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EXPLORING ALTERNATIVE MEASURES OF WELFARE IN THE ABSENCE OF EXPENDITURE DATA

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We consider an asset-based alternative to the standard use of expenditures in defining well-being and poverty. Our motivation is to see if there exist simpler and less demanding ways to collect data to measure economic welfare and rank households. This is particularly important in poor regions where there is limited capacity to collect consumption, expenditure and price data. We evaluate an index derived from a factor analysis on household assets using multipurpose surveys from several countries. We find that the asset index is a valid predictor of a crucial manifestation of poverty—child health and nutrition. Indicators of relative measurement error show that the asset index is measured as a proxy for long-term wealth with less error than expenditures. Analysts may thus prefer to use the asset index as an explanatory variable or as a means of mapping economic welfare to other living standards and capabilities such as health and nutrition.

1. Introduction

The analysis of household survey data, and in particular the measurement and the examination of the characteristics and causes of poverty, is an important input into the design of economic policy and poverty alleviation programs in developing countries. Armed with a growing number of household income, consumption, and expenditure surveys, development economists have constructed poverty profiles that have become a major source of attention for local governments and international organizations such as the World Bank and International Monetary Fund. Considerable methodological advances have been made as increased rigor has been employed in defining poverty lines[1] and related indices,[2] and as other statistical methods for constructing poverty profiles by making poverty comparisons across populations and sub-groups have been explored.[3] This information has been subsequently used to design and/or evaluate policies and targeted intervention schemes, the successes of which are measured in terms of raising people above the poverty line.

Economists have relied on a money metric of utility—income or consumption expenditures—as the preferred indicator of poverty and living

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[1]See Ravallion (1994, 1996b).

[2]For example, the Foster, Greer, Thorbecke (1984) class of poverty measures has been widely adopted because of their desirable properties.

[3]For a discussion of using stochastic dominance to compare poverty across populations, see Davidson and Duclos (1998).

standards.[4] While income is generally the measure of choice in developed countries, the preferred metric in developing countries is an aggregate of a household's consumption expenditures. The choice of expenditures over income is dictated by a variety of difficulties involved in measuring income in developing countries, including the seasonal variability in such earnings, and the large shares of income in developing countries that are from self-employment both in and outside of agriculture.

In this paper, we consider an alternative—asset based[5]—approach to defining well-being and poverty. While the discussion of the causes of poverty, whether measured in income (expenditure) space or some more direct notion of functionings and capabilities, has often alluded to assets as underlying determinants, measurement of poverty in developing countries has rarely focused on the level of assets or distribution of assets as the objective of policy or programs. For the most part (with education being the possible exception), discussion of the measurement of poverty, and the related issue of inequality, has given relatively little attention to the asset ownership of individuals or households, or the skewed distribution of assets across the population. This in turn may, in part, explain why the objectives of anti-poverty programs have been articulated in terms of raising people above the income (or expenditure) determined poverty line, or raising command over certain commodities. Since meaningful poverty alleviation is largely predicated on the individual's ability to accumulate productive assets, and since income inequality will be reduced by addressing the unequal distribution of income generating assets, there is considerable merit in moving the process of poverty measurement away from solely expenditure-based measures, toward a more asset-based focus. Such a focus will in turn have implications for poverty reduction strategies. It implies that more emphasis be placed on economic and social forces that contribute to asset inequality, rather than on anti-poverty measures that are targeted and evaluated based on expenditure levels.

Beyond the merits of focusing policy on asset accumulation, there are also a series of measurement problems that particularly hinder the use of income and expenditures measures in developing countries, and that commend consideration of an asset-based indicator as an alternative. First, unlike in developed countries, consumption and expenditure surveys are intermittent at best, and with few exceptions, of low quality. This is particularly the case in the poorest countries where they are arguably most important. In Africa, it is rare to find more than one representative household budget survey conducted during the past decade. Making inter-temporal comparisons is therefore often not possible, regardless of the range of other technical problems discussed below. The technical capacity within governmental agencies charged with conducting such surveys is limited, and the budget constraints under which these agencies operate are severe. Consequently, donor agencies such as the World Bank have often assumed charge for the design and implementation of surveys at very high financial costs that are far beyond the means of government statistical agencies. In addition, the commitment of donors

[4]See Samuelson (1974).

[5]Below we detail the composition of the index. We note at the outset, however, that the index is composed partially of what may also be termed as durables, especially in more developed countries.

such as the World Bank, to ensuring the availability of quality household data is wavering and unreliable at best. This has led to a call for identifying more rapid, less costly, and less demanding approaches for measuring poverty and ranking household welfare as alternatives to the complex income and expenditure surveys that have been widely applied in developing countries.

Second, when consumption data is available from developing countries, it is collected on the basis of recall—usually 14 days, but sometimes one month. These recall data are prone to very large measurement errors. Some of this error is random—but not all. For example, the more commodities listed on the recall sheet, the higher is the measured aggregate consumption (Pradhan, 2000). Likewise, the longer the recall period, the lower is the consumption that is reported (Scott and Amenuvegbe, 1990).

Third, when constructing consumption aggregates, there is a need to derive the use values of goods consumed. To do so, at a minimum we need data on prices of goods, and in many instances, nominal interest rates, and depreciation rates for semi-durable or durable goods—all of which are difficult to discern. A similar problem arises with housing where the rental equivalent is almost impossible to determine, especially in rural areas or in transition economies where there is virtually no rental market for housing.

A fourth problem with measuring consumption-based poverty is the choice of deflators. Consumer price indices that are both readily available and reliable in developed countries are the exception rather than the rule in poor countries, especially where inflation tends to be high and variable. Further, it is unusual to find regional price indices. This may not be of great importance in countries where markets are well integrated and transportation and marketing costs are relatively small. But in poor countries, regional and seasonal price variability is often dramatic (Sahn, 1989).[6] Because of the absence of reliable national and regional price deflators, many researchers have no alternative but to employ unit prices derived from surveys to construct deflators, despite the obvious shortcomings in this approach. Thus, whether using flawed official prices or derived price indexes from budget surveys, inter-temporal comparisons of poverty are highly subjective exercises.

A fifth and related problem with using a money-metric of utility to assess poverty in developing countries arises when inter-country comparisons are made. Exchange rate distortions make the conversion of good purchases into common prices perilous. Purchasing power parity numbers are widely available and often represent the best option for converting local currency into dollars. However, these numbers are rough approximations, and certainly are subject to considerable error.

The above conceptual and technical problems with the use of a money-metric based on income and consumption expenditures motivate our pursuit of an alternative approach to defining poverty. We seek to identify a metric that (a) is consistent with the financial means and technical capabilities of government statistical offices, and (b) provides sufficient information to identify and profile the poor, target transfers, and even estimate demand or production functions for outcomes

[6]In many African countries, for example, it costs more to ship rice from the port to the interior, than from Bangkok to the port. Another manifestation of the high marketing costs is that the CIF and FOB prices often differ by 100 percent.

such as nutritional status of children that will be useful for designing programs and policy. The logic of directing our attention to an asset-based, rather than income-based framework to define the poor and promote poverty alleviation, is compelling: assets in poor countries are fewer and easier to measure; the standardization of questionnaires is less of a problem (e.g., the issue of recall period is minimal); the types of assets we propose are likely to be subject to less reporting bias; and as we discuss below, in many cases when we rely on the use of actual physical assets such as durables, human capital, or housing quality, we do not have to worry about problems of currency deflation.

While all the above reasons are compelling, they beg the underlying question of the relative merits of using the asset index as a metric of well-being, versus the use of the more traditional expenditure measure. To do so, we first compare the asset index to expenditure data in terms of their ranking of individuals based on household survey data in a number of countries. While these comparisons are interesting, they nonetheless beg a critical question: whether the asset index or consumption expenditures is a superior indicator of well-being. To the extent that the orderings of households based on the asset index and consumption expenditures are not mutually consistent, we have little conceptual basis for arguing which is a more accurate representation of the ranking of individual welfare. Therefore, we seek a way to "verify" how well our asset index does relative to a more traditional money metric of well-being in explaining what is arguably amongst the most crucial manifestations of poverty—child health and malnutrition. Our selection of child health as an outcome measure of interest is, in part, motivated by the recognition, as expounded by Amartya Sen (1985, 1987), of the importance of capabilities and functionings, such as nutritional status and health. These functionings have the advantage of being direct measures of well-being and functionings, unlike income and assets. We are thus interested in the relative ability of expenditure versus assets to predict or explain intrinsically important outcomes such as child health.

This paper's contribution to developing an asset-index as an alternative metric of economic well-being is organized as follows. In the next section, we explain the derivation of the asset index based on the use of factor analysis.[7] We then expand and present the comparison of the asset-based welfare measure relative to consumption data in Section 3. Following the discussion of the methods employed to compare assets and consumption-based welfare, Section 4 discusses briefly the source of data for our comparisons. Our results, presented in Section 5, indicate that assets are at least as good of a predictor of nutritional outcomes as are expenditures. Finally, we conclude with a discussion of our findings, and the implications of our empirical contribution for policy-makers and further research.

2. Asset Index

To construct an index of the household assets requires selecting a set of weights for each asset. That is, we want an index of the form

[7]See Sahn and Stifel (2000) for an earlier paper in which they create an asset index based on a set of dichotomous variables available in the Demographic Health Surveys, and then use that asset to compare poverty inter-temporally and across countries in Africa.

$$A_i = \hat{\gamma}_1 a_{i1} + \ldots + \hat{\gamma}_K a_{iK} \tag{1}$$

where A_i is the asset index, the a_{iK}'s are the individual assets recorded in the survey, and the γ's are the weights, which we must estimate. Because neither the quantity nor the quality of all assets is collected, nor are prices available in the data, the natural welfarist choice of prices as weights is not possible. Rather than imposing arbitrary weights, we let the data determine them directly. Hammer (1998) and Filmer and Pritchett (2001) use a similar method that employs principal component analysis to construct an asset index. The weights for their indices are the standardized first principal component of the variance-covariance matrix of the observed household assets. We use factor analysis instead of principal component analysis because the latter forces all of the components to accurately and completely explain the correlation structure between the assets. Factor analysis, on the other hand, accounts for the covariance of the assets in terms of a much smaller number of hypothetical common variates, or factors (Lawley and Maxwell, 1971). In addition, it allows for asset-specific influences to explain the remaining variances. In other words, all of the common factors are not forced to explain the entire covariance matrix. In our case, we assume that the *one* common factor that explains the variance in the ownership of the set of assets is a measure of purchasing power, or "welfare." Finally, the assumptions necessary to identify the model using factor analysis are stated explicitly.[8]

Unlike with principal component analysis, we must impose structure from the outset. Our structural model includes only one factor:

$$a_{ik} = \beta_k c_i + u_{ik} \quad \text{for} \quad \begin{array}{ll} i = 1, \ldots, \mathrm{N} & \text{(households)} \\ k = 1, \ldots, \mathrm{K} & \text{(household assets)}. \end{array} \tag{2}$$

The ownership of each observed asset (k) for each household (i), represented by the variable a_{ik}, is a linear function of an unobserved common factor for each household, c_i, which we label "household welfare."[9] Note that the relationship between the asset and the unobserved common factor, β_k, as well as the noise component ("unique element"), u_{ik}, are also unobserved and must be estimated.[10]

To identify the model, we make the following assumptions:

(A1) Households are distributed *iid*

(A2) $E(u_i | c_i) = \underset{Kx1}{0}$

(A3) $V(u_i) = Diag\{\sigma_1^2, \ldots, \sigma_K^2\}$,

Structure can now be imposed on the variance-covariance of the observed assets. To see what these restrictions are, first rewrite the set of k equations (2) in vector form,

[8]Nonetheless, the two methods create indexes that rank households similarly. The Spearman rank correlation between the principal components and factor analysis asset indexes is about 0.98 for each of our samples. Similarly, the succeeding analysis was repeated using the principal components asset index, and there was no striking difference. We also note that Ferguson *et al*. (2002) developed an alternative approach based on a variant of the hierarchical ordered probit model which they find to give similar results to the principal components asset index.

[9]Lawley and Maxwell (1971) argue that, given the theoretical and practical difficulties, it is not clear that a non-linear model is necessary or useful.

[10]The disturbances are unique in that for the true model once the common factor is accounted for, the remainder of the variance in the ownership of each asset is determined independently of the other assets.

(2a) $$a_i = \beta c_i + u_i,$$

where $\beta = (\beta_1, \ldots, \beta_K)$. Assumption (A3) implies that once the common factor accounts for a portion of the variance in the ownership of assets, the remainder of the variance, the disturbance terms ("unique elements"), should be uncorrelated across assets. Note that these errors are not constrained to be identically distributed. This gives us the variance-covariance matrix of the unique disturbances

$$E(u_i u_i') = Diag\{\sigma_1^2, \ldots, \sigma_K^2\} = \Psi.$$

Without loss of generality, we assume that the mean of the common factor (wealth) is zero, thus the variance of the common factor is

$$E(c_i c_i') = \sigma_c^2.$$

Orthogonality of the common factor and the disturbance (A2) permits us to write the variance of the assets as

$$E(a_i a_i') = E[(\beta c_i + u_i)(\beta c_i + u_i)'],$$

which gives us

(3) $$\Omega = \beta\beta'\sigma_c^2 + \Psi.$$

Note that identification requires the normalization of one of the parameters, and typically the variance of the unobserved factor is chosen ($\sigma_c^2 \equiv 1$). Although this normalization makes it difficult to interpret the coefficients on the common factor (β), we shall do so anyway since all statistical packages that provide factor analysis procedures do not have options for other normalizations and since interpretation of these parameters is not crucial to the analysis.[11]

If we assume multivariate normality of c_i and u_i, we can estimate β and Ψ using maximum likelihood techniques (Lawley and Maxwell, 1971). Once these parameters have been estimated, the common factor (asset index) can be estimated for each household, by defining the asset index as the projection of unobserved household wealth (c_i) on the observed household assets:

(4) $$E^*(c_i|a_i) = \gamma_1 a_{i1} + \ldots + \gamma_K a_{iK}, \quad \text{where}$$
$$\gamma = v(a_i)^{-1}\operatorname{cov}(a_i, c_i)$$

Given the normalization, $\sigma_c^2 \equiv 1$, it is reasonably straightforward to show that $\operatorname{cov}(a_i,c_i) = \beta$, and thus $\gamma = \Omega^{-1}\beta$. Finally, the estimate of the asset index for household i is defined as:

(4a) $$A_i = \hat{\gamma}_1 a_{i1} + \ldots + \hat{\gamma}_K a_{iK}, \quad \text{where}$$
$$\hat{\gamma} = \hat{\Omega}^{-1}\hat{\beta}\hat{\sigma}_c^2.$$

The assets included in the index can be placed into three categories: household durables, housing quality and human capital. The household durables consist of

[11]A more reasonable normalization would be $\beta_1 \equiv 1$, which allows us to interpret the importance of all other assets as being relative to the first asset. Nonetheless, we maintain the standard normalization in large part because interpreting the γ's is not fundamental to the index, and because the statistical programs which have programs that provide the necessary output, do not provide options for different normalizations. The commands in Stata and SAS are *factor* and *proc factor*, respectively.

indicators of ownership of radios, stereos, TVs, sewing machines, stoves, refrigerators, bicycles, and motorized transportation (motorcycles and/or cars). The housing quality includes indicator variables for source of drinking water (piped or surface water relative to well water), toilet facilities (flush or no facilities relative to pit or latrine facilities), cooking fuel (gas or electricity), and household construction material (indicators for quality of floors).[12] We also include the years of education of the household head to account for household's stock of human capital.[13]

The weights estimated from factor analyses on assets from each of our datasets appear in Table 1. As expected the weights on the indicators of lack of assets (i.e. surface drinking water, no toilet facilities, and low quality floors) are negative, while the weights on all of the indicators of access to assets are positive. The weights for particular assets are generally of similar magnitude across the surveys. The most glaring exception to this is the weight of 0.5 on refrigerators for Jamaica. We note that 54 percent of households in Jamaica own refrigerators, a share considerably larger than in any other country in our sample. A relatively large weight for TVs, and relatively small weight for drinking water and toilet facilities for Jamaica suggest that the ownership of household durable goods are better means of stratifying wealth classes than public good-type assets for this country. Conversely, public good-type assets such as piped drinking water and toilet facilities more effectively stratify wealth groups for the Madagascar and Pakistan samples, respectively.

3. Comparison Methodology

Comparison with Reported Consumption Expenditures

We begin by directly comparing our asset index and predicted consumption expenditures with the distributions of reported per capita consumption expenditures. The rationale for using predicted expenditures is that when we compare the ability of our asset index and consumption expenditures to predict nutrition outcomes, we prefer, in general, not to use reported consumption expenditures, but instead some instrumented value owing to issues of endogeneity of household choice. In comparing the ranking of our asset index and predicted expenditures with per capita expenditures, we should emphasize that the rationale for doing so is for informational purposes, rather than for making statements about how well our asset index corresponds to the "correct" ordering of household welfare.

Our model of consumption expenditures takes the following form:

$$x_j = f(d_j, q_j, Z, \varepsilon_j) \tag{5}$$

[12]This set of assets is a subset of those that are available in the LSMS datasets that we use here. We restrict the number of assets to those that are available in the Demographic and Health Surveys (DHS) in order to explore the legitimacy of ranking household well-being by this index with datasets of this type, since by far, they are the most widely available, comparable data from developing countries. An additional motivation is to examine the usefulness of a parsimonious measure made up of a relatively modest set of assets, information on which is easy to collect, as an alternative to expenditures.

[13]As a test of robustness, the asset index was constructed without the education of the household head. As noted below, the effect on the analysis was insubstantial. Consequently the results are not displayed, though they are available from the authors.

TABLE 1

SCORING COEFFICIENTS (WEIGHTS) FOR ASSET INDICES BY COUNTRY

	Durables					Characteristics					
	Radio	TV	Refrigerator	Bicycle	Motorized Transport	Piped Water	Surface Water	Flush Toilet	No Toilet	Low Quality Floor	Education of Head
Cote d'Ivoire (1988)	0.058	0.258	0.264	0.032	0.024	0.185	–0.035	0.172	–0.101	–0.058	0.129
Ghana (1988)	0.028	0.268	0.314	0.036	0.097	0.192	–0.089	0.212	–0.037	–0.049	0.108
Ghana (1992)	0.008	0.275	0.292	0.020	0.063	0.254	–0.075	0.174	–0.050	–0.054	0.098
Jamaica (1998)	0.050	0.356	0.475	0.034	0.077	0.093	–0.039	0.063	–0.038	–0.058	0.060
Madagascar (1993)	0.072	0.224	0.141	0.039	0.081	0.369	–0.063	0.242	–0.080	–0.054	0.041
Nepal (1996)	0.067	0.230	0.092	0.026	0.083	0.143	–0.016	0.346	–0.169	–0.161	0.065
Pakistan (1991)**	0.007	0.070		0.018	0.067	0.122	–0.033	0.433	–0.205	–0.222	0.085
Papua New Guinea (1996)	0.063	0.141	0.111	0.028	0.063	0.255	–0.099	0.320	–0.020	–0.158	0.098
Peru (1994)	0.033	0.148	0.150	0.035	0.038	0.181	–0.104	0.278	–0.131	–0.168	0.085
South Africa (1994)	0.024	0.117	0.142	0.024	0.087	0.278	–0.041	0.341	–0.055	–0.123	0.033
Vietnam (1993)	0.052	0.129	0.149	0.039	0.138	0.281	–0.041	0.381	–0.042	–0.096	0.126
Vietnam (1998)	0.026	0.096	0.212	0.030	0.146	0.251	–0.047	0.363	–0.051	–0.089	0.066
Unweighted mean	0.041	0.193	0.213	0.030	0.080	0.217	–0.057	0.277	–0.081	–0.107	0.083

*The Jamaica JSLC did not include information on floors, so wall material is substituted here.

**The Pakistan integrated household survey (PIHS) did not include information on ownership of refrigerators.

where x_j is the log of per capita expenditures of household j; d_j is a vector of household characteristics that may affect consumption and allocation decisions (e.g. household size, age-sex composition, and educational attainment of the household head and the stock of education in the household); q_j is housing quality (floor construction material); Z is a vector of dummies indicating access to public services, and ε_j is the household specific disturbance term. We control for any unobserved regional effects with region dummies. In practice, we employ a common set of right hand side variables for each of the countries.[14] Separate models were estimated for urban and rural areas, and the dependent variable in the least squares regressions was the log of per capita household consumption expenditure. The effects of the survey design (clustering) are taken account of in estimating the standard errors.

We could easily construct anonymous distributions of asset indices and of per capita household consumption expenditures estimated from these models and compare them with the distributions of reported expenditures (e.g. through graphs of density estimates or cumulative distribution functions). But such an exercise misses any re-ranking of households within these distributions; and when targeting the poor is an objective, we need to be able to identify them. Thus our form of evaluation is to compare the consistency with which the asset index and predicted expenditures rank households relative to reported expenditures.

There are several degrees to which household rankings can be examined. We report measures that capture the extremes. At one extreme, Spearman rank correlations provide information on the overall rankings of individual households within the entire sample. At the other extreme, transition probabilities between quantiles, as reported in transition matrices, indicate the degree to which our wealth proxies rank households in appropriate quantiles. The use of transition matrices and shares is borrowed from the labor economics literature on earnings and income mobility (Cox and Alm, 1995; Fields and Ok, 1996; Leary, 1998), though the emphasis here is on immobility or fit (Hentschel and Lanjouw, 1995). For example, the more households in the first quintile of reported expenditures that are identified in the first quintile of the alternative measure of welfare, the less "mobility" there is between the two distributions and the greater is the fit. Those who are relatively poor as measured by reported expenditures, will also be considered relatively poor under the alternative measure. If significant re-rankings of households occur, then the identification of the poor differs, for example, between the asset index and reported expenditures. Instead of illustrating the various rankings of household in the form of transition matrices, we summarize them in a scalar measure of distance as described in Hentschel and Lanjouw (1995) and Swaminathan (1988). This correspondence index can be written as:

$$FI = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}(i-j)^2 m_{ij}}{2\sum_{i=1}^{n/2}(i-n)^2} \times \frac{1}{0.322}, \qquad (6)$$

[14]These follow the general form used by Glewwe (1991) and Grootaert and Kanbur (1997), and others.

where n is an even number of quantiles, i and j are the row and column quantile, respectively, and m_{ij} is the transition share associated with the ij-th cell of the transition matrix. The idea of this measure is that it gives weights to only the off-diagonal elements of the transition matrix, and these weights increase with the distance from the diagonal. This gives an intuitive measure of correspondence, with perfect correspondence (i.e., 100 percent probability of households being placed in the diagonal elements of the matrix) taking a value of zero. The index is then divided by 0.322, the value that the left-hand side takes on when there is an equal probability of being in any column cell associated with any given row. This makes interpreting the index more straightforward, with values of zero indicating perfect fit, and values of one indicating perfectly random association between the two distributions. We calculate this measure for deciles.

Evaluation through Health and Nutrition Models

While the preceding form of comparing the correspondence between household orderings based on assets and on expenditures is informative, it begs the question as to which is a better metric of household welfare. In this section we attempt to address that question. We do so by comparing the ability of the various metrics of economic well-being (the asset index and reported and predicted consumption) to explain child health and nutrition outcomes through graphical representations (i.e. plot stunting rates by wealth quintiles) and through econometric estimation of health and nutritional outcomes. Before elaborating on the means by which the model estimation can be used to evaluate the asset index and predicted expenditures, we need to describe the theory and estimation strategies for modeling nutrition outcomes of children under five years of age.

The theoretical foundations for modeling household expenditures and child health and nutrition must be considered concurrently given the simultaneity of choices that govern the levels and patterns of consumption with those of "inputs" into child nutrition. We thus follow Behrman and Deolalikar (1989), Horton (1988), Sahn (1990) and Thomas, Lavy and Strauss (1996) in estimating reduced form equations. Further, since we are interested in the role of our proxies for wealth, we follow the method of Sahn (1990) in estimating these reduced-form equations conditional on consumption expenditures. The appropriate means of doing so would be to instrument per capita expenditures to ensure that they are not jointly determined by the nutritional outcomes that they are meant to explain. This provides an opportunity to test our asset index against the instrumented variable typically used in nutrition models.

The models of household per capita consumption expenditures and child nutritional status are derived from a household model in the tradition of Becker (1981). Assume that the household maximizes a quasi-concave utility function that takes as its arguments consumption of commodities and services, x, and the leisure, l, and health status, θ (of which a child's anthropometric measurement, h, is one dimension), of each household member. Without considering how household decisions are made, the household solves the following problem,

$$\max_{x,l,\theta} u(x,l,\theta;A,Z),$$

where A and Z respectively represent household and community characteristics, some of which are not observed. Allocation choices are conditional on the budget constraint:

$$px = w(T - l) + y,$$

where p is a vector of prices, w is a vector of household members' wages, T is a vector of the household members' maximum number of work hours, and y is household non-wage income.

The health and nutritional status of children, h, is determined by a biological health production technology:

$$h_i = h(I, A, Z, \mu_i), \tag{7}$$

where I is a vector of health inputs and μ_i represents the unobservable individual, family, and community characteristics that affect the child's nutritional outcomes. Household characteristics (e.g., demographics, educational levels,[15] etc.), A, can have an impact on health by affecting household allocation decisions. Community characteristics, Z, such as vaccination rates and access to clean water, can also have direct impacts on nutritional outcomes. Note that the input vector, I, includes consumption goods which contribute positively to household welfare both directly through x, and indirectly through h. This represents the simultaneous choice of consumption goods and health inputs.

Solving the household's optimization problem leads to reduced-form demand equations including those for consumption, nutrition inputs, and child nutrition. The nutrition functions for each child conditional on per capita expenditures (quasi-reduced form) can be represented as follows:

$$h_i = \tilde{h}(x, A, Z, \varepsilon_i), \tag{7a}$$

where ε_i is the child-specific random disturbance term, which as such is assumed to be uncorrelated with the other elements of the demand function. Since consumption, x, is a choice variable, it is unlikely that it is uncorrelated with the disturbance term, and instrumental variables approaches are typically employed.

This is the model that we estimate, substituting our asset index and predicted consumption expenditures for x as instruments. Because we are predicting expenditures at the household level (instead of the level of the individual), we cannot use two-stage least squares. Further, since the asset index is constructed using factor analysis, other means of correcting the standard errors must be found. For these reasons, the models were bootstrapped to estimate standard errors and to test parameter differences across models.

The dependent variable is the standardized anthropometric height-for-age Z (HAZ)-score (see Appendix A). We select this measure of child health and

[15]Note that since the education of the household head is an asset included in the asset index, collinearity following from the inclusion of similar education variables in the estimation equations may bias the parameter estimates and affect the levels of significance for the asset index. While this does not affect the consistency of predicted nutritional outcomes, it does affect comparisons of significance for the asset index and expenditures. As such, the models were also estimated with the education-excluded asset index. The few differences between the models were insubstantial and are therefore not presented here.

nutrition because of the abundance of medical and public health research showing that children's height is an ideal, objective indicator of their general health and nutritional status (Tanner, 1981; Beaton *et al.*, 1990; WHO, 1995; Onis, Frongillo and Blossner, 2000). The principle determinants of the distribution of children's height in a population are the accumulation of episodes of inadequate nutrient intake, disease, and deprivation that result in stunted growth (Scrimshaw, Taylor and Gordon, 1968; Martorell *et al.*, 1975); and consequently, height deficits are considered an excellent indicator of poor health and nutrition. On the strength of this evidence, the most prominent indicator of child health status used in the economic literature in developing countries is children's height (Behrman and Deololikar, 1988; Strauss and Thomas, 1995).

The set of right-hand side covariates consists of characteristics of the child (e.g., age, gender, birth order), household demographic variables such as household size and age-sex composition, characteristics of the parents (e.g., educational attainment, age, and height), community characteristics where available (e.g., distance to nurse and doctor, vaccination prevalence), month of the measurement (to control for seasonality), and region dummies.

Separate quasi-reduced form models conditioned on (a) the log of predicted per capita household expenditures, (b) the log of household asset indexes, (c) the log of reported per capita household expenditures, and (d) both the log of asset indexes and the log of predicted per capita household expenditures. Standard errors were estimated using bootstrapping methods for the models.

The logic for estimating the latter model (d) is that while collinearity between the asset index and consumption expenditures will bias the coefficient estimates, it does not bias the predicted values of the dependent variable, the child's nutritional outcome. Further, if the predicted outcomes from the models that include both asset indexes and consumption expenditures perform better than those with either one or the other, we could reasonably conclude that each has more to add to the model. When this is not the case, then the asset index and household consumption expenditures can be viewed as practical substitutes for explanatory variables in models of child nutritional outcomes.

Once the models are run, we use them to predict child HAZ-scores and compare the rank correlations and fit indices of the fitted nutritional outcomes with the actual measured outcomes. We further compare the estimated wealth coefficients and examine relative explanatory power across the models for each dataset.

Additional insight into the relative merits of the alternative measures can be gained when we consider that each variable is a proxy for the same thing—long-term wealth—but is measured with error. We employ our nutrition models and the logic behind the Hausman test of measurement error here to construct a relative indicator of measurement error between predicted expenditures and the asset index (Filmer and Pritchett, 2001). The preferred measure is the one that has a level of measurement error lower than the other to which it is being compared.

If we assume that the measurement error for predicted expenditures and for the asset index are not perfectly correlated, then each can be used as an instrument for the other to alleviate (though not eliminate) the attenuation bias in the OLS parameter estimate. The ratio of the OLS estimator to the instrumental variable (IV) estimator is a relative measure of measurement error, which as Filmer and Pritchett (2001) point out is an estimate of the relative signal to signal plus noise of the two variables. In other words, the lower the ratio (the more noise or measurement error), the worse the variable is as a proxy for long-term wealth in predicting nutritional outcomes.

Although instruments are valid only when they are uncorrelated with the error term in the estimating equation, Appendix B shows that this approach is still valid as a means of indicating *relative* measurement error because the IV estimates for both expenditures and assets will converge to the same constant. We thus compare the difference in the ratios of the OLS to IV estimators in the nutrition models for each survey to determine if the asset index measures wealth with more or less error than predicted expenditures.

4. Data

Living Standards Measurement Study (LSMS) and LSMS-type household surveys for Côte d'Ivoire, Ghana, Jamaica, Madagascar, Nepal, Pakistan, Papua New Guinea, Peru, South Africa and Vietnam are used in the paper.[16] The purpose of these surveys is to collect individual, household, and community level data to measure levels and changes in living standards of the populations sampled. The national statistical offices of each of the countries conducted the surveys with technical support from the World Bank. Multi-stage sampling techniques were used in selecting the samples of households, and sampling was done in a way to ensure self-weighting (i.e., each household has equal probability of being in the sample) in some, though not all, of these surveys. For those datasets in which certain strata were oversampled, we apply sampling weights throughout the analysis. The household surveys collect detailed information on expenditures, income, employment, assets, basic needs, and socio-economic characteristics of the households.

Analysts in the LSMS division of the World Bank or consultants constructed the expenditure variable used in the analysis. The measure of household expenditures in the 12 months preceding the interview is a combination of food expenditures (market purchases and imputed value of home production), nonfood expenses (weekly expenses, annual expenses, depreciated consumer durables, utilities, housing rent or rental value, and educational expenses), and in-kind wages.

The Côte d'Ivoire sample (CILSS) was collected between March 1987 and March 1988 (hereafter 1988), in two visits to households two weeks apart. The sample size of 1,600 households includes anthropometric measurements of 2,169 children under five years of age. Grootaert (1986) and Ainsworth and Munoz (1986) discuss this data in detail.

The two Ghana samples were collected between October 1988 and August 1989 (hereafter 1988 or GLSS2), and September 1991 and September 1992 (hereafter 1992 or GLSS3). The sample sizes are 3,192 and 4,552 households, respectively. Anthropometric measurements are available for 2,551 children under the age of five for the GLSS2. The GLSS3 differs from the GLSS2 in that the former

[16] All of these data can be downloaded from the World Bank's LSMS website (http://www.worldbank.org/lsms/guide/select.html). The authors are extremely grateful to the World Bank's LSMS division and to the respective national statistical offices for access and permission to use the data.

is concentrated more on income and expenditures of households at a more disaggregated level. Consequently, it does not include an anthropometry section. The survey instruments also changed. Whereas in the GLSS2, two visits were made to each household, two weeks apart, and two-week recall of expenditures was collected in the second visit, the GLSS3 involved eight visits, two days apart for two-day recall of expenditures. Demery and Mehra (1996) show that welfare comparisons for Ghana using these two surveys are sensitive to this change, as well as to the change in the list of food and non-food items included in the later questionnaire.[17]

The Jamaica Survey of Living Conditions (JSLC) was collected between May and August 1998. During the one visit to the 7,375 households, anthropometric measures were taken for 2,613 children under the age of five. Households were asked in the food consumption module about purchases made over the past seven days and over the past month.

The Enquete Permanente Aupres des Menages (EPM) in Madagascar was collected in two visits, two weeks apart between May 1993 and April 1994. The sample of 4,800 households includes 2,632 children under the age of five for whom anthropometric measurements were recorded. The EPM, in a manner unlike most LSMS-type surveys, permitted the interviewer to select the recall period for each expenditure item (i.e. day, week, month or year).

The Nepal Living Standards Survey (NLSS) is comprised of 3,388 households and has anthropometric measurements for 1,601 children under the age of three. A subset of the data was collected over a month-long period in June and July of 1995. Following a review of the data quality, teams returned to the field in August–October to collect the remainder of the data. The questionnaire is designed for one visit, though in practice, the number of visits depended upon the length of time needed to complete the questionnaire. For large families with many plots of land, this could take up to three visits. Nonetheless, most interviews were completed in one visit.

The Pakistan Integrated Household Survey (PIHS) data was collected in two visits, two weeks apart over the course of the twelve months of 1991. In the 4,794 households sampled, anthropometric measurements were recorded for 4,014 children under the age of five. Separate questionnaires were used for men and women to gather information from the most appropriate members of the household. However, there is some overlap between the male and female questionnaires.

The Papua New Guinea Household Survey (PNGHS) data was collected in two visits, two weeks apart from January to December 1996. The sample consists of 1,396 households and 864 children under the age of five with anthropometric measurements.

The Encuesta Nacional de Hogares Sobre Medicion de Niveles de Vida (ENNIV) data of Peru were collected between June and August 1994. The most informed members of the 3,623 households were asked about food consumption with a two-week recall period. Anthropometric measurements were collected for 2,064 children under the age of five.

[17]This is an example of the types of empirical results that motivate our use of assets.

The South Africa Integrated Household Survey (SAIHS) data was collected in one visit during the months from January to December 1994. The 8,848 households were queried about their food consumption over the one month prior to the interview date. The actual recall period (one month or one week) depended upon their response to a question about the frequency of the purchase. Anthropometric measurements were collected for 4,873 children under the age of five.

The Vietnam Living Standards Study surveys (VNLSS) were collected between October 1992 and October 1993 (hereafter 1993), and December 1997 and December 1998 (hereafter 1998), in two visits to each household two weeks apart. Expenditure data was collected during the second visit to the 4,800 (5,999) households in the sample, and 2,813 (2,146) children under age five were measured in the anthropometry section for 1993 (1998).

5. Results

We begin by presenting the results of Spearman rank correlations between reported expenditures and asset indices and predicted expenditures in Table 2. The rank correlations for the reported and predicted values models of expenditures vary quite a bit, from a low of 0.60 in Pakistan and Vietnam (1993), to a high of 0.86 in South Africa. The rank correlations between reported expenditures and the household asset index are all lower, with the Jamaica number being only 0.31. Other low correlations include 0.42 in Ghana (1992) and Pakistan. Highs of 0.71 are found in the Peru and South Africa samples. Generally, countries with a higher correlation between expenditures and predicted expenditures also have a higher correlation between expenditures and the asset index. In all cases the Spearman tests of independence between the distributions of reported expenditures and estimated variables are rejected.

The correspondence indexes are presented in Table 3.[18] As expected, relative to reported expenditures, rankings based on predicted expenditures are more

TABLE 2

Spearman Rank Correlations between Reported Expenditures and Alternative Measures of Welfare

Log Per Capita Household Expenditure	Predicted Expenditures	Asset Index
Cote d'Ivoire—CILSS (1988)	0.71	0.51
Ghana—GLSS2 (1988)	0.72	0.43
Ghana—GLSS3 (1992)	0.72	0.42
Jamaica—JSLC (1998)	0.65	0.39
Madagascar—EPM (1993)	0.71	0.50
Nepal—NILSS (1996)	0.70	0.55
Pakistan—PIHS (1991)	0.60	0.42
Papua New Guinea—PNGHS (1996)	0.55	0.47
Peru—ENNIV (1994)	0.78	0.71
South Africa—SAIHS (1994)	0.86	0.71
Vietnam—VNLSS (1993)	0.60	0.55
Vietnam—VNLSS (1998)	0.74	0.67

[18] The transition matrices associated with these correspondence indexes are available upon request from the authors.

TABLE 3

CORRESPONDENCE INDEXES BETWEEN REPORTED EXPENDITURES AND ALTERNATIVE MEASURES OF WELFARE

Log Per Capita Household Expenditure	Predicted Expenditures	Asset Index
Cote d'Ivoire—CILSS (1988)	0.30	0.46
Ghana—GLSS2 (1988)	0.37	0.56
Ghana—GLSS3 (1992)	0.37	0.59
Jamaica—JSLC (1998)	0.20	0.60
Madagascar—EPM (1993)	0.50	0.73
Nepal—NILSS (1996)	0.42	0.71
Pakistan—PIHS (1991)	0.46	0.64
Papua New Guinea—PNGHS (1996)	0.54	0.66
Peru—ENNIV (1994)	0.21	0.28
South Africa—SAIHS (1994)	0.18	0.31
Vietnam—VNLSS (1993)	0.42	0.48
Vietnam—VNLSS (1998)	0.29	0.36

Note: All fit indexes are divided by 0.322 (value with equal probability of falling in any cell).

similar to reported expenditures than is the asset index. But perhaps of greater importance, even in the case of expenditures and predicted expenditures, these values vary widely and indicate a fair degree of difference in ranking.

As we stress above, consumption expenditure is itself a proxy for welfare, and certainly measures long-term wealth with error. By comparing the distribution of household asset indexes to the distribution of reported expenditures, we must remember not to implicitly assume that the latter represents the true measure of welfare.[19] This is especially pertinent considering such problems as non-sampling errors, the lack of reliable regional price indexes, the inconsistency of survey instruments, and so forth. We thus turn to an indirect, but what we argue is a more meaningful means of evaluating the asset index and predicted expenditures variables, one that is more in the spirit of the capabilities approach to measuring welfare—modeling child nutrition outcomes.

Table 4 reports the mean bootstrapped parameter estimates on wealth and the ordinary least squares (OLS) R^2 for each of the models.[20] The signs are all as expected, and for the rural models, the asset index parameter is significant in all cases except Peru. Contrast this with predicted expenditures, where the parameter estimate is significant in only 4 of the 11 cases. The R^2 values in the models are similar for the expenditure and asset models. In urban areas, the asset variable is significant in 7 of 11 models, again doing better than the predicted or reported expenditure variables. Like the rural models, the R^2 are very similar across choice of assets or expenditures in the models. Because the scale of the asset index is different from that of expenditures, the coefficients of the former cannot be compared directly with those of the latter.[21] Nonetheless, since the distribution of asset

[19]Given that the asset index is a stock measure, while expenditure is a flow measure, it is not entirely surprising that the two differ in their rankings of households.

[20]For ease of exposition, the other parameters in the model are not presented, but are available from the authors upon request.

[21]Elasticities are uninformative because a 1 percent change in the asset index does not represent the same concept of change as does a 1 percent change in expenditures because the asset index can be scaled up or down without changing any of the information conveyed.

TABLE 4

MEANS OF BOOTSTRAPPED WEALTH COEFFICIENTS FROM HEIGHT-FOR-AGE QUASI-REDUCED FORM MODELS (250 REPETITIONS)

	Urban			Rural		
	Coefficient	t statistic	R^2	Coefficient	t statistic	R^2
Cote d'Ivoire 1988						
Predicted expenditures	0.604*	2.33	0.121	0.011	0.04	0.082
Asset index	0.217**	3.16	0.124	0.216+	1.79	0.086
Reported expenditures	0.232*	2.01	0.118	0.324**	3.04	0.092
Ghana 1988						
Predicted expenditures	0.097	0.71	0.327	0.229	1.24	0.249
Asset index	1.858**	2.95	0.340	2.563*	2.07	0.253
Reported expenditures	0.115	1.57	0.330	0.069	0.98	0.249
Jamaica 1998						
Predicted expenditures	0.532**	3.36	0.171	0.559**	3.39	0.200
Asset index	0.187**	2.80	0.170	0.166**	4.02	0.202
Reported expenditures	0.278**	3.19	0.172	0.226**	3.82	0.198
Madagascar 1993						
Predicted expenditures	0.580	1.13	0.160	0.732	1.16	0.112
Asset index	1.068	1.47	0.157	4.237**	2.89	0.115
Reported expenditures	0.354	1.05	0.167	0.023	0.09	0.112
Nepal 1996						
Predicted expenditures	0.567	1.64	0.391	0.361	1.27	0.203
Asset index	0.143	1.51	0.394	0.222*	2.48	0.203
Reported expenditures	0.596*	2.40	0.413	0.179	1.65	0.201
Pakistan 1991						
Predicted expenditures	–0.221	–1.01	0.178	0.049	0.24	0.129
Asset index	0.086	1.26	0.178	0.132+	1.82	0.132
Reported expenditures	0.141+	1.87	0.181	0.226**	2.77	0.136
Papua New Guinea 1996						
Predicted expenditures	0.543	1.48	0.277	0.397+	1.80	0.175
Asset index	0.221	1.44	0.283	0.607**	4.24	0.199
Reported expenditures	0.395	1.63	0.288	0.193*	2.12	0.175
Peru 1994						
Predicted expenditures	0.582**	2.99	0.281	0.200	0.74	0.240
Asset index	0.385**	5.50	0.297	0.193	1.64	0.243
Reported expenditures	0.518**	5.83	0.297	0.055	0.54	0.242
South Africa 1994						
Predicted expenditures	0.573**	2.65	0.158	0.137	0.89	0.095
Asset index	0.358**	4.80	0.161	0.297**	3.44	0.099
Reported expenditures	0.392**	4.69	0.168	0.301**	4.86	0.109
Vietnam 1993						
Predicted expenditures	0.694**	2.63	0.264	0.427*	2.28	0.225
Asset index	2.490**	2.99	0.274	3.063**	3.43	0.227
Reported expenditures	0.476**	3.71	0.274	0.295**	3.80	0.230
Vietnam 1998						
Predicted expenditures	0.687+	1.84	0.264	0.599*	2.09	0.267
Asset index	0.247**	3.64	0.281	0.279**	2.83	0.271
Reported expenditures	0.214+	1.94	0.263	0.231*	2.35	0.267

+, * and ** indicate significance at the 90%, 95% and 99% levels of confidence.

indices across all of the surveys is standardized, comparisons of the size of the asset index parameter estimates are valid across countries. For both urban and rural areas, the parameter estimates are largest for Ghana, Madagascar and Vietnam. It is also noteworthy that there is a large divergence between predicted and reported expenditures, even when both these variables are significant.

Spearman rank correlations between measured and predicted HAZ scores (Table 5) indicate that in terms of predictive capabilities, it does not matter which alternative welfare measure is used. These correlations are similar across the alternatives, ranging from 0.251 for the reported expenditure in the Côte d'Ivoire sample, to 0.590 for assets in the Peru sample. The rank correlations do not improve when predicted expenditures are added into the models with the asset index. These low rank correlations are not surprising given the explanatory power of the models. We find a similar story by examining the correspondence indexes for the three measures, as well as predicted expenditures and assets combined.[22] For 7 of 11 countries, the index has a lower value for the asset variables than either expenditure variables. But these differences are generally small and do not represent a meaningful difference. In combination, the above findings suggest that analysts are no worse off, and may be better off, conditioning child nutrition models on the asset index rather than reported expenditures in their effort to predict nutritional outcomes and target programs.

Models of nutritional outcomes are rarely estimated for their predictive capabilities (our R^2 values of 0.413 for urban Nepal are unusually high). More precisely, interest is in the parameter estimates and their significance. We therefore employ tests of stability of the other parameter estimates (with standard errors estimated using bootstrapping methods) in the models. Regardless of which measure of wealth is used, these results do not lead to rejections of the null hypothesis that the parameters are the same. This adds more evidence that our results indicate that the asset index can be appropriately employed as a welfare proxy.

Another approach to assessing the relative merits of using expenditures relative to assets is to examine the predicted level of nutritional status across the quintiles of the expenditure and asset distributions. We do so in Table 6 for rural areas.[23] As expected the level of stunting declines across the quintiles, although the gradient varies quite substantially between countries. For example, it is quite high in the case of Papua New Guinea, and quite low in the case of Cote d'Ivoire. Thus, the correlation between expenditure (or assets) and nutrition is high in the case of the former, and low in the case of the latter. Our main interest, however, is not the difference in gradients among the countries, but between the asset index and expenditures. While not a formal test of the quality of the welfare ranking, it is noteworthy that the spread in predicted percentages of malnourished children between the upper and lower quintile of the asset distribution is greater than or equal to the spread based on predicted expenditures in a number of cases, and that the

[22]The transition matrices associated with these correspondence indexes are available upon request from the authors.

[23]We do not show the data for urban areas to save space, but it is qualitatively similar.

TABLE 5

Performance of Predicted HAZ Scores Using Predicted Expenditures and Asset Index as Explanatory Variables

	Spearman Rank Correlations				Correspondence Indexes			
Reported HAZ	Predicted Expenditures	Asset Index	Reported Expenditures	Asset Index & Pred. Expenditures	Predicted Expenditures	Asset Index	Reported Expenditures	Asset Index & Pred. Expenditures
Cote d'Ivoire 1988	0.251	0.257	0.259	0.258	0.748	0.734	0.786	0.731
Ghana 1988	0.549	0.561	0.524	0.535	0.490	0.478	0.489	0.475
Jamaica 1998	0.371	0.364	0.362	0.374	0.623	0.631	0.632	0.621
Madagascar 1993	0.356	0.355	0.359	0.359	0.654	0.656	0.647	0.650
Nepal 1996	0.401	0.403	0.414	0.405	0.624	0.619	0.603	0.613
Pakistan 1991	0.330	0.336	0.337	0.338	0.669	0.671	0.665	0.665
Papua New Guinea 1996	0.436	0.472	0.440	0.455	0.578	0.539	0.575	0.525
Peru 1994	0.576	0.590	0.588	0.590	0.416	0.405	0.410	0.404
South Africa 1994	0.340	0.350	0.354	0.352	0.678	0.664	0.658	0.663
Vietnam 1993	0.490	0.496	0.496	0.497	0.514	0.508	0.586	0.506
Vietnam 1998	0.527	0.529	0.528	0.531	0.470	0.469	0.472	0.470

Note: All fit indexes are divided by 0.322 (value with equal probability of falling in any cell).

TABLE 6

RURAL STUNTING RATES BY QUINTILE OF WEALTH PROXY

	Percent Stunted			Mean HAZ-score		
Quintile	Asset Index	Predicted Expenditures	Reported Expenditures	Asset Index	Predicted Expenditures	Reported Expenditures
Cote d'Ivoire 1988						
Poorest	19.1	17.5	27.4	–0.75	–0.62	–1.02
2nd	22.5	21.0	18.3	–0.70	–0.57	–0.60
3rd	18.2	19.5	18.9	–0.50	–0.74	–0.36
4th	17.6	16.0	12.2	–0.49	–0.43	–0.42
Richest	13.3	16.5	13.7	–0.36	–0.44	–0.40
Ghana 1988						
Poorest	35.6	33.5	32.9	–1.36	–1.16	–1.26
2nd	28.2	30.9	25.9	–1.08	–1.11	–1.02
3rd	32.6	25.7	35.8	–1.33	–1.19	–1.33
4th	24.4	30.0	30.0	–1.06	–1.26	–1.24
Richest	26.3	27.2	22.6	–1.10	–1.21	–1.09
Jamaica 1998						
Poorest	9.3	7.9	6.2	–0.28	–0.17	–0.12
2nd	8.4	8.1	11.3	–0.22	–0.24	–0.19
3rd	5.7	7.2	8.6	–0.11	0.07	–0.28
4th	5.6	5.7	4.3	0.13	–0.11	–0.07
Richest	3.8	3.9	2.5	0.16	0.11	0.32
Madagascar 1993						
Poorest	52.9	47.0	47.3	–2.29	–2.10	–1.94
2nd	50.7	50.0	53.3	–2.08	–2.02	–2.23
3rd	47.4	50.3	57.4	–1.98	–2.10	–2.26
4th	45.6	52.0	43.4	–1.89	–2.13	–1.96
Richest	45.6	44.7	42.6	–2.00	–1.97	–1.90
Nepal 1996						
Poorest	57.5	46.0	48.4	–2.13	–1.74	–1.75
2nd	43.9	50.9	51.3	–1.82	–1.85	–2.01
3rd	47.9	45.6	46.2	–1.79	–1.87	–1.99
4th	45.9	54.0	45.4	–1.81	–2.11	–1.67
Richest	34.7	36.8	41.8	–1.42	–1.51	–1.65
Pakistan 1991						
Poorest	52.2	48.2	52.1	–2.03	–1.83	–1.94
2nd	50.7	50.0	47.7	–1.84	–1.82	–1.92
3rd	47.6	50.2	55.5	–1.66	–1.91	–1.92
4th	47.3	46.0	45.1	–1.83	–1.70	–1.73
Richest	46.9	49.7	44.7	–1.74	–1.82	–1.61
Papua New Guinea 1996						
Poorest	54.8	34.6	46.6	–2.24	–1.21	–1.80
2nd	43.0	38.7	47.6	–1.56	–1.49	–1.67
3rd	39.4	41.8	29.2	–1.47	–1.65	–1.14
4th	23.4	40.2	32.6	–0.86	–1.59	–1.22
Richest	15.4	21.3	20.1	–0.55	–0.74	–0.85
Peru 1994						
Poorest	51.3	50.8	53.9	–2.00	–1.92	–1.96
2nd	49.2	62.1	49.1	–1.89	–2.17	–1.99
3rd	47.3	40.2	45.8	–1.91	–1.76	–1.82
4th	40.9	38.4	40.6	–1.54	–1.55	–1.61
Richest	31.9	30.4	32.5	–1.42	–1.42	–1.45

TABLE 6 (*continued*)

	Percent Stunted			Mean HAZ-score		
Quintile	Asset Index	Predicted Expenditures	Reported Expenditures	Asset Index	Predicted Expenditures	Reported Expenditures
South Africa 1994						
Poorest	38.0	35.1	38.5	–1.59	–1.43	–1.56
2nd	32.0	32.0	33.4	–1.39	–1.44	–1.44
3rd	29.3	29.4	26.4	–1.27	–1.28	–1.20
4th	22.7	24.8	24.2	–1.10	–1.17	–1.23
Richest	22.1	22.6	21.5	–1.07	–1.10	–0.99
Vietnam 1993						
Poorest	53.6	60.4	57.3	–2.03	–2.28	–2.18
2nd	55.1	55.7	59.6	–2.06	–2.13	–2.18
3rd	54.3	53.1	55.0	–2.05	–1.96	–2.07
4th	56.8	51.7	46.7	–2.09	–1.82	–1.78
Richest	42.1	41.6	43.9	–1.68	–1.74	–1.72
Vietnam 1998						
Poorest	41.7	44.0	46.2	–1.62	–1.69	–1.65
2nd	41.6	43.0	38.8	–1.67	–1.58	–1.58
3rd	42.5	36.2	43.0	–1.60	–1.57	–1.65
4th	32.9	35.3	30.9	–1.32	–1.44	–1.41
Richest	26.5	26.7	26.4	–1.28	–1.21	–1.21

decline over the quintiles tends to be smoother in the case of our asset index, than for the expenditure measure. For example, take the case of Cote d'Ivoire, where there is a decline in the share malnourished from 19 percent of the population in the lowest asset quintile to 13 percent of the population in the highest asset quintile. When using predicted expenditures, the comparable values in the lowest and highest quintile are 18 and 17 percent, respectively. Similarly, in the case of Papua New Guinea, the spread across the quintiles for the asset index is from 55 to 15 percent, while it is only 35 to 21 percent in the case of predicted expenditures. In many other countries the spread is quite similar across the quintiles for the asset index and predicted expenditures. Once again, based on the fit of the data, these results suggest that at least when it comes to predicting a key welfare outcome, that the asset index does an equal or better job at stratifying the population into well and poorly nourished individuals.

Finally, Table 7 presents the estimated ratios of OLS to IV estimates from regressions of HAZ scores on predicted expenditures using the asset index as an instrument, and from regression on the asset index using predicted expenditures as an instrument.[24] In each case except urban Jamaica and Madagascar, and rural Jamaica and Vietnam (1993), the ratio of OLS to IV estimators is higher for the asset index than for expenditures, suggesting that measurement error is larger for the latter. Statistical tests of these differences, however, are only significant in the cases of Pakistan and Papua New Guinea.

[24]The exercise was also carried out for reported expenditures. The results do not differ substantially from those in Table 7, and consequently are not reported.

TABLE 7

Test of Measurement Error between Predicted Expenditures and Asset Index (Bootstrapped Difference in Ratio of OLS to IV Parameter Estimates on Wealth Proxies)

	Urban		Rural	
	Difference	z-statistic	Difference	z-statistic
Cote d'Ivoire 1988	0.573	1.073	0.034	0.037
Ghana 1988	0.034	0.059	0.201	0.353
Jamaica 1998	–0.294	–0.762	–0.281	–0.782
Madagascar 1993	–0.362	–0.557	0.049	0.089
Nepal 1996	0.225	0.013	0.663	0.057
Pakistan 1991	0.093+	1.661	0.277	0.322
Papua New Guinea 1996	0.127	0.158	0.833*	2.060
Peru 1994	0.571	1.542	0.249	0.358
South Africa 1994	0.308	0.770	0.659	0.775
Vietnam 1993	0.296	0.520	–0.033	–0.084
Vietnam 1998	0.767	1.515	0.098	0.238

Note: A positive (negative) value indicates that there is less measurement error when the asset index (expenditure) is used as an explanatory variable.

6. Conclusions

This paper evaluates the potential of our index of household assets as a measure of the household economic welfare. Our motivation is in part to see if there exist simpler and less demanding alternatives to collecting data on expenditures for purposes of measuring economic welfare and ranking households. This is particularly important for poor countries that not only lack the requisite household survey data to design policies and evaluate program effectiveness, but also do not have the financial or human resources to generate such information. Similarly, even when survey data are available at one or more point in time for a given country, the demands in terms of survey capability and related data collection (such as required to generate regional price deflators) make inter-temporal and inter-regional welfare comparisons extremely difficult.[25]

The first form of evaluation, comparing the asset index and predicted expenditures to reported expenditures, indicates that the ranking of household welfare according to the asset index is less consistent with reported expenditures than is the case with predicted expenditures.

While these results are informative, they beg the question of whether direct comparisons to household consumption expenditures are the appropriate means of evaluation. Like the household asset index, household expenditures are a proxy for welfare (and notionally, utility). But they are measured with large errors. The reliance on recall data, the large share of goods consumed from home production, poorly trained and supervised enumerators and field staff, inconsistencies in survey

[25]A related motivation is to assess the practicality of using the Demographic and Health Surveys to study inter-temporal and inter-regional welfare dynamics. This is particularly pertinent given the absence of widely available and comparable household consumption and expenditure survey data from Africa, and the fact that the DHS data are inter-temporally and internationally consistent and prevalent for Africa. And while the DHS also have considerable information on health and education, these surveys lack information on income or consumption expenditures. The asset index is a simple way to circumvent the absence of the more widely used money-metric of welfare (e.g., consumption expenditures) in the DHS.

instruments, and suspect price deflators are the types of factors that make household rankings and analyses of poverty dynamics based on expenditure data suspect and problematic.

We therefore resort to a second form of evaluation that involves testing the power of the asset index and both instrumented and reported expenditures to predict a basic capability—adequate nutrition. Our findings show that the asset index is a perfectly valid predictor of child nutrition outcomes. In the context of estimating models of nutrition, we find no compelling reason to believe that either reported or instrumented expenditures serve as a better proxy for economic welfare than does the asset index. In fact, for most of the samples included in this paper, the asset index performs as well, if not better than reported expenditures in predicting children's height-for-age Z-scores. Further, indicators of relative measurement error estimated in the nutrition models show that expenditures (both reported and predicted) are measured as a proxy for long-term wealth or welfare with more error than is the asset index.

Despite the ambiguous results from direct comparison of the asset index and predicted expenditures to reported household expenditures, this paper finds no reason to abandon the use of the asset index as a measure of economic welfare in the absence of expenditure data. In addition, even when expenditure data are available, our results suggest that analysts may prefer to use the asset index as an explanatory variable or as a means of mapping a metric in permanent income space to other living standards and capabilities such as nutrition. In fact, while further empirical testing is required, our research raises the prospect of relying on assets as an alternative to the collection of expensive expenditure data in contexts where the latter are likely to be ridden with large measurement errors.

Appendix A: Anthropometric Nutrition Measures

The indicators of nutritional status used in this paper (and available in the DHS) are anthropometric measurements of children under age five. From these measures, along with reported ages of children, normalized measures of weight-for-height, height-for-age, and weight-for-age can be constructed as follows:

$$z\text{-}score = \frac{x_i - x_{median}}{\sigma_x},$$

where x_i is a given measurement such as height or weight for child i, x_{median} is the median of that measurement for a healthy and well-nourished child from a reference population of the same age or height and of the same gender, and σ_x is the standard deviation from the mean of the reference population. Note that the z-score for the reference population has a standard normal distribution in the limit. Thus, a child has a probability distribution on the expected value of a z-score. If more that 2.5 percent of a given population have z-scores that fall two standard deviations below the mean of the normal population (zero), then there is said to be malnutrition in the country.

As recommended by the World Health Organization (WHO, 1983), the standard reference population used here is that of the United States National Center for Health Statistics. Studies such as Martorell and Habicht (1986) which found that less than 10 percent of worldwide variance in height is due to differences in genetics or race among children of the same sex under the age of ten, help to establish the appropriateness of using such a reference population.

The height-for-age z-score (HAZ) is an indicator of a child's long-term nutritional status. Children who are "stunted" are those whose past chronic nutritional deprivations leave them shorter than expected for their age and gender cohorts in the reference population. The weight-for-height z-score (WHZ), on the other hand, reflects short-term nutritional status. Current nutritional stress manifests itself in acute "wasting" of children independent of chronic malnutrition. The third measure, the weight-for-age z-score (WAZ), captures a combination of "stunting" and "wasting." We limit ourselves to modeling only the HAZ scores.

Appendix B: Indicator of Relative Measurement Error

To illustrate that the ratio of the *OLS* to *IV* estimators is a valid indicator of *relative* measurement error, we first set up the model and briefly review the basis of the Hausman test. We simplify notation by assuming that there is only one explanatory variable, though this can be easily generalized to multivariate regression.

Define the following variables (individual subscripts are dropped for simplicity) as:

y = HAZ score of the child
x^* = True value of wealth (not observed)
x_e = Expenditures
x_a = Asset Index

Suppose that the underlying model is

$$y = \beta x^* + \varepsilon,$$

and our proxies for wealth are measured with error as follows,

$$x_e = x^* + u_e \quad u_e \sim N(0, \sigma_e^2), \quad \text{and}$$
$$x_a = x^* + u_a \quad u_a \sim N(0, \sigma_a^2).$$

Starting with the model in which we regress y on expenditures, x_e, we have

$$y = \beta x_e + (\varepsilon - \beta u_e).$$

If the asset index were a valid instrument for expenditures, then

$$\operatorname{cov}(x_a, x_e) \neq 0, \quad \text{and}$$
$$\operatorname{cov}(x_a, u_e) = 0.$$

The first condition is clearly the case given the rank correlations between the asset index and reported and predicted household consumption expenditures reported in Table 1. The second condition is unlikely to hold since there is sure to be some component of the measurement error common to both expenditures and the asset index. Note first that if both conditions hold, then

$$p\lim \hat{\beta}_{e,IV} = \beta \geq p\lim \hat{\beta}_{e,OLS},$$

where $\hat{\beta}_{e,IV}$ is the IV estimator when the asset index is used as an instrument for expenditures. This follows from the fact that in the presence of measurement error, the OLS estimator suffers from attenuation bias, and implies that

$$\frac{\hat{\beta}_{e,OLS}}{\hat{\beta}_{e,IV}} \leq 1$$

in the limit. The same would be the case for the model in which y is regressed on the asset index. Thus if each of the wealth proxies were valid instruments for each other, then the proxy for wealth in the model with the higher ratio of OLS to IV estimators in the limit, is the proxy that suffers from relatively less measurement error.

The consistency of the IV estimator follows from the orthogonality between the instrument and the error term. This is not likely to be the case for expenditures and the asset index. In other words,

$$\begin{aligned} &\text{cov}(x_a, x_e) \neq 0, \quad \text{and} \\ &\text{cov}(x_e, u_a) \neq 0. \end{aligned}$$

Nonetheless, provided that the measurement error of the asset index and expenditures is not perfectly correlated, comparison of the ratios of OLS to IV estimators remains a valid indicator of *relative* measurement error. This is apparent if we rewrite the measurement error as

$$\begin{aligned} x_e &= x^* + \tilde{u} + \tilde{u}_e, \quad \text{and} \\ x_a &= x^* + \tilde{u} + \tilde{u}_a, \end{aligned}$$

where $\tilde{u}$ is the component of the measurement error common to both the asset index and expenditures, and $\tilde{u}_e$ and $\tilde{u}_a$ are the idiosyncratic measurement error terms for expenditures and the asset index respectively. The covariance between the instrument and the error for nutrition regressed on expenditures, can now be written as

$$\text{cov}(x_a, u_e) = \text{cov}(x_a, \tilde{u})$$

since

$$\text{cov}(x_e, \tilde{u}_a) = 0.$$

Using this information, it follows from the definition of the IV estimator that

$$p\lim \hat{\beta}_{e,IV} = p\lim \hat{\beta}_{a,IV} = \left(\frac{\text{var}(x^*)}{\text{var}(x^*) + \text{var}(\tilde{u})} \right) \beta.$$

Thus, although the IV estimators are not consistent, they converge to the same constant and

$$\frac{\hat{\beta}_{i,OLS}}{\hat{\beta}_{i,IV}} \leq \left(\frac{\text{var}(x^*)}{\text{var}(x^*) + \text{var}(\tilde{u})} \right) \quad \text{for} \quad i = e, a.$$

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