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Estimating Expenditure-Based Poverty from the Bangladesh Demographic and Health Survey

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It is widely believed that inequalities in health are related with poverty but formal analysis of the health-poverty nexus is hampered by data constraints. In particular, the most common measure of poverty compares expenditure with poverty lines, but expenditure surveys usually do not collect detailed health data. Conversely, the large repository of internationally comparable Demographic and Health Surveys has detailed health data but no expenditure data. This has led DHS researchers to control socio-economic status using an asset index defined in terms of housing characteristics and ownership of durable goods. While this may be a valid conception of poverty, it is difficult to compare the asset-based measure with the more common consumption-based measure. This paper presents a simple poverty scorecard for Bangladesh that allows researchers to estimate the likelihood that expenditure is below a given poverty line using ten verifiable, inexpensive-to-collect indicators found in both Bangladesh's 2004 DHS and also in the 2005 Household Income and Expenditure Survey. The estimates of poverty from the scorecard are then compared with those of the DHS asset index.

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I. INTRODUCTION

This paper applies a simple poverty scorecard (Table 1 in Appendix A) to Bangladesh's 2004 Demographic and Health Survey (DHS) to estimate the likelihood that a given person has expenditure below a given poverty line. This allows researchers to look at how health outcomes vary with socio-economic status as seen through an expenditure lens.

Such an expenditure-based poverty measure is useful because while the DHS surveys are the largest repository of nationally representative data on population, health, HIV, and nutrition (covering more than 75 countries, often for multiple rounds), they do not collect data on consumption. DHS researchers seeking to relate health outcomes to socio-economic status have had to rely on an asset index that in recent years comes pre-packaged with DHS data (Rutstein and Johnson 2004).

The DHS asset index is widely used. Constructed with Principal Components Analysis (PCA), it defines socio-economic status in terms of housing characteristics, asset ownership, and employment of domestic servants. PCA does not explicitly model any particular conception of poverty; rather, it finds the linear combination that maximizes the explained variation among a given set of indicators. Nevertheless, the resulting asset indexes seem to be related to socio-economic status, especially when this is conceived as "permanent income" or "expected long-term control over resources." The indexes turn out to be correlated in intuitive ways with outcomes such as fertility (Bollen, Glanville, and Stecklov 2007), use of emergency obstetric care (Pitchforth *et al.* 2007), maternal and child mortality (Knowles *et al.* 2008), food security (Dekker 2006), child health and nutrition (Sahn and Stifel 2003), and education (Filmer and Pritchett 2001).

Table 2 in Appendix A is the asset index for Bangladesh's 2004 DHS (Gwatkin *et al.* 2007). It has 20 indicators and 84 point values. The DHS index ranks people on a relative scale; a higher value of the index implies higher socio-economic status/lower poverty.[1]

The contribution of this paper is to allow DHS analysis in terms of expenditure-based poverty: a person is poor if the monetized value of his/her per-capita household expenditure is below a poverty line such as the Bangladesh national poverty line or the Millenium Development Goals' $1.25/day line at

[1] A PCA asset index may be seen as a measure of absolute poverty as defined by its indicators and points, and as such it can be used to measure poverty over time and across countries (Booysen *et al.* 2008, Sahn and Stifel 2000). In practice, however, the index is usually treated as a relative measure.

2005 purchase power parity (PPP). Expenditure-based poverty lines are commonly used by governments, the World Bank, policymakers, and others.

While the expenditure-based conception of poverty is not more valid than the asset-based conception, it is more commonly used and better understood in the larger development community.[2] Thus, DHS research might be more relevant for policy if it compared health outcomes not only with an asset index but also with expenditure-based poverty. The rub is that collecting expenditure data is complex and costly (Sahn and Stifel 2003, Deaton and Zaidi 2002). In the case of Bangladesh, the 2005 Household Income and Expenditure Survey (HIES) runs 40 pages and asks respondents about more than 380 expenditure items. This cost and complexity explain why the DHS does not collect data on consumption.

The scorecard in this paper allows researchers to estimate expenditure-based poverty in Bangladesh's 2004 DHS. The estimates come from a three-step method similar to that of poverty mapping (Elbers, Lanjouw, and Lanjouw 2003). First, potential poverty indicators are matched between a survey that collects expenditure data (Bangladesh's 2005 HIES) and another survey that does not collect expenditure data (Bangladesh's 2004 DHS). Second, a poverty scorecard is constructed based on data from the 2005 HIES, using only indicators that appear in both the 2005 HIES and the 2004 DHS. Third, the scorecard is applied to the 2004 DHS to produce estimates of expenditure-based poverty.

This poverty-scoring/poverty-mapping approach rests on three strong, difficult-to-test assumptions. The first is that scorecard indicators are well-matched across the two surveys, so that, say, reporting ownership of a sewing machine in the 2005 HIES has the same meaning as in the 2004 DHS. Unfortunately, the validity of matched indicators is never certain, as questions on the same topic may be worded differently, offer different response options, or appear in a different context.

The second strong assumption is that the relationships between indicators and poverty are constant over time (Schreiner, 2010; Christiaensen *et al*. 2010). This is plausible for the Bangladesh data analyzed here, as the 2005 HIES covered an undocumented period in 2005, and the 2004 DHS covered January to

[2] Arguments in favor of the asset-based view include Carter and Barrett (2006), Schreiner and Sherraden (2006), and Sherraden (1991). In practice, the two views, though distinct, are tightly linked, as income/consumption are flows of resources received/consumed from the use of stocks of assets (wealth). The two views are low-dimensional simplifications—due to practical limits on definitions and measurement—of a higher-dimensional and more complete conception of the production of human well-being. Section 6 below discusses the correlation between health outcomes, asset indexes, and consumption-based poverty likelihoods.

May 2004. The assumption is less plausible for longer time gaps and in periods of greater socio-economic change.

The third strong assumption is that the scorecard is applied to nationally representative groups (Schreiner 2010, Elbers, Lanjouw and Leite 2008, Tarozzi and Deaton 2007). This holds for Bangladesh's 2004 DHS.

If all three assumptions hold, then scorecard estimates of expenditure-poverty rates are unbiased, that is, their average in repeated samples matches the true rate.

The scorecard can be used to estimate the poverty likelihood of a person responding to a survey. It can also be used to estimate the poverty rate of a group of people, such as people who use public-sector health services or women whose last childbirth was not attended by trained personnel.

The next section documents data, poverty lines, and indicator-matching. Section III describes scorecard construction. Section IV defines the concept of poverty likelihood and details the estimation of expenditure-based poverty rates. Section V compares the poverty scorecard with the pre-packaged asset index in terms of ranking people in Bangladesh's 2004 DHS. Section VI places the scorecard in the context of related work, and the final section is a summary

II. DATA, POVERTY LINES, AND INDICATOR MATCHING

This section briefly discusses the data and poverty lines used to construct and test the poverty scorecard. It also discusses the matching of indicators across surveys.

Data

The poverty scorecard is constructed from a random sample of half the people clustered in the 10,080 households in the 2005 HIES surveyed by the Bangladesh Bureau of Statistics (BBS). (The other half is used for testing accuracy).

Poverty Lines

Bangladesh has a "lower" national poverty line and an "upper" national poverty line. For the country as a whole in 2005, the lower line of BDT23.62 per person per day corresponds with a person-level poverty rate of 25.1 per cent, and the upper line of BDT28.33 corresponds with a poverty rate of 40.0 per cent (Table 3 in Appendix A).

This paper also calibrates scores from its single scorecard to poverty likelihoods for lines of $1.25/day and $2.50/day 2005 PPP. The derivation uses

the 2005 PPP exchange rate for "individual consumption expenditure by households" of BDT25.49 per $1.00 (World Bank 2008). Because both the 2005 PPP exchange rate and the HIES measure of expenditure are in units of average prices for 2005, the formula for $1.25/day 2005 PPP (Sillers 2006) is $1.25 x (BDT25.49/$1) = BDT31.86.

This 2005 PPP line applies to Bangladesh as a whole. It is adjusted for regional differences in cost-of-living as implicitly reflected in the upper national poverty lines (Table III in Appendix A) using:

- L, the national-level 2005 PPP poverty line
- P_i, population proportions by stratum (i = 1 to 16)
- π_i, upper national poverty lines by stratum

The stratum cost-of-living-adjusted 2005 PPP poverty line L_i for region i is then:

$$L_i = \frac{L \cdot \pi_i}{\sum_{j=1}^{16} p_j \cdot \pi_j}.$$

For Bangladesh as a whole, the poverty rate for the $1.25/day 2005 PPP line is 50.0 per cent, and the poverty rate for $2.50/day 2005 PPP is 88.6 per cent.

Matching Indicators Across the HIES and DHS

The validity of the estimation of expenditure-based poverty in this paper rests on the assumption that indicators in the 2005 HIES mean the same as in the 2004 DHS. Ideally, indicators in both surveys would have identical wording, offer identical response options, appear in identical contexts, be interpreted by enumerators and respondents identically, and elicit identical distributions of responses. Furthermore, indicators ideally would have a balanced distribution of responses (for example, half own an asset, and half do not, rather than 95 percent are owners), with variation in responses for people close to a given poverty line.

The Appendix documents the quality of the matching of scorecard indicators for Bangladesh. In the poverty-mapping approach, indicators are supposed to be used only if the frequency of a given response for a given indicator across the two surveys are not statistically different at conventional levels such as $p < 0.05$. This standard would reject 20 of the 32 responses in the scorecard here, even though—compared with national surveys and the DHS in other countries—the Bangladesh surveys do not appear to have an unusual level of differences.

While the quality of matching for Bangladesh is less than ideal, in order to proceed, this paper accepts as "well-matched" any indicator for which the difference in response percentages by survey does not exceed 10 per cent of the most common response.

While the quality of matching does not matter for the construction of the scorecard from the 2005 HIES, it does matter for the application of the scorecard to the 2004 DHS. The weaker the match, the lower the correspondence between measured accuracy in the 2005 HIES and assumed accuracy in the 2004 DHS. The extent of inaccuracy, unfortunately, is untestable.

III. SCORECARD CONSTRUCTION

The first step in scorecard construction is to identify matched indicators from the 2005 HIES and 2004 DHS. About 50 potential indicators were identified in the areas of:

- Family composition (such as number of household members in an age range)
- Education (such as school attendance by children in an age range)
- Employment (such as number of males who are working)
- Housing (such as the construction material of walls)
- Ownership of durable goods (such as sewing machines)
- Ownership of agricultural assets (such as land)
- Location (such as urban/rural)

Initial screening eliminated 8 potential indicators, either due to egregiously weak matching, highly unbalanced response distributions, or close similarity with other indicators that, from experience, are more powerful and/or better accepted.

The scorecard is built using the upper national poverty line and Logit regression on the construction sub-sample from the 2005 HIES. Indicator selection uses both judgment and statistics (forward stepwise, based on "c"). The first step is to use Logit to build one scorecard for each candidate indicator. Each scorecard's accuracy is taken as "c", a measure of ability to rank by poverty status (SAS Institute Inc. 2004).

One of these one-indicator scorecards is then selected based on several factors (Schreiner *et al.* 2004, Zeller 2004), including improvement in accuracy, likelihood of acceptance by users (determined by simplicity, cost of collection, and "face validity" in terms of experience, theory, and common sense),

sensitivity to changes in poverty status, variety among indicators, and verifiability.

A series of two-indicator scorecards are then built, each based on the one-indicator scorecard selected from the first step, with a second candidate indicator added. The best two-indicator scorecard is then selected, again based on "c" and judgment. These steps are repeated until additional indicators do not add any power.

The final step is to transform the Logit slope coefficients into non-negative integers such that total scores range from 0 (most likely below a poverty line) to 100 (least likely below a poverty line). This linear transformation makes the scorecard's points simple for users, and it does not affect estimated poverty ranks.

This algorithm is the Logit analogue to the familiar R2-based stepwise with least-squares regression. It differs from naïve stepwise in that the criteria for selecting indicators include not only statistical accuracy but also judgment and non-statistical factors. The use of non-statistical criteria can improve robustness through time and, more important, helps ensure that indicators are simple and make sense to users.

The single poverty scorecard here applies to samples that are nationally representative of Bangladesh. Tests for India and Mexico (Schreiner 2006 and 2005), Sri Lanka (Narayan and Yoshida 2005), and Jamaica (Grosh and Baker 1995) suggest that developing segmented scorecards by urban/rural does not improve ranking accuracy much, although such segmentation may improve the accuracy of estimated poverty rates (Tarozzi and Deaton 2007).

IV. ESTIMATES OF POVERTY LIKELIHOODS FOR INDIVIDUALS, AND ESTIMATES OF POVERTY RATES FOR GROUPS

This section describes how scores are converted to poverty likelihoods, that is, the probability that an individual person has expenditure below a given poverty line. It also explains how the poverty likelihoods of individuals in a group are aggregated to estimate the group's expenditure-based poverty rate. The accuracy of estimates of poverty rates is measured for the validation sample of the 2005 HIES, which provides the best guess for accuracy when the scorecard is applied to the 2004 DHS.

Poverty Likelihoods and their Calibration with Scores

The sum of scorecard points for a person is called the score. As described above, scores range from 0 (most likely below a poverty line) to 100 (least likely

below a poverty line). While higher scores indicate less likelihood of being below a poverty line, the scores themselves are ordinal and do not have equal-interval or ratio units. For example, doubling the score does not double the likelihood of being above a poverty line.

To get equal-interval or ratio units, scores are converted to poverty likelihoods, that is, probabilities of being below a poverty line. This is done via simple look-up tables. For the example of the upper national line, scores of 20–24 have a poverty likelihood of 70.8 per cent, scores of 25–29 have a poverty likelihood of 55.9 per cent, and so on (Table 4 in Appendix A).

The poverty likelihood associated with a score varies by poverty line. With the $1.25/day 2005 PPP line, for example, scores of 20–24 are associated with a poverty likelihood of 82.9% (Table 4 in Appendix A).

A given score is non-parametrically associated ("calibrated") with a poverty likelihood by defining the poverty likelihood as the share of households in the 2005 HIES construction sub-sample with the score who are below a given poverty line.

For the example of the $1.25/day 2005 PPP line (Table 5 in Appendix A), there are 10,729 (normalized) people in the construction sub-sample with a score of 20–24, of whom 8,896 (normalised) are below the poverty line. The estimated poverty likelihood associated with a score of 20–24 is then 82.9 per cent, because 8,896/10,729 = 0.829.

The same method is used to calibrate scores with estimated poverty likelihoods for all the poverty lines.

Although the points in the scorecard are transformed Logit coefficients, scores are not converted to poverty likelihoods via the Logit formula of $2.718281828^{score} \times (1+ 2.718281828^{score})^{-1}$. This is because the Logit formula is esoteric and difficult to compute by hand. It is more intuitive to define the poverty likelihood as the share of households with a given score in the construction sample who are below a poverty line. Thus, the (transformed) Logit coefficients are used to order people by relative ranks, and the ranks are then calibrated with absolute poverty likelihoods.

Estimates of a Group's Poverty Rate

A group's estimated poverty rate is the average of the estimated poverty likelihoods of the individuals in the group.

To illustrate, suppose a programme samples three people on January 1, 2010 and that they have scores of 20, 30, and 40, corresponding to poverty likelihoods of 70.8, 41.3, and 16.2 percent (upper national line, Table 4 in Appendix A**).** The group's estimated poverty rate is the households' average poverty likelihood of (70.8 + 41.3 + 16.2) ÷ 3 = 42.8 per cent.[3]

Accuracy of Estimates of Poverty Rates

As long as the relationship between indicators and poverty does not change and as long as the scorecard is applied to people who constitute a representative sample from the same population from which the scorecard was constructed, then the scorecard produces unbiased estimates of poverty rates. Unbiased means that in repeated samples from the same population, the average estimate matches the true value.

Of course, the relationship between indicators and poverty does change over time and across sub-groups within Bangladesh's population, so the scorecard will generally be biased to some unknown extent when applied after the end of the HIES fieldwork in 2005 (as it must be in practice) and/or when applied to non-nationally representative groups. To the extent that indicators are mismatched, it will also be biased when applied to the 2004 DHS. Unfortunately, this bias cannot be measured, and accuracy as measured for the 2005 HIES validation sample is the best available approximation of accuracy for the 2004 DHS.

How accurate are scorecard estimates of poverty rates for nationally representative samples in the time period corresponding to the 2005 HICE? Table 6 in Appendix A reports estimates of bias (average differences between estimated and true poverty rates) as well as precision (confidence intervals for the differences) for the scorecard applied to 1,000 bootstrap samples[4] of size n = 16,384 from the 2005 HIES validation sample. For the upper national line, the scorecard has no bias; on average, it estimates a poverty rate of 39.9 percent for the validation sample, and that is indeed the poverty rate for that sample (Table III). For the example of the $1.25/day 2005 PPP line, bias is +0.9 percentage

[3] The group's poverty rate is *not* the poverty likelihood associated with the average score. Here, the average score is (20 + 30 + 40) ÷ 3 = 30, and the poverty likelihood associated with the average score is 41.3 per cent. This is not the 42.8 per cent found as the average of the three poverty likelihoods associated with each of the three scores.

[4] Efron and Tibshirani (1993).

points; the average scorecard estimate for the validation sample is 50.8 per cent, but the true rate is 49.9 per cent.[5]

In terms of precision, the 90 per cent confidence interval for a group's estimated poverty rate at a point in time with n = 16,384 is 0.6 percentage point or less (Table 6 in Appendix A**).** This means that in 900 of 1,000 bootstraps of this size, the difference between the estimate and the true value is within 0.6 percentage point of the average difference. In the specific case of the $1.25/day 2005 PPP line and the validation sample, 90 percent of all samples of n = 16,384 produce estimates that differ from the true value in the range of +0.9 – 0.6 = +0.3 to +0.9 + 0.6 = +1.5 percentage point, as +0.9 is the average difference and +/– 0.6 is its 90-percent confidence interval.

As shown in Schreiner (2009), the standard error of the estimated poverty rate is $\alpha \cdot \sqrt{\frac{p \cdot (1-p)}{n}}$, where:

p is the proportion of sampled households below the poverty line,

n is the sample size, and

α is a factor specific to the country, scorecard, and poverty line.

α factors below 1.0 (such as those for the upper and lower national lines and the $1.25/day 2005 PPP line in Table 6) imply that the scorecard is more precise that direct measurement, while factors above 1.0 (such as that for the $2.50/day 2005 PPP line) imply the converse.

V. VALUE-ADDED BY THE POVERTY SCORECARD

This section asks whether the poverty scorecard and the DHS asset index produce similar rankings. If not, then the poverty scorecard may have something new and useful to offer.

On the one hand, large differences in rankings would seem possible, given that the poverty scorecard and the asset index define poverty differently (expenditure versus assets). Also, the two tools are constructed differently; subject to usability constraints, the scorecard uses Logit to choose indicators/points to maximise the accuracy of ranking based on expenditure

[5] There are differences, in spite of the estimator's unbiasedness, because the scorecard comes from a single sample. The average difference by score would be zero if samples were repeatedly drawn from the same population and split into sub-samples before repeating the entire process of constructing and calibrating the scorecard.

poverty, while the asset index uses PCA to maximise the explained variance among a pre-selected set of indicators.

On the other hand, differences might be small. After all, many indicators are similar in the two tools, and the correlation between assets and expenditure may be strong.

The answer to this question matters because it would be convenient if the DHS index ranked people about the same as the poverty scorecard. In that case, the DHS asset index could be calibrated to poverty likelihoods and researchers could estimate expenditure-based poverty rates using the familiar asset index.

Table 7 in Appendix A shows the quintile correspondences for people in Bangladesh's 2004 DHS when ranked by the two tools.[6] By construction, the sample is sorted and divided into equal-sized quintiles twice, once for the scorecard and once for the asset index, so each row total and each column total is 20 per cent.

There are 25 cells in the matrix (5 quintiles in the rows x 5 quintiles in the columns). Each cell contains the percentage of all people who rank in a given row quintile on the poverty scorecard and who also rank in a given column quintile on the asset index. The five cells on the diagonal show the percentage of people who fall in the same quintile by both tools (first quintile on both the scorecard and the asset index, second quintile on both the scorecard and the asset index, as so on). If the correspondence across the two rankings were perfect, all diagonal cells would be 20 per cent and all off-diagonal cells would be zero. At the other extreme of no correspondence, all the cells would be 4 per cent.

The actual correspondence in Table 7 in Appendix A is better than random,[7] as diagonal cells always exceed 4 percent and most off-diagonal cells are less than 4 per cent. About 43.6 per cent of people fall in the same quintile in both rankings (versus 20% if random). The correspondence is not terrible (the two tools differ by more than one quintile for 15.9 per cent of people), but it is also not great (more than half of people do not fall in the same quintile for both tools).

A simpler test is to replace the quintiles with a single cut-off. Table 8 in Appendix A shows two examples, one with a 40^{th}-percentile cut-off (corresponding to Bangladesh's poverty rate for the upper national line) and a

[6] DHS research on the links between poverty and health traditionally use quintiles, ordering people by their asset-index score, dividing them into five equal-sized groups, and then examining how health outcomes vary from the first quintile (most-poor) up through the fifth quintile (least-poor).

[7] $p < 0.01$ for a Chi-square test for no association.

second with a 50th-percentile cut-off (corresponding to Bangladesh's poverty rate for $1.25/day 2005 PPP line). Having a single cut-off increases the share of people in cells on the diagonal who are classified the same by both tools, as some cells that are off-diagonal with quintiles are now part of the (larger) diagonal cells (Friedman 1997).

In Bangladesh's 2004 DHS, about three-fourths of the people (0.749 = 30.3 ÷ (30.3 + 10.7)) with poverty scores below the 40th percentile also have asset scores below the 40th percentile. Thus, on the most-poor end of the scale, there are some differences in ranks between the two tools, but not huge differences. On the least-poor end, agreement is even better, at about four in five (0.819 = 48.3 ÷ (48.3 + 10.7)).

Increasing the cut-off improves accuracy for the most-poor but worsens accuracy for the least-poor. With cut-off at the 50th percentile, there is agreement between the two tools for 78.2 per cent of the most-poor (39.9 ÷ (39.9 + 11.1)) and for 77.3 per cent of the least-poor (37.9 ÷ (37.9 + 11.1)).

In summary, the poverty scorecard and the DHS asset index generally concentrate a good number of the same people among low scores (most-poor) or among high scores (least-poor). The two tools are decent proxies for each other, and expenditure-based poverty may not be sufficiently different from asset-based poverty as to require its own measuring tool.

VI. ESTIMATING EXPENDITURE-BASED POVERTY WITH THE POVERTY-SCORING/POVERTY-MAPPING APPROACH IN THE DHS

This paper is not the first to build an expenditure-based poverty scorecard using only indicators matched to a DHS (or DHS-like) survey. This section asks two questions of previous (non-Bangladesh) work. First, how does their accuracy and precision compare with that of the scorecard here? And second, are poverty scores more strongly linked with health outcomes than asset-index scores? Of course, the answers to these questions are related to the overall usefulness of the poverty scorecard, but they are distinct from the main point of this paper, namely, that expenditure-based poverty can be estimated in the DHS, even though it does not collect expenditure data.

How Accurate is this Scorecard versus Others?

This sub-section describes three cases where comparisons of bias and precision are possible. Some papers (for example, Filmer and Pritchett 2001, Kijima and Lanjouw 2003) are omitted because they compare health only with true (reported) expenditure (not predicted expenditure) or because their scorecards use only a subset of the indicators used here.

Stifel and Christiaensen

Stifel and Christianensen (2007) seek to an intuitive and inexpensive way to track changes in poverty. They build three scorecards (Nairobi, other urban, and rural) using expenditure data from Kenya's 1997 Welfare Monitoring Survey and indicators matched to Kenya's DHS.[8] The scorecards are applied to the 1993, 1998, and 2003 DHS to estimate changes in poverty in years without expenditure surveys. Like most poverty scorecards—but unlike the one in this paper—Stifel and Christianensen regress the logarithm of per-capita household expenditure against a set of indicators, many of which are similar to those in this paper.

When Stifel and Christianensen's scorecards constructed with Kenya's 1997 WMS is applied to that same data (that is, in-sample), bias ranges from –1 to –2 percentage points. Such in-sample tests overstate accuracy. If the scorecard here were applied in-sample, bias would be exactly zero. Applied out-of-sample—that is, to data not used to construct the scorecard—bias ranges from 0.0 to +0.9 percentage points (Table 6 in Appendix A). Thus, the scorecard here is not more biased than that of Stifel and Christianensen.

For precision, Stifel and Christianensen report a standard error of 1.7 percentage points for an in-sample poverty-rate estimate (n = 10,639). Ignoring again the in-sample overstatement of precision, the implied alpha factor is about 3.5, suggesting that the scorecard here (alpha of 0.92 to 1.04, Table 6 in Appendix A) is more precise.

Simler, Harrower, and Massingarela

Simler, Harrower, and Massingarela (2003) use poverty mapping as a simple, inexpensive way to track changes in poverty rates without complex, costly expenditure surveys. They build 11 scorecards (one per province) using Mozambique's 1996/7 National Household Survey of Living Standards, using only indicators matched to Mozambique's 2000/1 Core Welfare Indicator Survey.[9] The scorecards predict the logarithm of expenditure using indicators in the areas of education, housing, asset ownership, community averages, and GIS variables.

Based on an in-sample test with the 1996/7 expenditure survey, bias is –3.9 percentage points, and the alpha factor is about 2.29. These numbers are much larger than those for the Bangladesh scorecard here.

Azzarri et al.

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[8] *Matching* means the distribution of responses does not differ at $p < 0.05$.

[9] The CWIQ is like the DHS, but with less detail on health.

Azzarri *et al.* (2005) construct a poverty scorecard from the 2002 Albania Living Standards Measurement Survey and then apply it to a sub-sample of those households who were revisited in 2003. Thus, indicators are perfectly matched. Like the others reviewed here, the scorecard predicts the logarithm of expenditure, and indicators are selected with stepwise regression. Azzarri *et al.* also include some subjective indicators.

In an in-sample test with the 2002 data, bias is –4.8 percentage points, much greater than for the Bangladesh scorecard here. Azzarri *et al.* do not report standard errors.

VII. WHICH TOOL IS MORE CLOSELY RELATED WITH HEALTH OUTCOMES?

The poverty scorecard and the DHS asset index rank people somewhat differently for Bangladesh, but this need not imply differences in their relationship with health (Wagstaff and Watanabe 2003). This subsection discusses two papers that compare how health relates with poverty scores and with DHS-like asset scores. Other papers are omitted if they look at health vis-à-vis true (not predicted) expenditure.

Sahn and Stifel

In a seminal paper covering nine countries, Sahn and Stifel (2003) look at whether child health (percentage stunted, and mean height-for-age z scores) is more closely related to ranks based on expenditure from a poverty scorecard or ranks from a DHS-like asset index. As usual, they predict the logarithm of per-capita expenditure.

On the one hand, Spearman correlation coefficients and correspondence indices suggest that, "in terms of predictive capabilities, it does not matter which welfare measure is used" (Sahn and Stifel, p. 480). On the other hand, they find that the gradient with child health outcomes between the fifth and first quintile was greater for the asset index than for predicted expenditure from a scorecard in 17 of 22 cases.

In the end, Sahn and Stifel fail to reject the hypothesis of no differences: "In the context of estimating models of nutrition, we find no compelling reason to believe that either reported or instrumented [predicted by a scorecard] expenditures serve as a better proxy for economic welfare than the asset index" (p. 485).

Filmer and Scott

Filmer and Scott (2008) compare ranks for reported (true) expenditure, scorecard-predicted expenditure, and DHS-like asset indices. Several results from their tests with 11 countries are of interest here.

First, "predicted per capita expenditure [from a scorecard] yields the most similar household rankings to per capita expenditure" (p. 18). If matching true expenditure is the goal, then poverty scorecards are better than asset indexes. Still, Filmer and Scott report that asset indexes are highly correlated with true expenditure.

Second, "despite household rerankings, conclusions about inequalities across quintiles in education outcomes, health-care-seeking behavior, fertility, and child mortality, as well as labor-market outcomes, are not very sensitive to the particular economic-status measure used to classify households" (p. 22).[10] Filmer and Scott's scorecards do better than their asset indexes at estimating expenditure-based poverty and just as well as asset indexes with health outcomes.

Filmer and Scott's third point is that scorecards and asset indices "show vastly different gradients in household composition" because scorecards do not adjust for household economies of scale (for example, one bathroom can serve five people at less than five times the cost of serving one person). Thus, the two "equivalence" results just described may not apply to the poverty scorecard here; Filmer and Scott's scorecard omits household size (and education and employment as well), but household size is by far the most powerful predictor of expenditure-based poverty for Bangladesh (and for other countries).

The scorecard here uses more types of indicators than those of Filmer and Scott, and so their results—that asset indices and scorecards perform about the same—may not hold. Further tests, however, are beyond the scope of this paper.

VIII. CONCLUSION

The poverty scorecard provides a way to estimate expenditure-based poverty for people and for groups in Bangladesh's 2004 DHS. The approach resembles poverty mapping in that it constructs a scorecard based on an expenditure survey (the 2005 HIES) using only indicators that are also in the 2004 DHS (which does not collect expenditure data). Researchers can then apply the scorecard to the

[10] This is consistent with Wagstaff and Watanabe (2003) with 19 countries, but not with Lindelow (2006) with one country.

2004 DHS and analyze how health outcomes vary with expenditure-based poverty.

It turns out that the poverty scorecard ranks people somewhat differently than the DHS asset index; asset-based poverty (a longer-term concept) is a good—but not great—proxy for expenditure-based poverty (a shorter-term concept). While both conceptions of poverty are legitimate, the expenditure-based definition is more straightforward and dominates discussion among both the polity and policymakers. Thus, using expenditure-based estimates may give DHS research greater policy relevance.

Like poverty mapping, poverty scoring makes three basic assumptions about its data sources: that they represent the same population, that they represent the same time period, and that the indicators are well-matched. The poverty-scoring approach here also improves on traditional poverty mapping in that it reports the bias of its estimator and provides a simple formula for standard errors.

Of course, the results here hold only for Bangladesh's 2005 HIES and 2004 DHS; they may or may not generalise to other countries and/or data sources.

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Appendix A

Table 1: Simple scorecard for estimating expenditure-based poverty in the Bangladesh DHS

Entity	Name	ID		Date (DD/MM/YY)
Client:			Joined:	
Region:			Today:	
Service point:			HH size:	

Indicator	Value	Points	Score
1. How many household members are 11-years-old or younger?	A. Four or more	0	
	B. Three	3	
	C. Two	7	
	D. One	12	
	E. None	23	
2. Do all household members ages 6 to 11 currently attend school?	A. No	0	
	B. No children ages 6 to 11	1	
	C. Yes	4	
3. What is the highest grade that the female head/spouse has completed?	A. None, or Year 4 of primary or less	0	
	B. No female head/spouse	0	
	C. Year 5 of primary or Year 1 of secondary	3	
	D. Year 2 of secondary	5	
	E. Year 3 of secondary	7	
	F. Year 4 of secondary	8	
	G. Year 5 of secondary	14	
	H. Year 1 or more of post-secondary	19	
4. What is the main material of the walls of the residence?	A. Other	0	
	B. Finished (brick/cement, or tin)	3	
5. What is the main material of the roof of the residence?	A. Natural (katcha, bamboo/thatch), or other	0	
	B. Rudimentary (tin)	6	
	C. Finished (pukka, cement/concrete/tiled)	18	

(Cont. Table 1)

Indicator	Value	Points	Score
6. Does the household have electricity?	A. No	0	
	B. Yes	8	
7.Where is cooking usually done?	A. Outdoors, in a room used for living or sleeping, or other	0	
	B. In a separate room (same building or separate building)	2	
8. How much land does the household own (other than the homestead land)?	A. None	0	
	B. 1 to 50 decimals	2	
	C. 51 to 200 decimals	6	
	D. 201 decimales or more	14	
9. Does the household (or any of its members) have a sewing machine?			A. No 0
			B. Yes 3
10. Does the household (or any of its members) have a watch or clock?			A. No 0
			B. Yes 6

Table 2: DHS Asset Index for Bangladesh (2004)

Question	Score if "Yes"	Score if "No"	Item score
1. In your household is/re there.....?			
Electricity	0.09516	-0.07613	-
One or more radios	0.07258	-0.03473	-
One or more televisions	0.15536	-0.05581	-
One or more bicycles	0.04116	-0.01288	-
One or more motorcycles, scooters	0.26771	-0.00634	-
One or more telephones	0.29830	-0.02066	-
One or more almirah (wardrobes)	0.11771	-0.05620	-
One or more tables	0.04540	-0.07326	-
One or more chairs, benches	0.04252	-0.08264	-
One or more watches, clocks	0.04483	-0.09778	-
One or more cots, beds	0.01016	-0.10997	-
One or more sewing machines	0.18794	-0.01308	-
2. Do your household own land?	0.01942	-0.01958	-
3. Does your household have a domestic worker not related to the head?	0.34984	-0.00073	-
4. What is the principal source of drinking water for your household?			
Piped water in residence	0.28570	-0.01938	-
Piped water to tap in yard, plot	0.09279	-0.00200	-

(Cont. Table 2)

Question	Score if "Yes"	Score if "No"	Item score
Well	-0.05152	0.00048	-
Tubewell	-0.02463	0.12106	-
Shallow tubewell	0.00738	-0.00003	-
Deep tubewelll	0.04628	-0.00216	-
Surface water	-0.04742	0.00130	-
5. What is the principal type of fuel for cooking used by your household?			
Gas	0.26599	-0.02803	-
Kerosene	0.18912	-0.00120	-
Wood	0.02032	-0.01289	-
Dung	-0.03259	0.00269	-
Crop residue	-0.07547	0.05647	-
6. What is the principal type of toilet facility used by your household?			
Flush toilet	0.25212	-0.03510	-
Closed pit latrine	-0.03026	0.01576	-
Open latrine	-0.06059	0.02049	-
Slab latrine	0.04908	-0.00877	-
Hanging latrine	-0.06158	0.00110	-
Bush, field is latrine	-0.10139	0.01297	-
7. What is the principal material used for the floors in your household?			
Natural materials	-0.05550	0.22266	-
Cement (includes vinyl and other floor types)	0.23031	-0.05490	-
Wood	0.01826	-0.00010	-
8. What is the principal material used for the Walls in your household?			
Wood	-0.02369	0.00062	-
Concrete, brick, stone	0.19743	-0.05485	-
Tin	-0.02690	0.01186	-
Bamboo, other natural materials	-0.07559	0.06206	-
9. What is the principal used for the roof of your household?			
Natural materials	-0.10132	0.00927	-
Tin	-0.02156	0.09140	-
Cement, concrete, tile	0.24314	-0.02903	-
Total household asset score (sum of individual score items):			-

Source: Gwatkin *et. al.* 2007.

Table 3: Sample sizes, poverty lines, and poverty rates for all Bangladesh and by sub-sample, 2005 HIES stratum, and poverty line

	Rate of Line	Sampled Household	% with expenditure below a poverty line			
			National lines		Intl. 2005 PPP lines	
			Upper	Lower	$1.25/day	$2.50/day
All Bangladesh	Line	-	28.33	23.62	31.86	63.72
	Rate	10080	40.0	25.1	50.1	88.60
Construction sub –sample	Rate	4961	40.1	25.3	51.4	88.7
Validation sub-sample	Rate	5119	39.9	24.9	49.9	88.50
By 2005 HIES stratum						
Barisal Rural	Line	560	30.45	24.76	34.25	68.50
	Rate	-	54.1	37.2	63.1	93.6
Barisal Municipality	Line	260	31.26	26.31	35.16	70.31
	Rate	-	40.4	26.4	47.9	82.2
Chittagong Rural	Line	1160	29.30	24.374	32.96	65.91
	Rate	-	36.0	18.7	49.0	64.4
Chittagong Municipality	Line	460	31.67	24.63	35.62	71.24
	Rate	-	29.8	12.8	38.8	84.2
Chittagong SMA	Line	180	38.50	25.17	43.31	86.62
	Rate	-	26.6	5.3	39.3	77.5
Dhaka Rural	Line	1720	27.68	23.95	31.14	62.28
	Rate	-	39.0	26.1	48.7	88.2
Dhaka Municipality	Line	740	29.25	24.63	32.90	65.80
	Rate	-	29.9	18.9	37.7	75.8
Dhaka SMA	Line	480	33.45	26.50	37.63	75.25
	Rate	-	17.5	7.0	23.9	70.8
Khulna Rural	Line	880	24.42	21.43	27.46	54.92
	Rate	-	46.4	32.7	56.5	93.0
Khulna Municipality	Line	440	27.13	22.04	30.52	61.03
	Rate	-	32.9	19.1	41.7	77.3
Khulna SMA	Line	140	30.83	23.20	34.67	69.34
	Rate	-	55.4	38.1	65.0	94.2
Rajshahi Rural	Line	1700	25.20	21.56	28.34	56.68
	Rate	-	52.3	35.6	63.0	94.3
Rajshahi Municipality	Line	720	28.16	22.89	31.68	63.35
	Rate	-	49.6	31.5	60.7	88.2
Rajshahi SMA	Line	100	28.314	23.75	31.65	63.30
	Rate	-	20.8	11.7	29.7	81.5
Sylhet Rural	Line	380	27.03	22.93	30.41	60.81
	Rate	-	36.1	22.3	47.4	91.3
Sylhet Municipality	Line	160	33.54	26.51	37.73	75.46
	Rate	-	18.6	11.0	21.8	69.4

Source: Nobuo Yoshidsa of the World Bank. Poverty rates are percentages and are weighted by people Poverty lines are BDT per person per day in average 2005 prices.

Table 4: Poverty likelihoods by score and poverty line

Score	Poverty likelihood			
	National lines		Intl. 2005 PPP lines	
	Upper	Lower	$1.25/day	$2.50/day
0-4	94.4	83.2	100.0	100.0
5-9	91.3	78.8	96.0	100.0
10-14	87.7	69.5	93.5	100.0
15-19	80.6	58.4	88.2	100.0
20-24	70.8	48.0	82.9	99.2
25-29	55.9	34.4	72.0	99.4
30-34	41.3	18.9	55.6	96.8
35-39	29.2	13.9	41.5	93.0
40-44	16.2	7.3	26.9	88.6
45-49	8.8	2.2	20.5	84.9
50-54	7.3	2.3	15.3	82.7
55-59	2.7	1.4	4.1	62.4
60-64	0.8	0.0	3.5	50.9
64.69	2.0	1.0	2.6	36.4
70-74	0.0	0.0	0.0	21.9
75-79	0.0	0.0	0.0	10.3
80-84	0.0	0.0	0.0	18.9
85-89	0.0	0.0	0.0	4.0
90-94	0.0	0.0	0.0	0.0
95-100	0.0	0.0	0.0	0.0

Table 5: Source of Poverty Likelihoods Associated with Scores, Example Poverty Line of $1.25/day 2005 PPP

Score	People below poverty line		All people at score		Poverty likelihood (estimated, %)
0-4	883	÷	883	=	100
5-9	1,966	÷	2,048	=	96.0
10-14	4,032	÷	4,312	=	93.5
15-19	7,820	÷	8,863	=	88.2
20-24	8,896	÷	10,729	=	82.9
25-29	8,129	÷	11,284	=	72.0
30-34	7,369	÷	13,258	=	55.6
35-39	5,265	÷	12,697	=	41.5
40-44	2,714	÷	10,102	=	26.9
45-49	1,652	÷	8,060	=	20.5
50-54	958	÷	6,252	=	15.3
55-59	133	÷	3,277	=	4.1
60-64	111	÷	3,176	=	3.5
64.69	54	÷	2,087	=	2.6
70-74	0	÷	1,459	=	0
75-79	0	÷	610	=	0
80-84	0	÷	495	=	0
85-89	0	÷	326	=	0
90-94	0	÷	67	=	0
95-100	0	÷	14	=	0

Number of people normalized to sum to 100,000.

Table 6: Bias, Precision, and Sample-size for Bootstrapped Estimates of Poverty Rates for Groups of People at a point in time for the Scorecard Applied to the 2005 HIES Validation Sample.

	National lines		Intl. 2005 PPP lines	
	Upper	Lower	$1.25/day	$2.50/day
Estimate minus true value				
Scorecard applied to 2005 HIES validation sample	+0.0	+0.5	+0.9	+0.2
Precision of difference				
Scorecard applied to 2005 HIES validation sample	0.6	0.5	0.6	0.4
∞ *factor for standard errors*				
Scorecard applied to 2005 HIES validation sample	0.92	0.94	0.93	1.04

Precision is measured as 90 percent confidence intervals in units of +/- percentage points.
Differences and precision estimated from 1,000 bootstraps of size n = 16,384.
∞ is estimated as described in Schreiner (2010).

Table 7: Correspondence of Quintile Ranks, Poverty Scorecard and Asset Index Applied to the Bangladesh 2004 DHS

		Pre-Packaged asset index				
		1	2	3	4	5
Poverty scorecard	1.	12.2	5.4	1.9	0.4	0.1
	2.	5.0	6.8	5.3	2.2	0.7
	3.	2.2	4.7	5.6	5.1	2.5
	4.	0.5	2.7	5.1	7.0	4.8
	5.	0.0	0.5	2.2	5.3	12.0

Table 8: Correspondences of Ranks with Cut-offs at the 40th and 50th Percentiles (corresponding to the National Upper Poverty Line and $1.25/day 2005 PPP), Poverty Scorecard and Asset Index Applied to the Bangladesh 2004 DHS

		Pre-packaged asset index	
		<40th	>=40th
Poverty scorecard	<40th	30.3	10.7
	>=40th	10.7	48.3

Cut-off at 50th Percentile ($1.25/day 2005 PPP poverty line)

		Pre-packaged asset index	
		<50th	>=50th
Poverty scorecard	<50th	39.9	11.1
	>=50th	11.1	37.9

APPENDIX B

Matching Scorecard Indicators across the 2005 HIES and the 2004 DHS for Bangladesh

This appendix documents how responses are grouped to create matching indicators across the 2005 HIES and 2005 DHS. Only indicators that appear in the scorecard in Table 1in Appendix A are included here; documentation for the matching of other indicators is available on request.

1. How many household members are 11-years-old or younger?

DHS 2004: How many people usually live with the household?

HIES 2005: How many people live with the household (live together and take food from the same kitchen) six months out of the year?

	% of people		Difference
	2004 DHS	2005 HIES	
None	11.1	9.6	1.5
One	17.1	15.6	1.5
Two	28.3	28.2	0.1
Three	25.2	27.1	-1.9
Four or more	18.3	19.5	-1.2

This is by far the most powerful indicator, and it seems well-matched, although the HIES reports households with larger numbers of young children.

2. Do all household members ages 6 to 11 currently attend school?

2004 DHS: Is<name>currently attending school?

2005 HIES: Does<name>currently attend school/educational institution?

	% of people		Difference
	2004 DHS	2005 HIES	
No	39.9	9.6	1.5
No members ages 6 to 11	12.4	14.5	-2.1
Yes	47.7	45.7	2.0

This indicator is well-matched. It is mostly picking up school attendance, not the absence of young school-aged children.

3. What is the highest grade that the female head/spouse has completed?
2004 DHS: What is the level of schooling that <name>has attended?

2005 DHS: What is the highest class that<name>has completed in that schooling?

HIES 2005: What is the highest grade<name>has completed?

	% of people		Difference
	2004 DHS	2005 HIES	
None, or year 4 of primary or less	68.8	64.0	4.8
No female head/spouse	3.9	2.9	1.0
Year 5 of primary or Year 1 of secondary	13.6	13.9	-0.3
Year 2 of secondary	2.7	2.8	-0.1
Year 3 of secondary	3.1	4.7	-1.6
Year 4 of secondary	3.4	4.0	-0.6
Year 5 of secondary	1.5	4.5	-3.0
Year 1 or more of post-secondary	3.0	3.2	-0.2

This indicator is well-matched, although the HIES shows somewhat higher levels of educations for two categories of responses.

4. What is the main material of the walls of the residence?

2004 DHS: What is the main material of the walls of the residence?

2005 HIES: What is the main construction material of the wall?

2004 DHS	Item %	Group %	2005 HIES	Item %	Group %	Diff. Group %
Natural walls (jute/bamboo/mud (thatch)	45.3		Tile/wood	16.7		
Rudimentary walls (wood)	1.7		Hemp/hay/bamboo	25.6		
Other	0.1	47.1	Other	0.3	42.6	4.5
Finished walls (brick/cement)	18.0		Brick/cement	20.5		
Finished walls (tin)	35.0	53.0	C.I. sheet/wood	36.9	57.4	-4.4

The wording of the answer options are quite different, but as shown above, they can be grouped to give categories that match to some extent.

5. What is the main material of the roof of the residence?

2004 DHS: What is the main material of the roof of the residence?

2005 HIES: What is the main construction material of the roof?

2004 DHS	Item %	Group %	2005 HIES	Item %	Group %	Diff. Group %
Natural roof (jute/bamboo/mud (thatch)	8.5		Hemp/hay/bamboo	1.9		
Other or no data	0.2		Tile/wood	6.8		
		8.7	Other	0.8	9.5	-0.8
Rudimentary roof (tin)	83.4	83.4	C.I. sheet/wood	82.5	82.5	0.9
Finished roof (pukka (cement/concrete/tiled)	8.0	8.0	Brick/cement	8.1	8.1	-0.1

The wording of the answer options vary greatly between the two surveys, but they nevertheless can be grouped to give well-matched categories.

6. Does the household have electricity?

2004 DHS: Does the household have electricity?

2005 HIES: Does the household have an electricity connection?

	% of people		Difference
	2004 DHS	2005 HIES	
No	58.7	54.6	4.1
Yes	41.3	45.4	-4.1

The match is not perfect, and the lower incidence for the HIES is likely due to the difference in question wording.

7. Where is cooking usually done?

2004 DHS: Where is cooking usually done?

2005 HIES: Does your dwelling possess a separate kitchen?

2004 DHS	Item %	Group %	2005 HIES	Item %	Group %	Diff. Group %
In a room used for living or sleeping	2.9		No	25.8		
Outdoors	21.7					
Others	0.1					
No data	0.0	24.7			25.8	-1.1
In a separate room in same building used as kitchen	11.1		Yes	74.2		
In a separate building used as kitchen	63.3	74.4			74.2	0.2

The questions and responses are worded quite differently, but a grouping that gives a nice match is possible.

8. How much land does the household own (other than the homestead land)?

2004 DHS: How much land does your household own (other than the homestead land)?

2005 HIES: In total, how many decimals of cultivable agricultural land does the household own?

	% of people		Difference
	2004 DHS	2005 HIES	
None	46.6	51.5	-4.9
1 to 50	17.9	15.8	2.1
51 to 200	21.4	21.1	0.3
201 to more	14.1	11.6	2.5

This is an acceptable match. The HIES shows less land probably because it specifically asks about non-homestead land that is "agricultural", which the DHS just asks about non-homestead land, some of which may be non-agricultural.

9. Does the household (or any of its members) have a sewing machine?

2004 DHS: Does your household (or any member of your household) have a sewing machine?

2005 HIES: Does the household have any sewing machines?

	% of people		Difference
	2004 DHS	2005 HIES	
No	93.8	93.6	0.2
Yes	6.2	6.4	-0.2

This very well matched, but it only helps to identify the wealthiest Bangladeshis, without helping to distinguish among the lower 90 percent.

10. Does the household (or any of its members) have a watch or clock?

2004 DHS: Does your household (or any member of your household) have a watch or clock?

2005 HIES: Does the household have any sewing clock?

	% of people		Difference
	2004 DHS	2005 HIES	
No	30.4	33.4	-3.0
Yes	69.6	66.6	3.0

The HIES asks this as two questions, while in the DHS it is one. The higher incidence in the HIES may be due to the increased diffusion of cellular telephones in the time between the two surveys. Nevertheless, the match is acceptable.