]/[1 - \alpha_2]. \tag{3}$$

Given parameter estimates of the Engel curve in (2) and a value for θ, equation (3) can be used to calculate a poverty line for a given household size. For alternative values of θ and a fixed household size, a set of poverty lines can be estimated.

Orshansky's method can be specified mathematically as

$$y^* = C_{EFP}/\theta \tag{4}$$

where C_{EFP} is the cost of the economy food plan for a given household size. The policy control variable, θ, is the ratio of the cost of the food plan to income. As stated earlier, Orshansky selected a value of one-third for this ratio.

In the 1977–78 Nationwide Food Consumption Survey, the source of data for this analysis, respondents were asked to evaluate the adequacy of their food supplies.[3] In particular, respondents were asked the question, "Which of the following statements best describes the food eaten in your household?"

A. Enough and the kinds of food we want to eat
B. Enough but not always what we want to eat
C. Sometimes not enough to eat
D. Often not enough to eat.[4]

We grouped the responses into three ordered food supply categories (worst to best): inadequate (responses C and D), barely adequate (B), and fully adequate (A), from which an "Index of Adequacy" (IA) can be constructed as follows. First, the underlying measurement model for IA is specified as

$$\begin{aligned} IA_i &= \beta_0 + \beta_1 \ln(HS_i) + \beta_2 \ln(Y_i) + \epsilon_i \\ &= X_i\beta + \epsilon_i, \qquad E(\epsilon_i | X_i) = 0, \\ &\qquad\qquad i = 1, \ldots, N, \end{aligned} \tag{5}$$

where N is the number of households in the sample, IA_i is a latent variable, Y and HS are household after-tax income and size, respectively, β_0, β_1, and β_2 are parameters, and ϵ is a standard normal error term. A household belongs to the first category (inadequate) if the latent variable is below some threshold, say $IA_i < \lambda_1$, in the second (barely adequate) if $\lambda_1 < IA_i < \lambda_2$, and in the third (fully adequate) if $IA_i > \lambda_2$. Thus, a household's "Index of Adequacy" is determined by a nonstochastic component, which is a function of income and household size, and an unobserved random component. Without loss of generality, the mean of the index is scaled such that $\lambda_1 = 0$ and $\lambda = \lambda_2 - \lambda_1$. Given this specification, the ordered probit model is an appropriate estimation technique (see Maddala for the specifics of estimating ordered probit models).

The proposed poverty threshold is defined as the minimum income that enables a given size household to purchase food supplies that are evaluated in society with probability $1 - \Phi$ of being at least barely adequate. This is equivalent to defining the threshold as the minimum income necessary to purchase food supplies that have probability Φ of being inadequate. This can be developed mathematically by noting that

$$\text{Prob}(IA < 0) = \int_{-\infty}^{0} f(u - X\beta)\, du = \Phi,$$

and by the change of variable technique

$$\text{Prob}(IA < 0) = \int_{-\infty}^{-X\beta} f(u)\, du \quad \text{or} \quad \Phi = F(-X\beta) \tag{6}$$

where $f(\cdot)$ and $F(\cdot)$ are the standard normal density and probability functions, respectively. Invoking the inverse function theorem,

$$\begin{aligned} F^{-1}(\Phi) &= -X\beta \\ &= -\beta_0 - \beta_1 \ln(HS) - \beta_2 \ln(Y) \end{aligned}$$

[3] The Orshansky, FPL, and our approach all rely on the accuracy of reported household survey information for their estimations. For example, the Orshansky method uses reported household income and food expenditures as well as other information as reported in the 1955 Household Food Consumption Survey. The FPL method uses households' reported information on food expenditures, income, and household size. Our method uses household reported income, household size and response to the food supply adequacy question. Inaccurate information, such as underreporting of income in the surveys, will influence the estimation of poverty thresholds from all three methods. The USDA food surveys are oriented towards at-home food use which makes it very difficult to devise methods for verifying information on variables such as income and answers to the food supply adequacy question. Results from all of the methods should be interpreted with the accuracy of the data kept in mind.

[4] The respondent's evaluation of food supplies is assumed to reflect that of all household members.

and subsequently solving for Y yields the poverty threshold,

$$(7)\quad Y_{min} = \exp\{[F^{-1}(\Phi) + \beta_0 + \beta_1 \ln(HS)]/-\beta_2\}$$

where Y_{min} is the minimum income necessary to purchase food supplies that are evaluated as inadequate with a probability equal to Φ. Consequently, for a given household size and Φ, households are defined as poor if actual after-tax income, Y, is less than Y_{min}. The exogenous policy control variable using this definition of poverty is Φ. Using (7), a set of poverty thresholds for a given household size can be derived for alternative probability or likelihood levels. Likewise, given Φ, poverty thresholds for households of different sizes can be computed. Given Y_{min} (such as the Orshansky threshold) and household size, one can also solve (7) to estimate the probability of an inadequate evaluation associated with this income level. The latter feature makes the "Index of Adequacy" approach especially useful for comparing poverty thresholds derived from alternative procedures.

From (7), it is easily shown that the change in Y_{min} required for a household to remain on a selected poverty contour—that is, have the same probability of an inadequate evaluation—for a change in household size can be approximated by

$$(8)\quad \partial Y_{min}/\partial HS \cong -(\beta_1/\beta_2)(Y_{min}/HS).$$

Empirical Results

The NFCS contains data on food expenditures, household characteristics, income, and many other variables on 14,000 households. Approximately 3%, 24%, and 72% of the households indicated that they had an inadequate, barely adequate, and fully adequate food supply, respectively. The Engel curve used to estimate the FPL specified that log weekly household food expenditure, less alcoholic beverages, is a function of log household size and log after-tax weekly income. Estimated parameters of the Engel relation are

$$(9)\quad \ln(E_f) = \underset{(.03)}{2.271} + \underset{(.01)}{.727}\ln(HS) + \underset{(.01)}{.113}\ln(Y), \qquad R^2 = .54,$$

where the numbers in parentheses are standard errors. Using these parameters and the formula given in equation (3), poverty thresholds can be calculated for alternative values of θ.

The ordered probit model for the "Index of Adequacy" is specified as a function of the same independent variables as the Engel curve in (9). The model estimates are

$$(10)\quad IA = \underset{(.08)}{-.710} - \underset{(.03)}{.424}\ln(HS) + \underset{(.02)}{.611}\ln(Y), \qquad \lambda = \underset{(.03)}{1.376},$$

where the numbers in parentheses are asymptotic standard errors. All parameters are of the correct sign and highly significant. The significance of λ confirms the ordered specification (Pitt and Rosenzweig).

Table 1 presents poverty lines (differentiated by households of sizes 3, 4, and 5) calculated from the FPL method for different food ratios as well as the official thresholds derived from the Orshansky procedure.[5] All lines are expressed in 1978 dollars. Also presented are the probabilities of alternative food supply evaluations occurring for each poverty line as estimated from the "Index of Adequacy" method. The probabilities were calculated by inserting the estimated coefficients in (10) and the appropriate income threshold into equation (7).

The Orshansky method indicates that an income of $5,175 is necessary for a three-person household to purchase adequate food supplies (measured by the economy food plan). Alternatively, the FPL method, assuming a food ratio of one-third, implies that the poverty threshold for the same household is $5,720. At these thresholds, the "Index of Adequacy" method indicates that there are probabilities of 5.1% and 4.5%, respectively, of inadequate food supply evaluations occurring. In other words, the *IA* method estimates a 13% increase in the probability of an inadequate food supply if the poverty threshold is set at $5,175 rather than $5,720. Using the FPL method, the poverty threshold associated with a food ratio of .25 and a household size of three is $7,902. By comparison, our method reveals that the probability of an inadequate food supply at this income level is .029 or 43% lower than the

[5] The Orshansky thresholds were taken from "Characteristics of the Population Below the Poverty Level: 1979," series P-60, issued December 1981, Bureau of the Census. The thresholds are for all households regardless of the sex of the household head or urban location of household residence.

Table 1. Food Poverty and Orshansky Thresholds with Index of Adequacy

Household Size	Index of Adequacy	Food Ratio .333	Food Ratio .300	Food Ratio .275	Food Ratio .250	Orshansky Method
		Poverty Thresholds and Probabilities				
3		$5,720	$,6434	$7,097	$7,902	$5,175
	Prob($IA > \lambda$)	.625	.652	.674	.692	.603
	Prob($0 < IA < \lambda$)	.330	.310	.293	.276	.347
	Prob($IA < 0$)	.045	.038	.034	.029	.051
4		$7,240	$8,145	$8,984	$10,004	$6,632
	Prob($IA > \lambda$)	.633	.659	.681	.705	.610
	Prob($0 < IA < \lambda$)	.324	.304	.287	.267	.341
	Prob($IA < 0$)	.043	.037	.032	.028	.049
5		$8,694	$9,779	$10,787	$12,011	$7,845
	Prob($IA > \lambda$)	.641	.666	.688	.709	.614
	Prob($0 < IA < \lambda$)	.319	.299	.281	.264	.338
	Prob($IA < 0$)	.041	.035	.031	.027	.048

Note: Prob($IA > \lambda$) is the probability of a fully adequate food supply; Prob($0 < IA < \lambda$) is the probability of a barely adequate food supply; and Prob($IA < 0$) is the probability of an inadequate food supply.

corresponding probability at the Orshansky threshold.

From table 1, it is readily seen that the probability of an inadequate food supply associated with any particular food ratio or the Orshansky threshold declines as household size increases. This is because the FPL and Orshansky methods do not fully account for voluntary substitutions between food and nonfood expenditures that a household makes with changes in family size. Compared to the *IA* approach, the FPL and Orshansky procedures overestimate the cost of an additional person. For example, using equation (8) and the Orshansky threshold for a three-person household as a reference point, it follows that

$$-(\beta_1/\beta_2)(Y_{min}/HS) = (.424/.611)(\$5,175/3) = \$1,197,$$

which is the cost of an additional person using the *IA* method. The cost of an additional member to a three-person household using the Orshansky threshold is $1,457, or $260 more than the amount indicated by the *IA* approach. This implies that larger households are on a higher poverty contour than smaller households. Equity considerations may require that all households, regardless of size, be on the same poverty contour—implying that the probability of an inadequate food supply occurring should be the same for all households. This can be accomplished, for example, by using the *IA* approach to adjust the thresholds derived from the other methods.

Of course, given a probability criterion for a socially or politically acceptable incidence of inadequate food supplies, the proposed procedures can be used to calculate poverty thresholds for a given household size. For example, if a probability of 2.5% of an inadequate food supply occurring is reasonable, then from equation (7), the poverty threshold for a three-person household is estimated to be $8,809. Conversely, at a one percent probability level, the poverty threshold for the same household is $16,140.

Summary and Conclusions

The proposed method for examining poverty thresholds is attractive because it allows probability statements to be made about the adequacy of food supplies at alternative income levels in society. This provides more information to policy makers than a subjective judgment about the proportion of income to be spent on food.

Perhaps the most useful characteristic of the proposed method is that it permits the comparison of poverty thresholds calculated from different methods. This was illustrated by comparing the food poverty line and Orshansky thresholds. Also, the method allows comparison of welfare levels, in terms of the probability of an inadequate food supply, across households of different sizes. The proposed method can be generalized to include other

household socioeconomic characteristics (e.g., region and urban location of residence) and adult equivalent scales. Extending the approach in this way would allow comparisons of welfare levels across various household characteristics.

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