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AN ECONOMETRIC APPROACH TO THE MEASUREMENT OF POVERTY

By MEGHNAD DESAI *and* ANUP SHAH

Abstract

This paper presents a method for specifying and measuring poverty defined as relative deprivation. We base our measure of an individual's poverty on the distance between his/her consumption experience relative to the norm. Consumption experience is defined in terms of events and the modal frequency of an event in the community defines the norm. Aggregation over events is made to capture the objective as well as subjective nature of deprivation. Our measure is related to that proposed by Townsend and econometric estimation is carried out using the Townsend data. Income is found to be neither the sole nor the most important indicator of deprivation.

ANY attempt to measure poverty runs into some familiar questions. First is the problem of definition. Do we mean by poverty some absolute state of existence at or below subsistence, visible to the naked eye or do we mean a state where some members of a community are relatively worse off? If the former, what determines the shopping list of minimum subsistence needs that must be met which will give us the cut-off point—the poverty line? If the latter, is there any way to avoid sinking into a morass of relativity and end up by defining poor in terms of subjective/ideological/policital criteria?

These questions are in some sense perennial and worse, difficult even to pose clearly. Notions of subsistence get revised in light of changing circumstances and "historical and moral elements" are brought to bear in such upward revision. A range of interpersonal variation in subsistence norms is easy to demonstrate even in such a basic need as nutrition [Sukhatme (1978), Srinivasan (1982)]. For relative deprivation, it is even more difficult to be precise once we disassociate the notion of poverty from that of subsistence or need. It is necessary however, to the extent possible, to reduce the element of personal bias and judgement involved and make the conceptual basis of the definition of poverty clear and its measurement adequate. In this paper we seek to do that with respect to the notion of *poverty as relative deprivation.*

Our reasons for choosing the relative definition should be made clear at the outset. For developed economies at least, poverty as relative deprivation is a notion that has gained increasing currency though its universal applicability across all countries, rich or poor, remains debatable [see Townsend (1962) (1979) for a defence of this notion. See Sen (1983) for a championing of the absolute poverty definition and Sen (1985a), Townsend (1985) for a subsequent debate]. As instances of absolute starvation become

rare enough in developed economies to be really shocking, the appeal of any redistributive policy which aims to reduce poverty has to rely on a relative notion. But it is necessary to clarify the norm relative to which a household is deprived. Such a norm is often specified a priori but a better way to define it may be observing and choosing measures of normative behaviour or asking the community to define the norm. After all any redistributive policy based upon a notion of relative poverty has to be tolerated by the community which has to bear the tax burden the policy entails.

Peter Townsend in a series of papers over many years culminating in a book [Townsend (1979) and the papers by him cited therein] has attempted to make a community based notion of relative deprivation precise and to measure it for the UK (among other countries).[1] His attempt has been criticised on some grounds which invoke some of the perennial questions of poverty studies [Piachaud (1981), Townsend (1981), Hagenaars (1986)].[1] In this paper we reexamine Townsend's measure by putting it in a more formal context than he has done. In the course of this re-examination, we arrive at a measure more general than his and one that is econometrically viable. This measure is econometric in two senses. It is based, of necessity, on an empirical measurement of the consumption practice, and is thus data based. This measure cannot be defined independently of, or prior to, an empirical account of daily life in the community. It is also econometric in the sense that to meet a crucial objection to the measurement of poverty, the question of consumer tastes, an econometric specification is absolutely necessary. Since however our measure is more general than that proposed by Townsend, the available data are not fully satisfactory. We use Townsend's data as the best available for a reasonable approximation to our measure. Only a future attempt to gather data along the lines proposed in the earlier parts of the paper could fully substantiate our proposed measure.

In Section I, we outline our theory which is based on examining consumption practice in a community, defining individual experience relative to the community practice. This leads to a measure of the disparity between the individual and the community for each 'event' which is a facet of the community's consumption practice. There follows a discussion on aggregation of this disparity over different events. Here again an econometric formulation of the aggregation operation is adopted. Although we focus on consumption practices, our approach can be extended to deprivation in terms of the living environment, work environment, etc.

Section II takes up a basic objection to measures of poverty such as the one we have proposed. Recall that having obtained his measure of

[1] Townsend has actually proposed a variety of measures. Most of the attention and criticism have concentrated on a summary index of deprivation he proposed from which he derived a threshold level of income as a poverty line. It is this particular index we are concerned with in all the discussion that follows. We are grateful to an anonymous referee for making this distinction clear.

deprivation, Townsend proceeded to translate it with a threshold level of income as a poverty line. It may however be objected that if income is directly observable why do we need another measure of poverty which then is translated into income? This leads us to compare the conditions under which our measure generates information which is *not* contained in income. While income and our measure of poverty overlap in terms of the variable they relate to, neither can substitute for the other. Poverty is *measured* (though not *explained*) by relative deprivation. It is a function of income but it is also explained by other variables whose impact on poverty is not captured by income. Poverty is thus a multidimensional phenomenon, income being only one of these dimensions. A consequence of this multidimensionality is that policies to eradicate poverty cannot act on income alone but have to pay attention to other observable variables that explain poverty. Section II is devoted to this issue. Our measure is continuous and can be estimated for each household, also it is suitable for constructing poverty indices (such as the one proposed by Sen) where previously income has been the sole variable [Sen (1976), (1981, Appendix 2].

Having thus established the non-redundancy of our measure, in Section III, we adapt our measure of deprivation to Townsend's data. These are readily available and in as much as our interest is in improving upon Townsend's measure, it is not inappropriate that we use this data. We conclude with a brief discussion of the relevance of our results to the issues aired in earlier debates.

I

A measure of poverty has to do two things. It should be possible to classify an individual/household[2] in the category poor or not poor on the basis of such a measure. To answer this question, we have to take into account the socio-economic characteristics of the household and allow for inter-household variation. Secondly, one may also wish to obtain a measure of poverty in the community as a whole either for inter-temporal or for inter-community comparison. Our concern is primarily with the first question although our answer can tackle the second one as well.

The best way to proceed would be to start with Townsend's definition of relative derpivation:

> "Individuals, families and groups in the population can be said to be in poverty when they lack the resources to obtain the type of diets, participate in the

[2] The appropriate unit may be an individual, an adult equivalent ('income unit' of SB programme) or a household. To some extent, this will be largely dictated by the available data. It has been customary to think of the household as a single unit but recently there has been some interest in intra-household distribution of resources. We shall have nothing to say on this important area. In what follows we use the words individual and household interchangeably. See however Sen (1985b), chapter 15, Brannen and Wilson (1987).

activities, and have the living conditions and amenities which are customary, or at least widely encouraged and approved, in the societies to which they belong. Their resources are so seriously below those commanded by the average individual or family that they are, in effect, excluded from ordinary living patterns, customs and activities." [Townsend (1979), p15]

This definition has several features:

(a) there is a community (society) to which individuals belong, both the individuals who are deprived and those who are not;
(b) the non deprived—'the average individual or family'—set the living pattern, customs and activities which, if practiced, constitute "belonging to the community";
(c) thus individuals are deprived by not having sufficient resources to enjoy "the living conditions and amenities which are customary, or at least widely encouraged in the societies to which they belong".

The implication of (a) is to confine one's investigation to a specific social/cultural community. Then (b) requires us to measure the average, the customary or the typical style of living in the community. Having got the style of living of the typical member defined and its resource cost noted we look at the style of living of those who do not conform. We ask whether these people who do not enjoy the typical style do so because of lack of resources, or because merely of a difference in tastes from those of the typical member.

Let us begin by considering consumption occurrences which happen to the people of a community. These are best thought of as a combination of goods (and services) and individuals in a specific time space context; supper, for example. The same consumption occurrence may recur with different specific goods being consumed; indeed it may be desirable not to have identical set of goods for each occurrence. Thus one would vary the dishes for supper from day to day; not to do so may often (but not always) indicate poverty of resources. Consumption occurrences may also involve more than one person. If the unit of study is a household, then consumption events will be typically multiperson activities e.g. the household going on holiday. Other activities for an individual member of a household may require other peoples' participation, going to the pub, for example.

We can use the statistical notion of events here. Consumption experience of an individual in a particular community over a period of time could be said to comprise of a set of events. There are of course many such events. It is sufficient for our purposes to concentrate on a subset of basic or crucial events. An event will be basic in two senses. For any particular individual, there is a very high probability that the event will occur to him during the period. By the same token, every basic event will be experienced by a majority of the community. These events differ from each other according to their frequency but together they 'span' the consumption experience of the community. As an illustration consider daily events. Then, over a week, we would include in our measure an event whose frequency is high, and, on

any one day, we should expect a high proportion of individuals to experience this event. Breakfast is an event of such a type. In the UK, 'have you had breakfast today' is a meaningful question to ask since a majority of people do have breakfast. It is also a high frequency event since in a week an individual is likely have breakfast almost every day.

The list of events will depend on the culture of the society and it may, over time, change for a given society. More specifically, however, the question is whether such a set of events, that is, events which happen to every one in a community sooner or later within a certain time interval, is an empty one. Thus, if, as Hagenaars points out, different households may engage in different activities, it may not be possible to define such a set across all households [Hagenaars (1986)]. There may also be the probability that consumption events are specific to class/race characteristics. Thus afternoon tea was a frequent event for the Victorian middle class but among the working class tea is a substantial early evening event. A community should therefore be defined as a group of households which has the practice of sharing a common set of events.

It should be emphasized that having a common set of events does not rule out an extreme diversity as to specific goods consumed as part of the event. There may be, of course, cultural constraints as to what is and what is not partaken in an event. Thus brandy at breakfast is unusual. Birthday parties usually involve consuming cakes etc. The inter-personal nature of events should also be kept in mind. Indeed, most events will involve other people and will not 'be the same' without other people.

It is tempting, at this stage, to define a utility function in terms of events which are themselves defined over goods and other poeple. Such a utility function would of course be different from the textbook one in involving other people as arguments. But then given the frequency dimension of events as well as their inter-personal character, a formal treatment of such a function becomes extremely complicated since we have to aggregate over time and over other people's utility functions.

This complication is avoided by presenting an empirical measure based on a hypothetical, but implementable, questionnaire. Events are indexed $i = 1,\ldots, I,$ individuals are $j = 1,\ldots, J$ and a good knowledge of the culture of the community is presumed. Having decided upon the set of events which are typical of the community's consumption practice, an individual's experience of any given event over a specified time interval is obtained. Attached to an event i, for a given time span, there will be a maximum frequency of occurrences—seven days a week for a daily event etc. Let the frequency with which an event has been experienced be denoted by θ. Then the questionnaire method yields θ_{ij}, the number of times individual j has experienced event i. From such data a measure of deprivation can be constructed as follows.

Let $\bar{\theta}_i$ be the modal value of the ith event in the community. The definition of events and community implies that θ_{ij} will have a *unimodal*

distribution. A multimodal distribution is an immediate signal that the event may be untypical or that the sample consists of heterogeneous communities. Given a unimodal distribution of θ_{ij}, deprivation for an individual relative to the community can be defined.

For the ith event and the jth person, define δ_{ij} as the disparity between the individual and the community. The function capturing this is

$$\delta_{ij} = \delta(\theta_{ij}, \tilde{\theta}_i), \qquad \delta(\theta_{ij}, \tilde{\theta}_i) < \delta(\theta_{ik}, \tilde{\theta}_i) \quad \text{if} \quad \theta_{ik} < \theta_{ij} \tag{1}$$

where δ is a monotonic function. It can be defined linearly as $(\tilde{\theta}_i - \theta_{ij})$ or a ratio $\tilde{\theta}_i/\theta_{ij}$ or any general non-linear function. It can take positive or negative values if linear, or be above or below one. In measuring relative deprivation, we automatically obtain measures of relative affluence, of being above the norm.[3]

The task then is to locate individuals who may have lower than modal frequency due to lack of resources rather than due to taste differences. This was the criticism levelled by Piachaud against Townsend's measure [Piachaud (1981)]. This is done by assuming that in the questionnaire concerning events, information concerning socio-economic characteristics of the individual—income, wealth, sex, age, household size, region of residence etc.—has also been gathered. Given a sufficiently large sample, θ_{ij} can be modelled in such a way so as to separate the systematic variation in θ_{ij} from the random variation due to tastes. Thus taking tastes to be randomly distributed across the population, we posit

$$\theta_{ij} = E(\theta_{ij} \mid Z_j) + \eta_{ij} \tag{2a}$$

$$= \hat{\theta}_{ij} + \eta_{ij} \tag{2b}$$

Here Z_j is the vector of socio-economic characteristics and η_{ij} is a random error. E denotes the expectations operator. It is further required that

$$\underset{j}{E}(\eta_{ij}) = \underset{j}{E}(\eta_{ij} \mid Z_j) = 0 \tag{2c}$$

Given (2a)–(2c), (1) can be refined as

$$\hat{\delta}_{ij} = (\hat{\theta}_{ij}, \tilde{\theta}_i) \tag{3}$$

since the modal value should not change if $\hat{\theta}_{ij}$ is used instead of θ_{ij}.

Equations (2a)–(2c) and (3) state that if an individual does not have breakfast due to tastes but the typical person in the community with the same characteristics Z_k does, then the individual has a negative random

[3] An alternative is to ask the community what it thinks of the minimum tolerable frequency θ_i^+ is below which a member of that community should feel deprived. This will then be an alternative to (1) above. We have

$$\Delta_{ij} = f(\theta_{ij}, \theta_i^+)$$

We do not pursue this alternative here. See however Mack and Lansley (1985) for data which allow one to implement such a measure.

error. Another individual may have low θ_{ij} due to differences in Z_j and that will persist in $\hat{\theta}_{ij}$.

Thus the problem of tastes is in principle soluble. A deprivation measure based on the notion of distance of actual frequency from modal frequency of an event which has unimodal distribution is the first step. The second step is to be able to get Z_j such that condition (2c) will be satisfied. Given these two conditions, $\hat{\delta}_{ij}$ is the appropriate distance measure. It is the specification of the error structure for θ_{ij} that allows us to tackle the problem of tastes and it is in this sense that our measure is econometric.

Aggregation

A simple approach would be to sum the θ_{ij} i.e. give them equal weights. This was Townsend's procedure. In our terms, Townsend's procedure is to pre-assign a frequency θ_i^* for each event and then define

$$\begin{aligned} t_{ij} &= 1 \quad \text{if} \quad \theta_{ij} < \theta_i^* \\ &= 0 \qquad\quad \theta_{ij} \geq \theta_i^* \end{aligned} \tag{4a}$$

Then the Townsend index (T_j) for deprivation is

$$T_j = \sum_i t_{ij} \tag{4b}$$

There is however no clear justification for equal weighting. Events have unequal expenditure implications even for a particular household. Households may also have different priority over events and they may economize on some but not on others. We have to therefore seek other weighting schemes which are less restrictive, but which will do justice to the inter-personal variation without losing the social dimension of deprivation.

One way of weighting events unequally is to ask about the *subjective feeling* of deprivation in addition to the *objective incidence* of deprivation. Thus, while $\hat{\delta}_{ij}$ is the objective incidence of deprivation, we might weight each $\hat{\delta}_{ij}$ in relation to the proportion of total community *not* deprived to capture the subjective feeling of being deprived. Thus a deprived person may feel more deprived if s/he was in a minority than if half the community was similarly deprived. Of course this would require that the event in question was relevant to the majority of the community i.e. that the mode should be above the median value for each θ_i. But even if that were not the case, the implication is that our weighting scheme should be robust whether the median is above the mode or below it. A simple scheme would be to weight θ_{ij} by the proportion of the community above the mode in the total community. Thus

$$\hat{D}_j = \sum \lambda_i \hat{\delta}_{ij} \tag{5a}$$

$$\lambda_i = J_i'/J_i \qquad J_i' = (\#j \mid \hat{\theta}_{ij} \geq \tilde{\theta}_i) \qquad j \in J \tag{5b}$$

Thus λ_i is the proportion of the non deprived (i.e. those above the norm) in the total population for the ith event. The advantage of λ_i is that it is robust against the range of the question being relevant for only a small minority of the population e.g. Have you had caviar for breakfast today? Such an 'event' will have a small λ_i and therefore will get a small weight in the overall index. The weights λ_i could be thought of as *objective* measures of *subjective* feelings of deprivation i.e. people *feel* more deprived if they see many more haves than have nots for any event, when they are among the have nots themselves.

II. Income and the proposed measure of poverty

In what sense does such a measure which involves gathering much information improve upon a straightforward use of income as an alternative and much simpler measure? Poverty measures have been based in the past on income as the basic variable treating income in its own right or as a surrogate for utility to indicate economic status. Is it worth abandoning this simple approach in search of a more elaborate, more information intensive measure such as $\hat{D}_j$?

There are two responses to this, one is a minor point and the other the major crucial distinction. Most poverty measures need to specify a minimum income level $\bar{y}$ arbitrarily and one could defend our data intensive procedure as a way of getting a more explicit and endogenous motivation for $\bar{y}$.

But the more crucial response is that a measure such as $\hat{D}_j$ should capture certain elements of living style which income does not capture. As we said above, events represent multiperson activities and an element of reciprocity is basic to being able to enjoy them. The aggregation of separate disparity measures based on particular events also attempts to capture social as against personal aspects of deprivation.

The best way to pose this issue is in terms of the information content of a measure (such as $\hat{D}_j$) which is a linear combination of individual event disparities and compare it to that of income, not measured income but permanent income for the adult equivalent household size taking account of other dimensions of household characteristics.

The framework we use is that of canonical correlation [Hooper (1959)]. On the one hand we have a linear combination of the variables $\hat{\delta}_{ij}$. We can represent this as

$$\hat{\delta}\alpha = \zeta_1 : \zeta_1'\zeta_1 = 1 \tag{6}$$

where α is the vector of linear coefficients (weights) of individual $\hat{\delta}_i$. The canonical variate ζ_1 has the property that its inner product with itself is unity. [It is not argued that $\hat{D}_j$ necessarily satisfies this orthogonality property.]

The vector of socio-economic variables Z_j introduced in (2a) can be thought of as including measured income y as its first component. Then

$Z_{2j},\ldots, Z_{kj}$ are other relevant socio-economic characteristics. Now define another canonical variate ζ_2 as combination of Z_{kj}

$$Z\beta = \zeta_2 : \zeta_2'\zeta_2 = 1 \tag{7}$$

The extent to which the deprivation measures δ have the same information as the income and household characteristic variables Z can be answered then in a straighforward way. The canonical correlation between the two sets of variables is defined as

$$|\mu| = \zeta_2'\zeta_1 \tag{8}$$

If $|\mu| = 1$ then the deprivation measures are redundant since we get no more information from them than from the Z variables. The composite income measure ζ_2 will contain information different from the deprivation aggregate ζ_1 as long as $|\mu| < 1$. If the correlation were zero, then deprivation would be random in the sense that it will be independent of the usual sort of variables thought to influence it. In this case, one could claim with Piachaud that it is a matter of taste. Thus the question of whether the deprivation measure is redundant can be answered in principle by computing the canonical correlation. We do not however propose to compute μ for our data set.

But while our measure of deprivation may have different information than income does, one may still wish to translate deprivation into income to determine a threshold level of poverty income. It is this attempt to locate a level of income which can be called a poverty line which has proved controversial. In terms of our discussion in the Introduction, income may not be sufficient as a sole variable to capture the complex phenomenon of poverty. Leaving that issue aside, can one locate a value of income y^* below which we could say that people are poor. Townsend's procedure was to fit one linear segment of high values of T_j to the corresponding Y_j (relative to the supplementary benefit entitlement of j) and another segment to lower values of j. These turned out to have statistically significantly different slopes. [For the test Desai (1986)]. But there is still arbitrariness about classifying some T_j as 'high' and other as 'low' and also about choosing two linear segments rather than a smooth nonlinear curve to represent the relationship of T_j to Y_j.

In our case this arbitrariness is removed. This is because implicit in the measure itself we have $\delta_{ij} = 0$ as the cut-off point. This leads to the appropriately aggregated $D_j = 0$, as the deprivation level corresponding to which we can locate the threshold income level.

To continue in the framework of canonical correlation mentioned above, we will seek to find out the value of $\hat{\zeta}_2$ which corresponds to $0 = \delta\hat{\alpha}$. Call this $\hat{\zeta}_2^*$. $\hat{\zeta}_2^*$ is then the synthetic income measure below which deprivation will increase and above which it will decrease (since μ will be negative). Now measured income is only one of the components of $Z\hat{\beta} = \hat{\zeta}_2^*$ but it would be a straightforward matter to extract the value of measured income

implied by ζ_2^*. Note that in view of the criticisms of Piachaud and Hagenaars mentioned above we can calculate such a threshold from a single continuous function. The difficulty in Townsend's case arises from the fact that since he prespecifies θ_i^*, $\tau_{ij} = 0$ does not have the same interpretation as our measure $\delta_{ij} = 0$ has. Thus in his case the location of a critical value of T_j involves an additional problem and this is why it requires an ad hoc specification of two segments to identify the threshold.

We have thus established that it is possible to provide a firm conceptual basis for a non-utilitarian, socially oriented view of poverty as relative deprivation.[4] This was the aim with which Townsend advanced his measure. We have shown that a more general approach can avoid many of the criticisms levelled against his measure. By relating Townsend's questions to an underlying concept of events, we can define deprivation as distance relative to the community norm. It provides a way of tackling the thorny problem of tastes. Aggregating event specific deprivation disparity into aggregate index we obtain a continuous measure of deprivation for the household. They could be viewed as alternative to income which has been used in many poverty indices as the relevant microeconomic measure. Thus from our D_j measures we could generate Sen's measure of poverty or Atkinson's measure of inequality [Sen (1976), Atkinson (1970)]. We have argued that our measure provides information other than that conveyed by the income measure. It is possible also to obtain a measure of the threshold level of income below which deprivation is a serious matter.

We do not however have the data to construct our $\hat{D}_j$ measure. In the next section, we implement many of our ideas with the data obtained by Townsend.

III. A Measure of poverty: empirical implementation

The task now is to implement our measure empirically. The largest data set currently available is that due to Townsend (op cit). The data set consists of 2,052 households interviewed in 1968–69. Each household was asked a list of sixty questions on 'style of living'. From these, Townsend chose twelve questions intended to represent the sixty and also apply equally to the different sexes and age groups in the sample. They covered 'major aspects of dietary, household, familial, recreational and social deprivation' in order to prepare a deprivation index. (See Appendix Table A1 for a list of these questions). As is readily apparent, all the questions with the exception of 9 and 10 captured what we call events. But note also that these questions are framed in a restrictive way.

Thus, instead of asking households 'how often have you had cooked meals in the last week?', they were asked 'have you had cooked meals more often than four times in the last week?'. In terms of the model in the

[4] Since we wrote our paper, Lewis and Ulph (1987) have advanced an argument based on utility maximization for the phenomenon of a threshold income which defines a poverty line.

previous section, this means that θ_i^* was set before the questions were asked. Households who had a frequency below this norm were scored 1 (deprived) and those at or above the stated frequency scored 0 (not deprived). Thus, we have a problem of censored data here; we observe a discrete rather than a continuous variable.

Balanced against this, we have the advantage that along with the questions, a lot of information was gathered on the socio-economic characteristics of house-holds—income, wealth, family type, health, education achievement of the head of the household etc. We can thus implement our equation (2) and separate the effects of tastes from those of systematic factors.

Given the data, we only observe households with $\theta_{ij} \geqslant \tilde{\theta}_i$ and $\theta_{ij} < \tilde{\theta}_i$ where $\tilde{\theta}_i$ is now to be interpreted as the preassigned norm θ_i^*. We wish to transform this zero/one classification into the probability of being deprived or not being deprived. Let p_{ij} be the probability attached to the (random) event that the jth household is *not* deprived with respect to the ith (consumption) event. Then obviously those households recorded with $\theta_{ij} \geqslant \tilde{\theta}_i$ are most likely to have $p_{ij} \geqslant \frac{1}{2}$, and those with $\theta_{ij} < \tilde{\theta}_i$ have $p_{ij} < \frac{1}{2}$.

This transformation of the observed discrete variable into a probability enables us to obtain a deprivation index similar to $\hat{D}_j$ (5a) above. Since it is based on T_{ij} rather than δ_{ij}, but the weights are as in (5b) we label it TD_j

$$TD_j = 1/I \sum \lambda_i \hat{\delta}(\hat{\theta}_{ij}, \tilde{\theta}_i) = 1/I \sum \lambda_i (1 - \hat{p}_{ij}). \tag{10}$$

In (10) $\hat{p}_{ij}$ is the probability of not being deprived as calculated from $\hat{\theta}_{ij}$ rather than θ_{ij}. Whereas the measure in (6) is defined over the entire real line, the measure in (10) is confined to being positive. There is clearly some loss of information involved due to the nature of the underlying data. But the advantage of interpreting $\hat{\delta}(\hat{\theta}_{ij}, \tilde{\theta}_i)$ as the probability is that (10) can be seen as analogous to an entropy measure. Thus if we take $\lambda_i = p_i$ i.e. the proportion in the population *not* deprived then we can interpret this observed frequency as a probability. Thus

$$TD_j = 1/I \sum \lambda_i (1 - \hat{p}_{ij}) = 1/I \sum \hat{p}_i (1 - \hat{p}_{ij})$$

$$= -1/I \sum \hat{p}_i \log \hat{p}_{ij}. \tag{11}$$

In (11) we approximate $(1 - \hat{p}_{ij})$ by $-\log \hat{p}_{ij}$. Of course (11) is only an approximation and is presented here for its suggestiveness. The usefulness of the deprivation index in (6) and in (10) does not depend on the closeness of its approximation to the entropy measure.

Returning to our empirical implementation, it seems appropriate given the one/zero nature of the data to posit a logistic specification for $\hat{p}_{ij}$

$$\hat{p}_{ii} = [1 + \exp(-Z_i \hat{\beta}_i)]^{-1} \tag{12}$$

TABLE 1[a]
Logit estimates of events

Variable \ Event i		$i=1$	$i=2$	$i=3$	$i=4$	$i=5$	$i=6$	$i=7$	$i=8$
Intercept		−0.316	−0.544*	0.284	−0.482*	−0.568*	−0.438	0.089	−0.104
FAM	2	−1.036*	−0.251	0.051	−0.433*	−0.126	0.376	−0.048	0.224
	3	0.160	0.547*	−0.124	−0.226	−0.208	0.424*	−0.064	−0.513*
	4	0.060	0.102	−0.030	−0.582*	−0.028	0.056	−0.302	−0.475*
	5	−0.170	−0.048	−0.631*	−0.670*	−1.147*	0.160	0.160	−0.308*
	6	−0.490*	−0.059	−1.086*	−0.809*	−1.181*	0.069	0.051	−0.350*
	7	−0.361*	0.038	−1.167*	−1.095*	−1.662*	−0.024	0.092	−0.485*
	8	−0.353*	−0.018	−1.134*	−0.801*	−1.201*	0.177	0.296	−0.010
	9	−0.300	0.071	−1.570*	−0.200	−1.061*	0.369	0.578	0.083
	10	−0.026	−0.003	−1.054*	−0.828*	−1.343*	0.162	0.470*	−0.084
	11	−0.385*	0.153	−1.253*	−1.153*	−1.510*	0.063	0.547*	−0.109
	12	−0.103	−0.181	−0.557*	−1.056*	−1.867*	0.234	0.380*	−0.111
	13	0.122	0.092	−0.617*	−0.681*	−0.859*	0.261	0.773	0.322
	14	−0.267	−0.073	−0.763*	−0.970*	−1.193*	0.426*	0.370*	−0.212
ED	2	−0.152*	−0.058	0.092	−0.252*	−0.053*	−0.147*	−0.090	0.012*
	3	−0.286*	−0.223*	−0.249	−0.463*	−0.212*	−0.274*	−0.447*	−0.339*
	4	−0.420*	0.051	−0.355	−0.290	0.236	−0.372*	−0.532*	−0.622*
	5	−0.367*	−0.287*	−0.087	−0.206	0.112	−0.467*	−0.274*	−0.219
	6	−0.504*	−0.281*	−0.482*	−0.302*	0.320*	−0.471*	−0.835*	−0.239*
INC	2	−0.004	−0.103	−0.054	−0.018	−0.023	−0.066	−0.029	0.160
	3	0.010	−0.128	−0.176	−0.350*	−0.251*	−0.295*	−0.020	−0.147
	4	−0.094	0.056	−0.193	−0.198	−0.250*	−0.388*	−0.097	−0.129
	5	−0.300*	−0.079	−0.459*	−0.638*	−0.375*	−0.633*	−0.113	−0.101
WLTH	2	−0.063	−0.093	0.121	−0.248*	−0.021	−0.170*	−0.175*	−0.194*
	3	0.087	−0.175*	−0.137	−0.191	−0.126	−0.322*	−0.323*	−0.483*
	4	0.144	−0.254*	0.175	−0.271	0.021	−0.533*	−0.051	−0.049
	5	0.205*	−0.278*	0.107	−0.242*	−0.329*	−0.512*	−0.180*	−0.298*
−2 Log Likelihood[b]		2278.8 (223.79)	2257.9 (89.25)	998.05 (168.81)	1683.5 (334.53)	1600.0 (490.43)	2268.2 (289.64)	2342.4 (212.48)	2201.7 (151.13)

[a] The regressions also include REG 2–REG 9, HEALTH AND ORIGIN (see Table A2). The sample size is 1850.

[b] The figure in the brackets is the difference between −2 log likelihood value for the estimated equation and the constrained equation in which all the coefficients except the constant term are set equal to zero and thus provide a likelihood ratio test for the null hypothesis that $\beta = 0$.

* The coefficient value is at least twice the standard error.

where $\hat{\beta}_i$ are the maximum likelihood estimates of the coefficients of Z_j. The vector Z_j comprises many socio-economic variables. These are listed in Appendix Table 2. The $\hat{\beta}_i$ estimates are listed in Table 1.

Looking at Table 1, it is obvious from the last row which gives the likelihood ratio statistic that the variables do contribute to the explanation of the observed data.

TABLE 2
Log likelihood values for alternative specifications

	All variables present	*Income omitted*	*Wealth omitted*	*Family type omitted*	*Education omitted*
DF	36	32	32	23	31
Event 1	223.79	201.64(R)	217.64(A)	168.21(R)	198.90(R)
Event 2	89.25	86.19(A)	79.22(R)	57.29(R)	78.25(A)
Event 3	168.81	155.34(R)	166.69(A)	95.78(R)	162.13(A)
Event 4	334.53	276.42(R)	325.54(A)	260.44(R)	317.33(R)
Event 5	490.43	474.57(R)	484.85(A)	268.79(R)	480.72(A)
Event 6	289.64	224.25(R)	254.38(R)	268.71(A)	265.12(R)
Event 7	212.48	210.31(R)	199.01(R)	141.23(R)	157.92(R)
Event 8	151.13	141.69(A)	127.07(R)	95.39(R)	127.47(R)

A—Accept the null hypothesis that the variable subset has a zero parameter subvector
R—Reject the null hypothesis

In arriving at the coefficient estimates given in Table 1, only a small number of alternative specifications was tried. The main experiment was introducing the actual amount of income and wealth and the number of years of education. Since there was hardly any change in the explanatory power of the independent variables, this was dropped in favour of the chosen specification where these variables are converted into step dummies. This allows for any nonlinearity in the influence of these variables on the probability of deprivation. The second major experiment was to drop subsets of variables and Table 2 lists the likelihood values for the unrestricted specification and for each set of restrictions that was imposed. The null hypothesis is that this restriction, i.e. omission of a subset of variables, does not lead to a significant loss of likelihood. Using twice the difference in the log likelihood values and comparing it to the χ^2 values for 95% and the appropriate degrees of freedom, the accept/reject decision can be made. As the table indicates, the omission of the family type variables set is a restriction which is rejected by the data in seven out of eight cases and in the eighth case it is rejected at the 90% level. Broadly speaking, the omission of income is also a restriction that is rejected by the data for it is only in two cases that the null hypothesis is acceptable at 90% level. On the other hand, omission of wealth is acceptable in more cases. Education falls in between income and wealth.

The deprivation index

From the coefficient estimates in Table 1, the $\hat{p}_{ij}$ can be calculated and the deprivation index constructed. Given the large number of variables, it is possible to construct as many as 75,600 separate $\hat{p}_{ij}$ but this would be an

TABLE 3
The effect of selected variables on measured deprivation

	TD_j^*		TD_j^*
INC 1	1.057	FAM 1	1.274
INC 2	1.033	FAM 2	1.197
INC 3	1.000	FAM 3	1.247
INC 4	0.993	FAM 4	1.160
INC 5	0.862	FAM 5	1.142
WLTH 1	1.000	FAM 6	1.053
WLTH 2	0.937	FAM 7	1.000
WLTH 3	0.888	FAM 8	1.102
WLTH 4	0.952	FAM 9	1.193
WLTH 5	0.900	FAM 10	1.145
ED 1	1.000	FAM 11	1.208
ED 2	0.960	FAM 12	1.169
ED 3	0.832	FAM 13	1.274
ED 4	0.822	FAM 14	1.206
ED 5	0.851	HEALTH	1.261
ED 6	0.753		

Base Value $TD_j^* = 1$ for a couple with 2 children, $120 \leq$ income < 140), WEALTH $<$ 2500, ED ≤ 9 years, good health, born in the UK and living in Greater London.

absurd task to undertake. We therefore proceed as follows. For the sample a base value for TD_j is calculated. This is done by setting all the dummy variables equal to zero except that for FAM 7 (a couple with two children) and INC 3 ($120 \leq$ INC < 140). This family is also assumed to be living in Greater London, born in the UK and in good health. It appears that such a base is the most representative of the average but, of course, if warranted different bases can easily be computed. The specific value for Base TD_j happens to be 0.176. Now let $TD_j^* = \dfrac{TD_j}{\text{Base } TD_j}$. For the base case chosen obviously $TD_j^* = 1$. Table 3 then lists TD_j^* for someone with all the characteristics of the base case except the one indicated. Obviously the lower the value of TD_j^* the less deprived a person is.

As expected, the first five entries in Table 3 show that deprivation falls with income. The noteworthy feature is that the index falls sharply as income increases from INC 4 ($140 \leq$ INC < 160) to INC 5 (INC ≥ 160). The implication is that income has a sizeable influence on deprivation only at the highest levels. Whereas deprivation is inversely and monotonically related to income its relationship with wealth is non-monotonic. Increasing wealth from WLTH 1 (WLTH < 2500) to WLTH 3($5000 \leq$ WLTH ≤ 7500) produces a sizeable drop in the index but thereafter there appears to be a limit below which deprivation cannot decrease with increases in wealth. The

relationship between the index and education is also non-monotonic. The most interesting feature of this relationship is that as ED increases from EC 2 (10 years) to ED 3 (11 years) there is a sharp fall in deprivation. Therefore staying at school for two extra years beyond the minimum school leaving age has a major impact on reducing deprivation but this may also represent a vintage effect since the older generations have fewer years of education. An almost equally powerful impact accompanies an increase in education from ED 5 (13 years) to ED 6 (14 years or more). This roughly coincides with a degree course at an institution of higher education. Finally, turning to family type, the influence is not regular as there is not a natural way of ordering the different types. Nevertheless, a few features can be noted. The lowest level of deprivation is for family type 7—couple with two children and the highest is for family type 13—All others without children. For adults only, deprivation appears to have a distinct relationship with number and age. Thus single person households are as greatly deprived as families with four adults. Among single person households, pensioners are highly deprived.

Several lessons emerge from this econometric exercise. Debates about poverty have frequently conflated various issues. In the debates surrounding Townsend's attempt to locate the poverty line as being at a certain multiple of the British Supplementary Benefit (SB) level, questions of measurement, behaviour and causation have been mixed up. What we have done amounts to saying that the *measurement* of poverty defined as relative deprivation can be based rigorously on the underlying consumption practices of the community and an individual's experience relative to the community. Then we have the issue as to whether a single 'objective' indicator of poverty, a marker to separate the poor from the not so poor, can be found and whether income is such an indicator. Our answer to that is no. Income is one of the variables besides wealth, education, health, ethnic origin etc. which defines the position of a household in the deprivation space. For some events, income has no influence; for others wealth does not. It would be a mistake therefore to look for just a single variable. A satisfactory indicator for poverty has to be vector valued rather than a scalar. After all, given such a complex phenomenon as poverty, it would be surprising if such a crude variable as income could capture it.

Conclusion

We have in this paper provided a firmer conceptual basis for measuring deprivation than has hitherto been advanced in the literature. By defining relative deprivation as relative to the community norm and making the norm the modal behaviour, we make the sociological view of poverty empirically measurable. The key here is to define consumption in terms of certain crucial events which are highly frequent and highly probable. We then proceed to define the modal value of frequency of consumption events

and the difference between an actual value and modal value as a simple measure of deprivation for any particular event. By making a suitable econometric specification, we finess the problem of tastes. In aggregating the differences between the actual and the modal value over the different events, we propose a procedure that weights events unequally but in a way that is robust against the inclusion of 'minority events'. This done, we explore the question as to whether our aggregate measure had any different information content from the income variable. We propose that one way to check this might to be use the canonical correlation approach. We we implement a modified measure with Townsend's data.

Our empirical results show that it is possible to use Townsend's data in a sophisticated way to extract from them information that can locate who the deprived are. In terms of family size there are at either end of the distribution—single person households and large adult dominated households. The state of health matters as well. As far as income is concerned, there is a sharp decline in the deprivation index beyond the 160% of SB level. But income is far from being the only or even the most important variable.

Thus we hope to have shown that while Townsend's measure has been criticised, it is possible by a suitable formalisation to meet most of the limitations. The notion of relative deprivation is more general than Townsend's particular measure of it and this notion is obviously worth formalising and measuring econometrically. Our approach produces a measure for each household and it captures the social, interpersonal aspects that are basic to the concept of relative deprivation.

Much further work remains to be done. The robustness of our measure could be tested by extending to more questions within the Townsend sample than the set used here. It could also be tried out on other samples. Ideally, of course, it should be tested by linking it to a questionnaire which allows the event specific distance to be measured. This however remains for the future.

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APPENDIX

TABLE A1
List of events

Event	*% of Sample*
1. Has not had an afternoon or evening out for entertainment in the last two weeks.	40.9
2. Has not had a cooked breakfast most days of the week.	67.0
3. Has gone through one or more days in the past fortnight without a cooked meal.	9.7
4. Does not have fresh meat (including meals out) as many as four days a week.	23.5
5. Household does not usually have a Sunday joint (3 in 4 times).	25.2
6. Has not had a week's holiday away from home in last 12 months.	53.0
7. Has not been out in the last 4 weeks to a relative or friend for a meal or snack.	46.4
8. Has not had a relative or friend to the home for a meal or snack in the last 4 weeks.	33.2
9. Household does not have a refrigerator.	43.8
10. Household does not have sole use of four amenities indoors (flush WC; sink or washbasin and cold-water tap; fixed bath or shower; and gas or electric cooker).	19.8
* The following two events apply only to children:	
11. Has not had a friend to play or to tea in the last 4 weeks.	
12. Did not have party on last birthday.	

TABLE A2
Definitions of variables

FAM 1–FAM 14:	Fourteen family types. (1) Single man ≥60 years, (2) Single man <60, (3) Single woman ≥60, (4) Single woman <60, (5) Couple, (6) Couple with a child, (7) Couple with 2 children, (8) Couple with 3 children, (9) Couple with 4 or more children, (10) 3 adults, (11) 3 adults with children, (12) 4 adults, (13) All others without children, (14) All others with children.
ED 1–ED 6:	Six education categories. (1) Years of education ≤9, (2) 10 years of education, (3) 11, (4) 12, (5) 13, (6) ≥14.
INC 1–INC 5:	Five income categories. (1) Income <100% of supplementary benefits scale rates, (2) 100%–120%, (3) 120%–140%, (4) 140%–160%, (5) >160%.
WLTH 1–WLTH 5:	Five wealth categories. (1) Wealth <2,500, (2) 2,500–5,000, (3) 5,000–7,500, (4) 7,500–10,000, (5) ≥10,000.
REG 1–REG 9:	Nine regions. (1) Greater London, (2) South East, (3) Anglia and East Midlands, (4) South West and Wales, (5) West Midlands, (6) North West, (7) North East, (8) Northern Ireland, (9) Scotland.
HEALTH:	1 = Poor health, 0 Otherwise.
ORIGIN:	1 = Born outside U.K., 0 Otherwise.

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