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INTERTEMPORAL COMPARISONS OF POVERTY AND WEALTH WITH DHS DATA: A HARMONIZED ASSET INDEX APPROACH

DHS METHODOLOGICAL REPORTS 15

SEPTEMBER 2014

This publication was produced for review by the United States Agency for International Development. It was prepared by Sarah Staveteig and Lindsay Mallick of ICF International.

DHS Methodological Reports No. 15

Intertemporal Comparisons of Poverty and Wealth with DHS Data: A Harmonized Asset Index Approach

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September 2014

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Acknowledgments: We are grateful to Tom Pullum for his guidance of the project and to Karen Foreit for her insightful review of an earlier draft.

Editor: Bryant Robey
Document Production: Natalie LaRoche

This study was carried out with support provided by the United States Agency for International Development (USAID) through The DHS Program (#AID-OAA-C-13-00095). The views expressed are those of the author and do not necessarily reflect the views of USAID or the United States Government.

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Recommended citation:

Staveteig, Sarah and Lindsay Mallick. 2014. *Intertemporal Comparisons of Wealth with DHS Data: A Harmonized Asset Index Approach*. DHS Methodological Reports No. 15. Rockville, Maryland, USA: ICF International.

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Preface

The Demographic and Health Surveys (DHS) Program is one of the principal sources of international data on fertility, family planning, maternal and child health, nutrition, mortality, environmental health, HIV/AIDS, malaria, and provision of health services.

One of the objectives of The DHS Program is to continually assess and improve the methodology and procedures used to carry out national-level surveys as well as to offer additional tools for analysis. Improvements in methods used will enhance the accuracy and depth of information collected by The DHS Program and relied on by policymakers and program managers in low- and middle-income countries.

While data quality is a main topic of the DHS Methodological Reports series, the reports also examine issues of sampling, questionnaire comparability, survey procedures, and methodological approaches. The topics explored in this series are selected by The DHS Program in consultation with the U.S. Agency for International Development.

It is hoped that the DHS Methodological Reports will be useful to researchers, policymakers, and survey specialists, particularly those engaged in work in low- and middle-income countries, and will be used to enhance the quality and analysis of survey data.

Sunita Kishor
Director, The DHS Program

Abstract

Over the past 30 years, the Demographic and Health Surveys (DHS) Program has conducted more than 300 household surveys in over 90 countries. As the number of countries with multiple surveys has risen, there is an increased opportunity for comparisons of health in relation to economic status over time. However, the DHS Wealth Index, which ranks relative economic standing among surveyed households, is computed separately for each survey. Existing approaches to make the DHS Wealth Index comparable across surveys appear to encounter problems when comparing early DHS surveys to later DHS surveys; the latter frequently contain triple the number of questions related to wealth than earlier surveys.

This study focuses on the particular challenge of conducting intertemporal analysis using DHS data from the mid-1990s to the present. It demonstrates how to generate a Harmonized Wealth Index (HWI) based on common assets and services across surveys. In eight focal countries—Bangladesh, Bolivia, Cameroon, Egypt, Ghana, Indonesia, Nepal, and Zimbabwe—we use pooled household data to compute an HWI. Results show that the HWI is highly correlated with the existing DHS Wealth Index. Loss of information due to asset harmonization compresses the index, but this occurs primarily toward the top of the distribution in the most recent survey; except for Bolivia in 1998 and Ghana in 2008, the HWI appears to perform well at differentiating gradations of poverty. Overall, the HWI approach is a promising avenue for analysts and policymakers interested in intertemporal comparisons of health and poverty in specific countries.

1. Introduction

The Demographic and Health Survey (DHS) Wealth Index, which was developed a decade ago, is an asset index designed to compare relative economic standing of households in the absence of income and expenditure data (Rutstein and Johnson 2004). The index is computed among the household population within each particular survey based household ownership of assets, such as a radio, a television, a car, livestock, land; household services such as the source of drinking water; and housing construction materials, such as type of flooring. It uses a methodology developed by Filmer and Pritchett (1999; 2001) of principal component analysis to produce a positive or negative weight associated with each household asset.[1] The resulting item weights are applied to the assets and summed to a composite factor score for each household.

The recoded dataset from almost every DHS survey from 1992 forward includes two wealth variables—the *Wealth Index factor score*, a continuous variable derived through principal component analysis, and the *Wealth Index quintile*, which ranks the de jure household population into five equal-sized groups based on their household wealth factor score.[2] The DHS Wealth Index is designed to measure economic well-being of households independently from education and health. Answers to questions on assets, services, and interviewer observations of construction materials in the context of a DHS survey are considered more reliable than self-reported income and expenditures both due to misreporting and because monetary income may be seasonal or transient in nature. Additionally, it is difficult to monetize in-kind income. Information on assets, services, and housing materials can provide a more stable picture of household economic status than monetary income alone; they reflect 'permanent income' (Friedman 1957).

1.1. Purpose

Over the past 30 years, the Demographic and Health Surveys Program has conducted more than 300 nationally-representative household surveys in over 90 countries. As the number of countries with multiple surveys has risen, there is an increased interest in and opportunity for comparisons of health in relation to economic status over time. However, the DHS Wealth Index is designed to compare households within a specific survey. Scores are relative, not absolute; the mean wealth score is 0 in any given survey. As economic status of the population in a country improves and household services (like piped drinking water) become more widely available and household assets (like televisions) become more affordable, the combination of assets and services that ranks a household in the top quintile in an earlier survey could rank a household toward the bottom quintile in a later survey.

An additional challenge of comparing household economic status over time is the changing number of asset questions available. Before the development of the DHS Wealth Index, most dimensions of household wealth were captured because of their relationship with other health indicators. For example, sanitation and flooring were important for analysis of prevalence of nutrition and diarrhea. Radios and televisions were important to help measure access to mass media for health messages such as family planning. The DHS Phase 3 Model Questionnaire (Macro International, Inc. 1995), which spans DHS surveys from 1992 to

[1] Principal component analysis is a data reduction technique to identify underlying uncorrelated dimensions of the relationship between variables in a dataset (Dunteman 1989). It computes a set of item weights designed to maximize the explained variance.

[2] In most DHS household datasets, the wealth index factor score variable is hv271 and the wealth index quintile is hv270. In 88 surveys from before 2003, the wealth index is contained in a separate dataset that must be merged into the household file. In those datasets the wealth index factor score is a variable called 'wlthindf' and the wealth quintile is called 'wlthind5.'

1997, contains 12 questions about assets, services, and construction materials.[3] In later years, after the development of the DHS Wealth Index, the number of questions about household assets and services increased dramatically. The most recent DHS Phase 6 Core Questionnaire (2008-2013) contains 28 questions that are used in the DHS Wealth Index, with the instruction to add at least 9 additional questions on asset ownership so that the final questionnaire "includes at least three items that even a poor household may have, at least three items that a middle income household may have, and at least three items that a high income household may have" (ICF International 2011). While individual surveys adapt the core questionnaire to local circumstances and survey objectives, over the course of the past twenty years, the number of questions in the DHS core questionnaire that can be included in the DHS Wealth Index has more than trebled, from 12 to 37.

The Comparative Wealth Index (CWI) (Rutstein and Staveteig 2014) is intended to adjust the DHS Wealth Index factor score of any household from any survey relative to the baseline survey, Vietnam 2002. It produces a linear displacement of the wealth index factor score provided in DHS datasets. The mean values of CWI perform well compared with trends in GDP per capita and are generally robust to sensitivity testing. However, in some countries there are apparent distortions in the CWI between earlier surveys with relatively few assets and later surveys with many more assets.

This study is intended to extend, test, and complement the CWI approach. It focuses on the particular challenge of doing trend analysis within a country using a small number of surveys. It compares a pooled-generation approach of common assets across surveys within a given country (that is, a Harmonized Wealth Index, or HWI) with the CWI approach, in order to test a different method of adjusting wealth in relation to the approach in current use. It is important to note that the HWI, unlike CWI, is not a universal metric. It is a method of computing a pooled asset index for a small set of surveys. The HWI is intended as an analytical approach that is likely to be useful to researchers and policymakers conducting trend analysis in a small set of countries.

1.2. The DHS Comparative Wealth Index

The DHS *Comparative Wealth Index* (CWI) (Rutstein and Staveteig 2014) is a methodology to adjust the DHS Wealth Index factor scores from a given DHS standard recode file so that they are comparable to one another. It uses an anchoring-points approach originally developed for the World Health Organization's World Health Survey (Murray et al. 2000; Murray et al. 2003). Eight anchoring points from across the economic distribution are regressed against those anchoring points on the baseline wealth index: four cutpoints based on the Unsatisfied Basic Needs framework[4] as well as the wealth index score at which half of the households had a television, refrigerator, a car/truck, and a fixed landline telephone. Regressing these anchoring points against a baseline survey (Vietnam 2002) produces an intercept (α) and coefficient (β) that are used to displace the original DHS Wealth Index factor score[5] such that:

[3] Source of drinking water, type of toilet facility, type of flooring, number of sleeping rooms, electricity, telephone, television, radio, refrigerator, bicycle, motorcycle, and car/truck. The DHS model questionnaire is adapted for use in each survey; refer to individual survey documentation to determine the number of questions on household assets, services, and construction materials.

[4] The version of the Unsatisfied Basic Needs index (UBN) developed by ECLAC for Peru (Llanos and Instituto Nacional de Estadistica e Informatica [Peru] 2000) was used to determine the appropriate criteria: inadequate dwelling construction, overcrowded housing, inadequate sanitation, and high economic dependency. Anchoring points were derived from the wealth scores of the proportion of households with each sum of unsatisfied basic needs (1-4).

[5] The raw wealth factor score provided in hv271 (interchangeably v191, mv191) typically has five implicit decimal places and needs to be divided by 100,000 to equal the wealth index factor score.

$$CWI = \alpha + \beta \times \frac{hv271}{100{,}000}$$

The CWI was calculated for 172 surveys by regressing anchoring points designed to capture a range of economic status points against a baseline wealth index. An advantage of the CWI is that, because it is a linear displacement of the DHS Wealth Index factor score, it is able to include the full range of unique assets used in the original DHS Wealth Index for each survey.

One concern about the CWI is the possible distortion introduced by linear displacement. The original DHS Wealth Index is normalized but unbounded: scores are centered at 0 with a standard deviation of 1, but the minimum and maximum scores vary widely, from around +/-1 to up to +/-4 or higher. The CWI computations provide an alpha and beta to displace the original raw score. Applying this linear displacement to such a wide range of scores may work well for the majority of cases, but toward either end of the distributions the displacement may cause some distortion.

Table 1 shows an example from data for Ghana. In 1993 the DHS Wealth Index factor score for Ghana had a minimum of -.801, whereas in 2008 the score had a minimum of -2.338. After the scores for each year are displaced using the CWI alpha and beta provided, the resulting minimum and maximum CWI scores are quite variable over time. The nature of asset and service accumulation over time means that economic status, unlike income, should be somewhat robust to short-term shocks. In some cases, apparent discrepancies in minimums and maximums are not meaningful: the maximum CWI score in 1993 is higher than the maximum CWI score in 2008, but only 17 household members in 1993 actually score above the 2008 maximum, a result that could either be 'real' or simply the effect of sampling variation. In other cases, however, the differences appear to be problematic. For example in 2008, 12.7 percent of Ghanaian household members scored below -1.27 on the CWI, meaning they were poorer than the poorest household members in 1993. It is difficult to imagine how this result could be plausible. In the case of a severe economic shock we would naturally expect the distribution of wealth to fluctuate, but not for one-eighth of the population to become poorer than the absolute poorest from an earlier survey. The CWI requires additional validation testing to ensure that a comparable set of assets from one survey produces a similar score as that set of assets in a different survey.

Table 1. Illustrative Application of the Comparative Wealth Index (CWI), Ghana

	Household members	DHS Wealth score min	DHS Wealth score max	CWI Alpha	CWI Beta	CWI min	CWI max
1993	21,900	-0.801	5.555	-0.573	0.868	-1.27	4.25
1998	21,665	-1.193	3.223	-0.380	0.828	-1.37	2.29
2003	25,154	-1.024	3.578	-0.439	0.927	-1.39	2.88
2008	44,080	-2.338	3.878	-0.194	0.965	-2.45	3.55

1.3. The International Wealth Index

A parallel effort to harmonize measures of wealth and poverty across household surveys is the *International Wealth Index* (IWI), developed by Smits and Steendijk (2012). The basic methodology of the IWI was to pool households from 165 different household surveys, primarily DHS and Multiple Indicator Cluster Surveys (MICS), to develop a universal set of asset weights based on 12 common assets and asset categories. A major advantage of the IWI, at least from the point of analysts, is that it creates a stable set of asset weights that can be applied to successive surveys without additional computation.

However the IWI has some key drawbacks. First, as new surveys are conducted and the socioeconomic status of the population changes over time, the original weights become increasingly less applicable. Second and more important, the index suffers from the problem of missing and reduced number of asset questions in earlier surveys compared with later surveys. The IWI includes 12 components: water source, floor type, toilet type, television, refrigerator, phone, electricity, car/truck, bicycle, cheap utensils (such as a watch or radio), expensive utensils (such as a computer or a car/truck), and number of sleeping rooms. There are 298 formulas available to enable analysts to adjust scores if a household has as many as three missing components. The wisdom of imputing important components of the wealth index is unclear. For example, earlier surveys frequently excluded number of sleeping rooms. The only type of toilet that counts as being of high quality is a private flush toilet, but information about toilet sharing is missing from many surveys. To impute an adjustment for a given average survey score might be reasonable, but to impute an adjustment to compare households across surveys with missing asset categories might be misleading.

The IWI counts the number of sleeping rooms independent of the number of members in a household. The underlying measure of living standards intended to be captured by the number of sleeping rooms is household crowding (Feres and Mancero 2001; Llanos and Instituto Nacional de Estadistica e Informatica [Peru] 2000). But with two bedrooms, for example, a household of four members and a household of ten have very different levels of crowding. A simple linear correlation of pooled DHS data from Bolivia[6] indicates only a moderate correlation (-.43) between number of sleeping rooms and household members per sleeping room. The failure to use data on number of household members may reduce the accuracy of the index.

The IWI also introduces a subtle but important intertemporal distortion. It groups assets into 'expensive utensils' (such as a car or truck, refrigerator, television) and 'cheap utensils' (such as radios, chairs, and watches). A household need only have one of the possible assets in order to receive the score for expensive or cheap utensil. The problem this creates is that in later surveys, which ask about a much larger set of durable assets, the proportion of households with either category of utensil is biased upward. For example, if an earlier survey only asks about radios and a later survey asks about radios, watches, and chairs, a household in the later survey has a greater chance of being counted as having a cheap utensil, independent of the household's actual economic status. This distortion is problematic because, as discussed previously, early DHS core surveys included 12 questions related to the wealth index, including seven questions on ownership of durable goods (Macro International, 1995). In the Phase 6 DHS Core Questionnaire, there are 37 questions related to the wealth index, including 20 suggested questions on ownership of durable goods (ICF International, 2011). While some countries elected to add a few additional asset questions early on, these changes in the structure of the surveys themselves likely contribute to an apparent increase in household wealth over the past two decades. Hence, while the IWI is a valuable innovation, there are reasons for pursuing an alternative approach for intertemporal analysis.

1.4. Assessing Metrics

By definition, the measure of wealth from household assets is a latent construct; in the absence of alternate external measures it is difficult to determine whether one asset index fits the data better than another. In some cases monetary income or expenditures are used as a gold standard to evaluate the accuracy of a wealth index (Azzarri et al. 2006; Foreit and Schreiner 2011; Sahn and Stifel 2003; Ucar 2014). As conceived by Filmer and Pritchett (2001) and as implemented by Rutstein and Johnson (2004), however, the DHS Wealth Index is intended as an *alternative to* rather than a *proxy for* income and expenditures. The wealth index is intended to measure 'permanent income', or long-term well-being, rather than short-term monetary income. The two are related but are not equal. When the set of assets measured by a survey is a

[6] Data were pooled from the 1994, 1998, 2003, and 2008 surveys. Households with non-numeric sleeping rooms (DK/NA) were excluded.

larger share of monetary expenditures, the resulting asset index will more closely approximate consumption (Filmer and Scott 2012; Montgomery et al. 2000). In the case of early DHS surveys, five of the twelve indicators of economic status are tied to housing construction (type of floor) and to public services (water, toilets) rather than to direct consumer durables.

Several analysts have addressed the challenge of comparing asset data across surveys by computing a harmonized index in the course of their analysis. For example, Sahn and Stifel (2000) sought to compare poverty over time and across countries in Africa by using the DHS to calculate a wealth index based on household asset information collected in the surveys. They computed their index using factor analysis instead of principal component analysis to account for covariance of a small number of common factors. The index was computed using pooled DHS data. Variables included in the index were asset, construction, and service variables typically included in the DHS Wealth Index, as well as the number of years of education of the head of household. The authors set poverty lines at the 25^{th} and 40^{th} percentiles of the index and compare poverty headcount ratios and tests of welfare dominance.

Booysen et al. (2008) assessed trends in poverty in sub-Saharan Africa using asset data from DHS surveys. Rather than pooling the data, the authors computed a baseline set of weights using multiple correspondence analysis, which they suggested was more appropriate than principal component analysis for creating an index of categorical variables. They applied these pre-computed weights to seven asset variables from multiple surveys in focal countries. The analysts noted the limitations of including earlier surveys with a limited number of assets. The study found that reductions in poverty tended to be driven by accumulation of private assets such as bicycles and televisions rather than by improvements in public services such as electricity and drinking water.

With many possible approaches, including IWI, CWI, and additional methods, it is important to consider the desirable attributes of a metric. One characteristic of a good metric is internal consistency: households with the same assets at two points in time should receive the same relative score. The method of computation should be standard and include, for example, consistent treatment of separate rural and urban indices. An additional criterion is ease of use. From the point of view of analysts, it is appealing to have a metric that can be quickly computed for new data without the need to compare with earlier datasets. At the same time, the metric should also accurately reflect household welfare and living standards. Finally, it is desirable to have a metric that can explain a sizeable amount of variation in household assets, in order to appropriately differentiate households from one another.

2. Methods

2.1. Survey Selection

All countries that had three or more Standard DHS surveys[7], at least one of which was in or before 1998 and at least one of which was in or after 2008, were examined for inclusion in this study. Twenty-seven countries[8] met these criteria. Two countries with continuous DHS surveys (Peru and Senegal) were excluded from consideration as case studies because the asset questions were identical among recent surveys.

The remaining 25 countries were narrowed down to eight focal countries for case studies. Within each region (South and Southeast Asia, Latin America and the Caribbean, sub-Saharan Africa, North Africa/West Asia)[9], focal countries were chosen to maximize diversity across GDP ranking, with slight preference given to countries with four or more surveys during the time period and to countries whose asset questions were more comparable over time.[10] The final eight focal countries selected for analysis are: Bangladesh, Bolivia, Cameroon, Egypt, Ghana, Indonesia, Nepal, and Zimbabwe.

2.2. Construction of a Harmonized Wealth Index

2.2.1. Harmonizing Asset Measures Across Surveys

Within each focal country, a listing of all household-level measures of assets, services, and construction materials was created from each survey. For each relevant variable, a table was produced to identify the category, label, and frequencies. The main requirement for a harmonized category was that it had to correspond with a category in all surveys covered. Appendix table A1 demonstrates the process of harmonization using the Bangladesh data from 1993 to 2011. In many cases, later surveys include many more detailed categories than were asked about in earlier surveys. In earlier surveys in Bangladesh, for example, jute/bamboo/mud walls were a single category whereas in later surveys these wall types were coded separately. For the purpose of harmonization, the disaggregated categories in later years naturally had to be collapsed back into a single group. Categories that appeared in later years only, such as wooden planks, were impossible to harmonize from earlier surveys and were necessarily collapsed into the 'other' category.

The process of harmonization was challenging at times. In earlier DHS surveys that asked about source of drinking water there were typically two types of wells, a well in the compound and a public well. Intermediate DHS surveys might differentiate between open and protected wells and by three well locations

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[7] In addition to standard DHS surveys, the DHS Program also conducts the AIDS Indicator Surveys (AIS) and the Malaria Indicator Surveys (MIS), along with continuous DHS surveys and interim/special DHS surveys. These surveys generally ask about a smaller number of assets than a standard DHS survey.

[8] Bangladesh, Benin, Bolivia, Burkina Faso, Cameroon, Colombia, Cote d'Ivoire, Egypt, Ghana, Haiti, Indonesia, Jordan, Kenya, Madagascar, Malawi, Mali, Mozambique, Namibia, Nepal, Niger, Nigeria, Peru, Philippines, Senegal, Tanzania, Uganda, and Zimbabwe. Note that some additional countries such as Madagascar would have qualified except that the earlier survey did not include a wealth index.

[9] DHS also conducts surveys in Central Asia and Australasia, but no countries in these regions met the criteria for inclusion.

[10] The average number of harmonized assets in the focal countries was 11.4 compared to 10.4 in the non-focal countries; this is largely owing to Egypt as an outlier with 16 harmonized assets, versus the next highest sum of 12 harmonized assets in other countries.

(in dwelling, in yard/plot, and public well), resulting in six possible types of wells. More recent DHS surveys distinguish only between protected and unprotected wells, not by location. In this case, to harmonize the categories across all surveys it would be necessary to keep 'well' as a single category of the source of drinking water. Special care was given to avoid distortions involving a large number of cases being classified into the 'other' category due to lack of backwards compatibility.

Table 2 summarizes, by country, household assets and variables related to housing condition distilled from the harmonization procedure to compute a harmonized wealth index for each focal country. The factors are divided into household services and housing conditions (source of drinking water, type of toilet, type of walls, type of roof, type of cooking fuel, members per sleeping room, and whether the household has electricity) versus household assets such as a bicycle or a refrigerator. For dichotomous variables an "X" indicates the presence or absence of that variable; for categorical variables the number of common categories is shown. Members per sleeping room is a continuous truncated integer value that starts at 0 (more than one sleeping room per member) and ends at the maximum for that country, often around 20. A sum of the total number of variables harmonized for each indicator is given the second-to-last column. Nepal had the smallest number of harmonized variables (8) while Egypt had the largest number (16).

Table 2. Harmonized Assets by Country

		Household services and housing conditions[a]								Household Assets																			
Country	**Survey Years**	**Source of drinking water**	**Type of cooking fuel**	**Type of toilet**	**Type of flooring**	**Type of walls**	**Type of roof**	**Members per sleeping**	**Electricity**	**Animal-drawn cart**	**Automatic washing**	**Bicycle**	**Car/Truck**	**Electric fan**	**Landline telephone**	**Motorcycle/Scooter**	**Owns dwelling**	**Owns land**	**Radio**	**Refrigerator**	**Sewing machine**	**Table/chair**	**Television**	**Video deck or DVD**	**Wardrobe**	**Water heater**	**Total number of harmonized variables**	Proportion of total variance explained[b]
Bangladesh	1993-94, 1996-97, 1999-2000, 2004, 2007, 2011	5		6	4	5	4		X			X						X	X			X	X		X		**12**	0.192
Bolivia	1994, 1998, 2003, 2008	6	6	5	5			X	X						X				X	X			X				**10**	0.223
Cameroon	1991, 1998, 2004, 2011	7		5	5			X	X			X	X			X			X	X			X				**11**	0.183
Egypt	1995, 2000, 2005, 2008	5		6	9			X	X		X	X	X	X		X	X	X		X	X		X			X	**16**	0.149
Ghana	1993, 1998, 2003, 2008	8		7	9				X	X		X	X			X			X	X			X	X			**12**	0.141
Indonesia	1997, 2002-03, 2007, 2012	9		6	7	4	6		X			X	X			X			X	X			X				**12**	0.120
Nepal	1996, 2001, 2006, 2011	8		5	6				X			X			X				X				X				**8**	0.180
Zimbabwe	1994, 1999, 2005-06, 2010-11	8		6	8				X			X	X			X			X	X			X				**10**	0.181

a. For variables that indicate a type of service or material the number of common categories is listed ('missing' is a residual/excluded category). For all other yes/no variable, an "X" indicates the presence of that variable. Members per sleeping room is a continuous integer variable that starts at 0 (less than 1 member per sleeping room) and goes to the maximum for that country, generally around 20.
b. The proportion of total variance explained by the first component of the common factor principal components analysis of the pooled harmonized wealth index; see text for details

2.2.2. Computing a Harmonized Wealth Index

In the eight focal countries selected for this study (Bangladesh, Bolivia, Cameroon, Egypt, Ghana, Indonesia, Nepal, and Zimbabwe), we pooled household data within each country and computed a harmonized wealth index based on the common factors shown in Table 1. Elements of the wealth index that need to be merged from individual interviews (whether there is a domestic servant in the household, whether any members of the household work their own agricultural land, and whether any member owns a dwelling unit) were not included unless measured at the household level[11]; the harmonized wealth index is computed using variables from the household interview only.

Using the harmonized variables, a pooled wealth index was computed in each country, following the standard DHS procedure outlined in Rutstein and Johnson (2004). Asset and service variables with yes/no answers (has electricity, has television) were recoded into dichotomous variables, with missing/DK/NA assumed to be 0, as is DHS standard procedure. For categorical variables, a variable for each harmonized category of a particular asset was created as a dichotomous variable. For example, in Bolivia, the six harmonized categories for floor material were: earthen, wooden, tile/ceramic/vinyl, cement, brick, or other, including carpet. Six mutually exclusive dichotomous variables were created representing each type of floor.[12] Additionally, if the number of sleeping rooms was asked about in each survey, then the number of members per sleeping room was computed using standard DHS procedure and truncated to the nearest integer, with 0 representing more than one sleeping room per household member.

Household member weights were normalized in the pooled country datasets so that each survey year would count equally. Using these normalized weights, a principal component analysis of the asset variables described above was computed using Stata version 12. As is the case in the DHS Wealth Index, a common factor index is computed first. Then, following the procedure outlined in Rutstein (2008) and currently used by DHS, the pooled HWI in each country was computed using a separate factor analysis for urban and rural areas. These rural and urban scores were regressed on the common factor scores to produce a constant term and a coefficient to displace those scores and recombine into a common wealth index. Quintiles are based on relative ranking within the pooled datasets.

Table 2 shows the proportion of total variance explained by the initial common factor analysis in the pooled dataset. It ranged from 12 percent in Indonesia to 22 percent in Bolivia. It is not possible to directly compare the share of variance explained by the HWI with that of the standard DHS Wealth Index, as the latter is, by definition, computed within a given survey only, rather than for pooled data. However, initial investigation suggests that the percent of variance explained by the HWI compares favorably to that of the DHS Wealth Index.[13]

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[11] One reason for not including these individual metrics of wealth is that they introduce nonstandardization due to the skip pattern of individual interviews within each country. For example, in many countries only half of the households are eligible for male interviews. In some countries only ever-married women are interviewed. These skip patterns or subsamples introduce inconsistency because not every household has the opportunity for adults to provide information on occupation or ownership of assets.

[12] The missing category is not a variable unto itself; it is the residual.

[13] For example, the total variance explained by the DHS Wealth Index in Ghana 2008 was 10.3 percent and in Egypt 2008 was 10.4 percent compared with 14.1 percent and 14.9 percent, respectively, explained by the HWI.

It is important to note that, while the HWI is centered at 0 across the surveys in a given country, the CWI is not. The CWI was centered at 0 for Vietnam in 2002 and every other survey is centered in relation to Vietnam. This means that in almost every country the mean CWI score will be different from 0. Therefore, in the analysis that follows the mean score of HWI and CWI should not be directly compared; instead we will focus on patterns in distribution and ranking.

3. Country Case Studies

3.1. Bangladesh

In Bangladesh, six different DHS surveys from 1993 to 2011 were used to compute a harmonized wealth index (HWI). The harmonization of assets shown in Appendix Table A1 resulted in 12 common factors, five of which were categorical and seven of which were dichotomous. As described in the methods section, the computations were done with normalized weights so that the household population in each survey would count equally.

Table 3 shows the overall summary statistics by year for the CWI, as computed by Rutstein and Staveteig (2014), versus the results of the HWI for each year.[14] The CWI and HWI are highly correlated in any given year, from 94.8 to 98.8 percent; because the CWI is a linear displacement of the DHS Wealth Index in each survey, then by extension the HWI and the DHS Wealth Index are highly correlated. As expected, in all six surveys the minimum value of HWI is almost perfectly constant, as is the maximum value (-1.25 and 3.19, respectively) compared with a range in the minimum value and an increasing maximum value computed by the CWI. The minimum of the CWI in 2011 (-2.23) is below that of earlier years; additional analysis indicates that, in 2011, 11.3 percent of the household population scored below the minimum wealth score in 2007 data, a finding that suggests problematic linear displacement of the CWI.

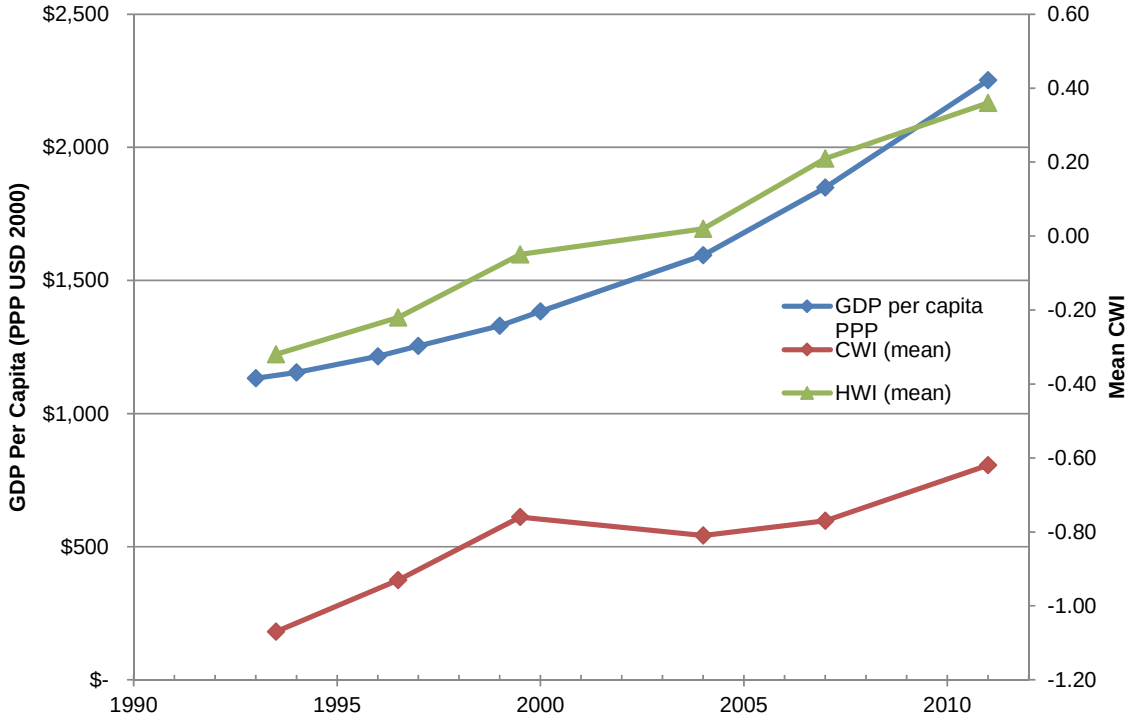
Table 3. Summary of CWI and HWI in Bangladesh, 1993-2011

		Comparative Wealth Index (CWI)				Harmonized Wealth Index (HWI)				
	weighted n	mean	sd	min	max	mean	sd	min	max	correlation CWI-HWI
1993-1994	49,895	-1.07	0.53	-1.59	0.82	-0.32	0.90	-1.25	3.19	0.988
1996-1997	45,820	-0.93	0.55	-1.35	1.11	-0.22	0.94	-1.25	3.19	0.976
1999-2000	50,965	-0.76	0.62	-1.55	1.37	-0.05	0.99	-1.25	3.19	0.980
2004	52,129	-0.81	0.77	-1.75	2.44	0.02	0.93	-1.25	3.19	0.976
2007	48,919	-0.77	0.78	-1.62	2.56	0.21	0.98	-1.17	3.19	0.948
2011	78,909	-0.62	1.04	-2.23	3.17	0.36	1.01	-1.25	3.19	0.960

While the CWI and the HWI are not intended to be comparable to GDP per capita, a comparison in overall trends of mean CWI and HWI is a useful check against some of the trends observed in each indicator. Figure 1 charts the mean CWI and mean HWI against the GDP per capita at purchasing power parity (World Bank 2014). Recall that HWI and CWI lines should not necessarily overlap; the HWI is intended to average out to 0 across these six surveys, whereas the CWI is based in relation to the baseline scores for Vietnam 2002. Only the parallels between the two lines should be considered. Figure 1 shows that in Bangladesh the mean CWI and HWI almost always increase in tandem with GDP, but that mean CWI has an early peak around 1999 and then increases only slowly, while the mean HWI increases steadily.

[14] Results shown differ slightly from the Rutstein and Staveteig report, which used household weights; this report weights by household members.

Figure 1. Mean CWI and HWI versus GDP per capita (PPP), Bangladesh 1993-2011



Figures 2 and 3 show the shape of the overall distribution of CWI and HWI in the household population in Bangladesh for all six surveys. In nearly every year there is a characteristic right-skewed distribution, with most relative wealth scores clumped toward the left end of the distribution with a relatively long rightward tail, indicating a small wealthy elite. The HWI data echo these trends, and also show a slight bimodal distribution in 2007 and 2011, suggestive of an emerging middle class in Bangladesh.

Figure 2. Distribution of comparative wealth index (CWI) in Bangladesh by year

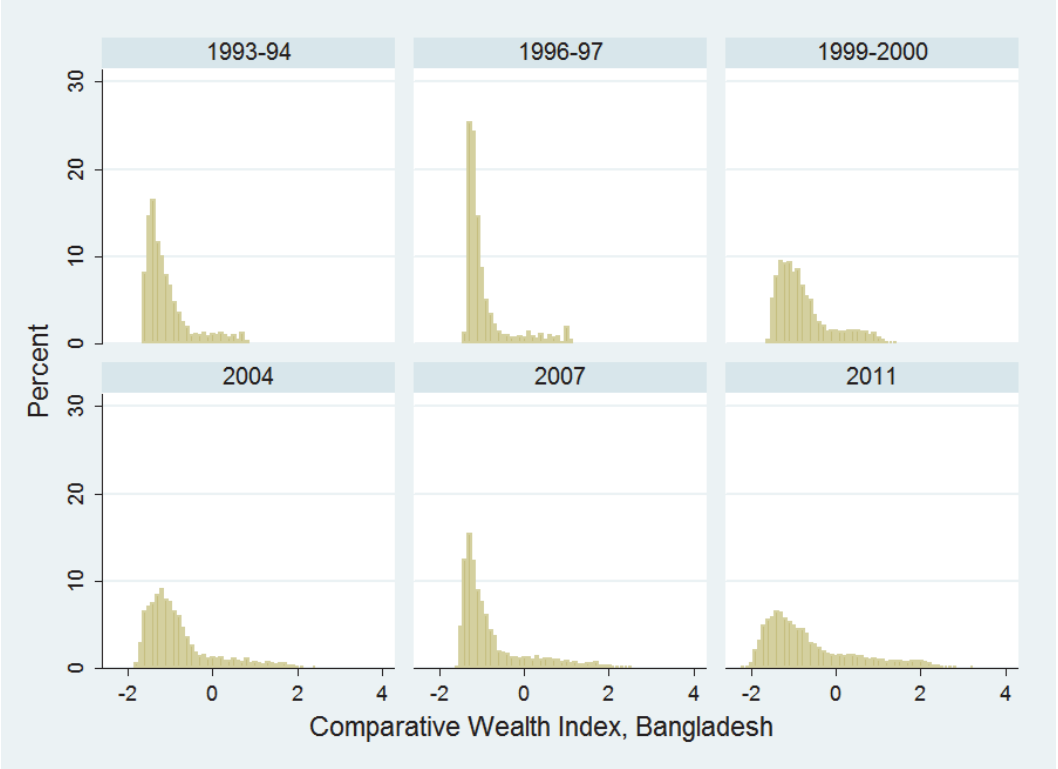
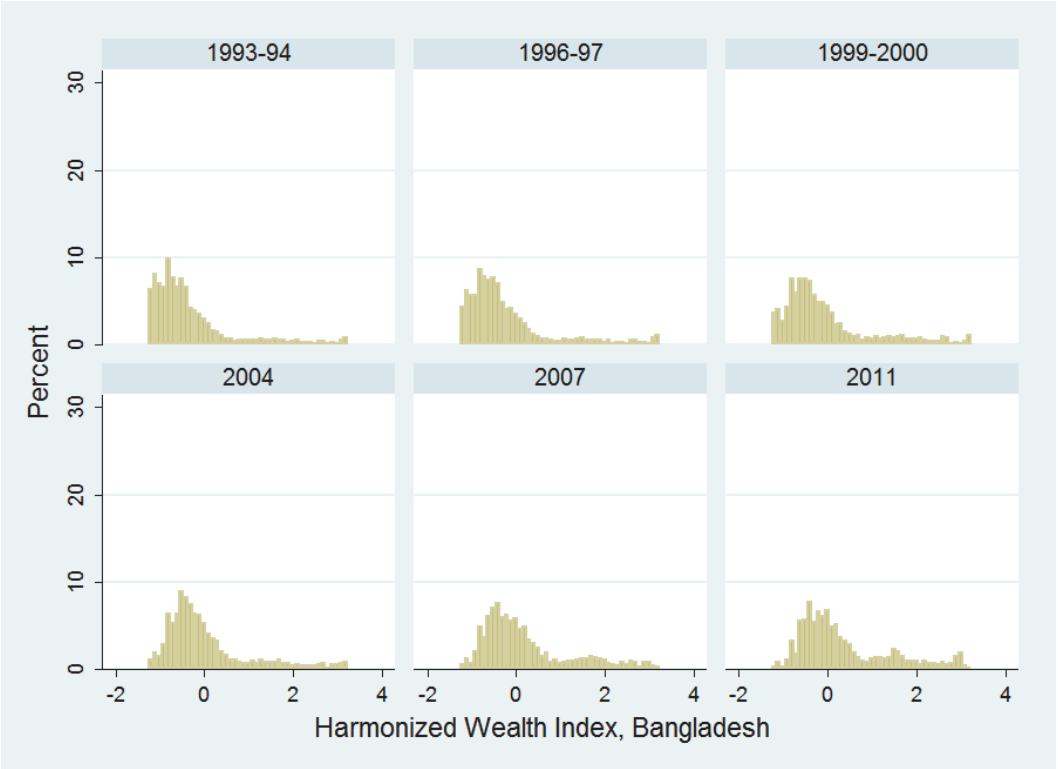


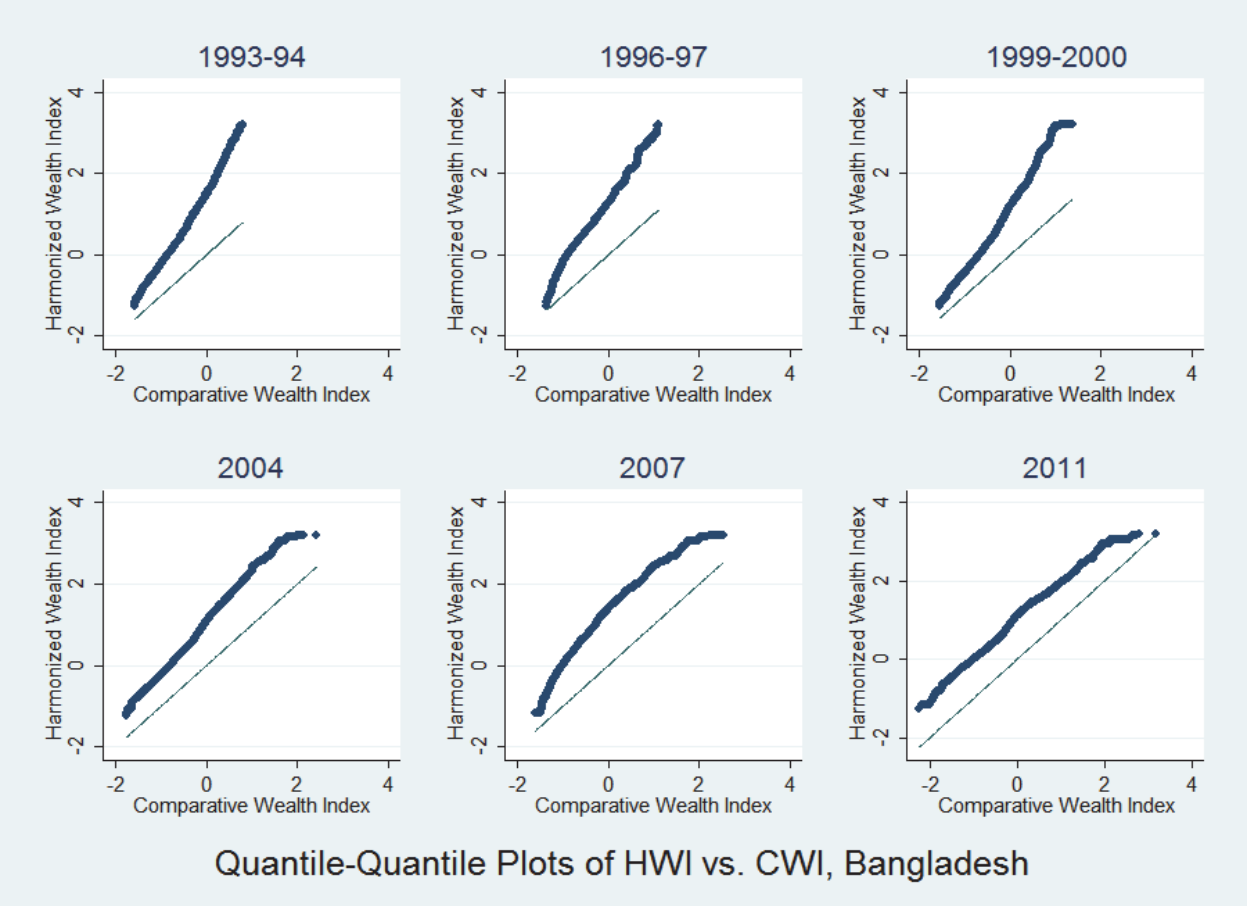
Figure 3. Distribution of harmonized wealth index (HWI) in Bangladesh by year



To compare the compression of each metric, a Quantile-Quantile (Q-Q) plot was created for HWI versus CWI for each year (Figure 4). For the purposes of this analysis, the distance between the Q-Q line and the y=x line is unimportant; this is determined by the mean CWI relative to Vietnam in 2002. Bangladesh is consistently poorer than Vietnam; consequently, the mean CWI is less than 0 and the Q-Q line is always above the y=x line. Instead, what is important is the *shape* of the line. If the two indices are perfectly correlated then the Q-Q line will be straight. The slope may be more or less than 1 because the range of values of the two metrics differs. What deserves attention is the extent to which the Q-Q line *curves* in one direction or the other; this reflects compression in an indicator.

Figure 4 shows that in most years the shape of the Q-Q plot is linear, but that in the 1999-2000 survey we start to see a compression of the Q-Q line toward the top of the range on the HWI metric. This indicates that a greater share of the household population has essentially 'topped out' at an upper bound in the HWI, but according to the CWI these households are still distinct. To the extent that most analysts use wealth quintiles rather than factor scores, the compression of values at a small extreme of the distribution should not be problematic. At the same time, the compression is less than desirable and indicates that, as expected, the HWI is missing assets that would have helped differentiate wealthier households from one another.

Figure 4. Quantile-Quantile plots of HWI versus CWI, Bangladesh



A final comparison between HWI and CWI in Bangladesh is shown in Table 4, which gives the distribution of household members (pooled across surveys) in any given quintile of the HWI that are in a quintile of the CWI. Note that for the purposes of this table CWI quintile is computed based on pooled data in the same way that HWI is. If the two metrics categorized members into the exact same quintiles we should see 20

percent of household members in each cell of the diagonal. However, perfect cross-classification is not ideal: if 100 percent of the population was on the diagonal, then the HWI would be entirely redundant with an existing metric. To the extent that cross-classification differs, it is not clear which metric is more accurate.

Table 4 shows that 60 percent of household members are categorized in the same quintile on both metrics, and an additional 35 percent are one step away on either metric (for example, in the third quintile of HWI but the fourth or second quintile of CWI, or vice versa). As anticipated, there are no cases out on the corners of the matrix; for example no household members are classified at the top of the CWI and the bottom of the HWI, or vice versa.

Table 4. Correspondence between pooled CWI and HWI quintiles in Bangladesh, 1993-2011

Proportion of household members in pooled CWI and pooled HWI quintile						
	CWI Quintile					
HWI Quintile	**lowest**	**second**	**third**	**fourth**	**highest**	**Total**
lowest	12	7	1	0	0	20
second	6	8	6	1	0	20
third	3	4	9	5	0	20
fourth	0	1	4	13	2	20
highest	0	0	0	2	18	20
Total	20	20	20	20	20	100
weighted n	65,328	65,389	65,266	65,330	65,324	326,637

3.2. Bolivia

For Bolivia, Table 5 shows a fairly consistent minimum and maximum for the HWI, as for Bangladesh, but shows a different maximum for the CWI in 1994 (1.64) compared with later surveys (3.1+). Additional analysis shows that an average of 18 percent of the household population in subsequent years is scored to be wealthier than the wealthiest household in 1994, which suggests a problematic displacement of CWI scores in later years unrelated to sampling variation.

Table 5. Summary of CWI and HWI in Bolivia, 1994-2008

		Comparative Wealth Index (CWI)				**Harmonized Wealth Index (HWI)**				
	weighted n	**mean**	**sd**	**min**	**max**	**mean**	**sd**	**min**	**max**	**correlation CWI-HWI**
1994	40,926	-0.18	1.06	-2.13	1.64	-0.18	1.03	-2.05	1.21	0.963
1998	52,451	0.32	1.48	-2.77	3.16	0.01	1.01	-2.09	1.21	0.950
2003	81,090	0.04	1.45	-2.61	3.39	0.00	0.98	-2.04	1.21	0.934
2008	77,081	0.31	1.33	-2.43	3.10	0.17	0.92	-1.92	1.21	0.949

Figure 5 shows that HWI more closely tracks the trend in GDP per capita than does CWI, which finds a dramatic increase in asset wealth in 1998 and a subsequent drop in 2003. The distribution of CWI, shown in Figure 6, suggests a relatively plateaued distribution of wealth in Bolivia. The distribution is generally bimodal, but the peak on the right hand side is larger in 1998 and 2008 than is the peak on the left (low) end of the distribution. The histograms of HWI scores, shown in Figure 7, have edge peaks, which suggest truncation of HWI scores at both ends of the distribution.

Figure 5. Mean CWI and HWI versus GDP per capita (PPP), Bolivia 1994-2008

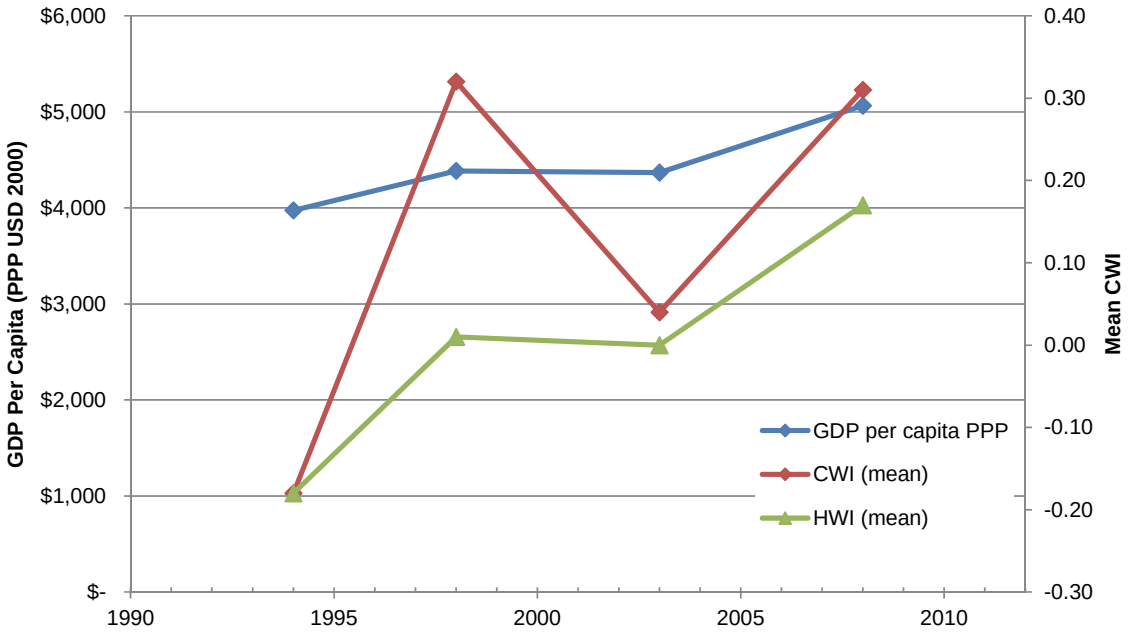


Figure 6. Distribution of comparative wealth index (CWI) in Bolivia by year

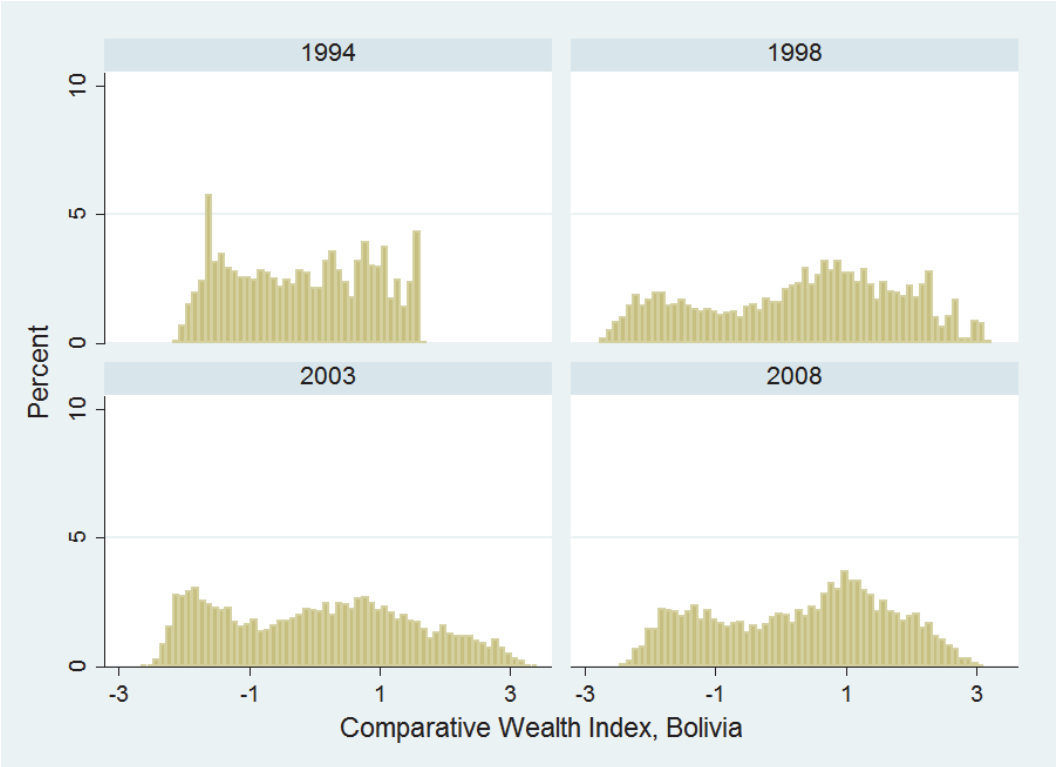
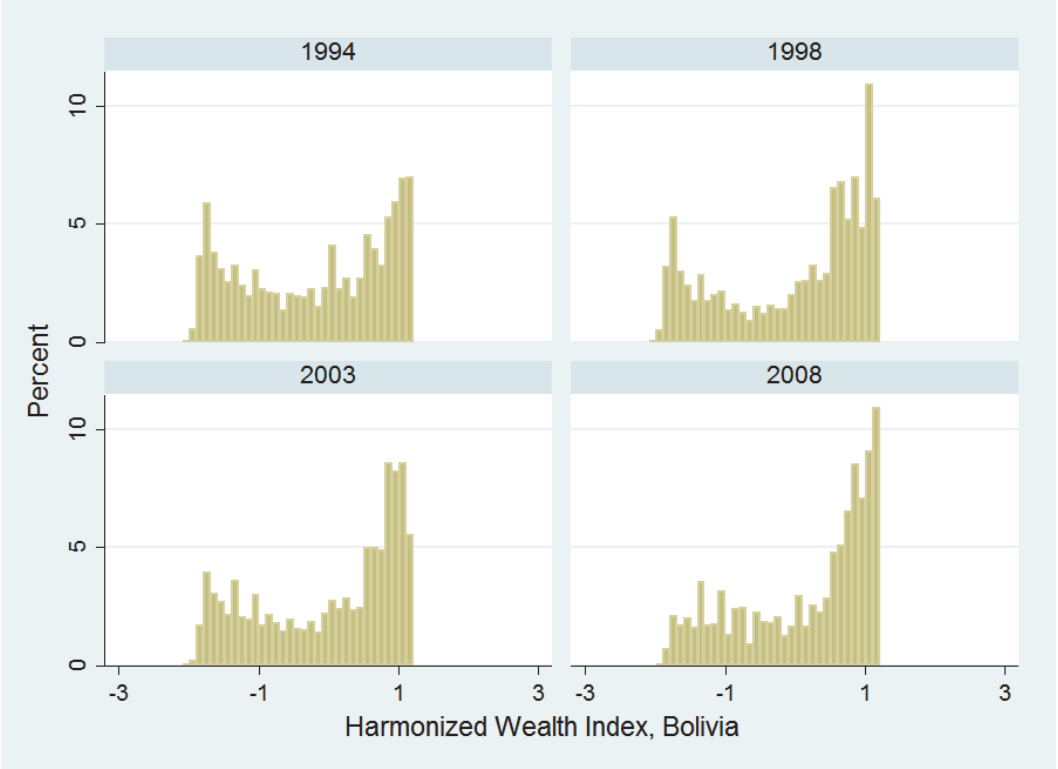


Figure 7. Distribution of harmonized wealth index (HWI) in Bolivia by year



The compression of HWI scores is also clearly evidenced by the Q-Q plot in Figure 8. We see that in 1998, 2003, and 2008 there is a small variation in HWI at the top of the distribution and a large distribution of CWI on those values. Additionally, there is some apparent compression at the bottom of the distribution in 1998 only. Interestingly, the HWI in Bolivia explained the most amount of variance in assets of any of the case study countries.

In the original computation of the Bolivia DHS Wealth Index in 2008, some of the most salient factors differentiating households were mobile phone, computer, Internet access at home or near home, and trash collection. None of these factors could be included in the harmonized index due to omission in earlier surveys, which helps explain the apparent truncation of scores in the HWI. Additionally, the HWI for Bolivia contains only one inexpensive asset (radio) to help distinguish households at the low end of the economic distribution. At the same time, the harmonized assets that remained across survey years apparently captured a good amount of variation in assets across households.

Figure 8. Quantile-Quantile plots of HWI versus CWI, Bolivia

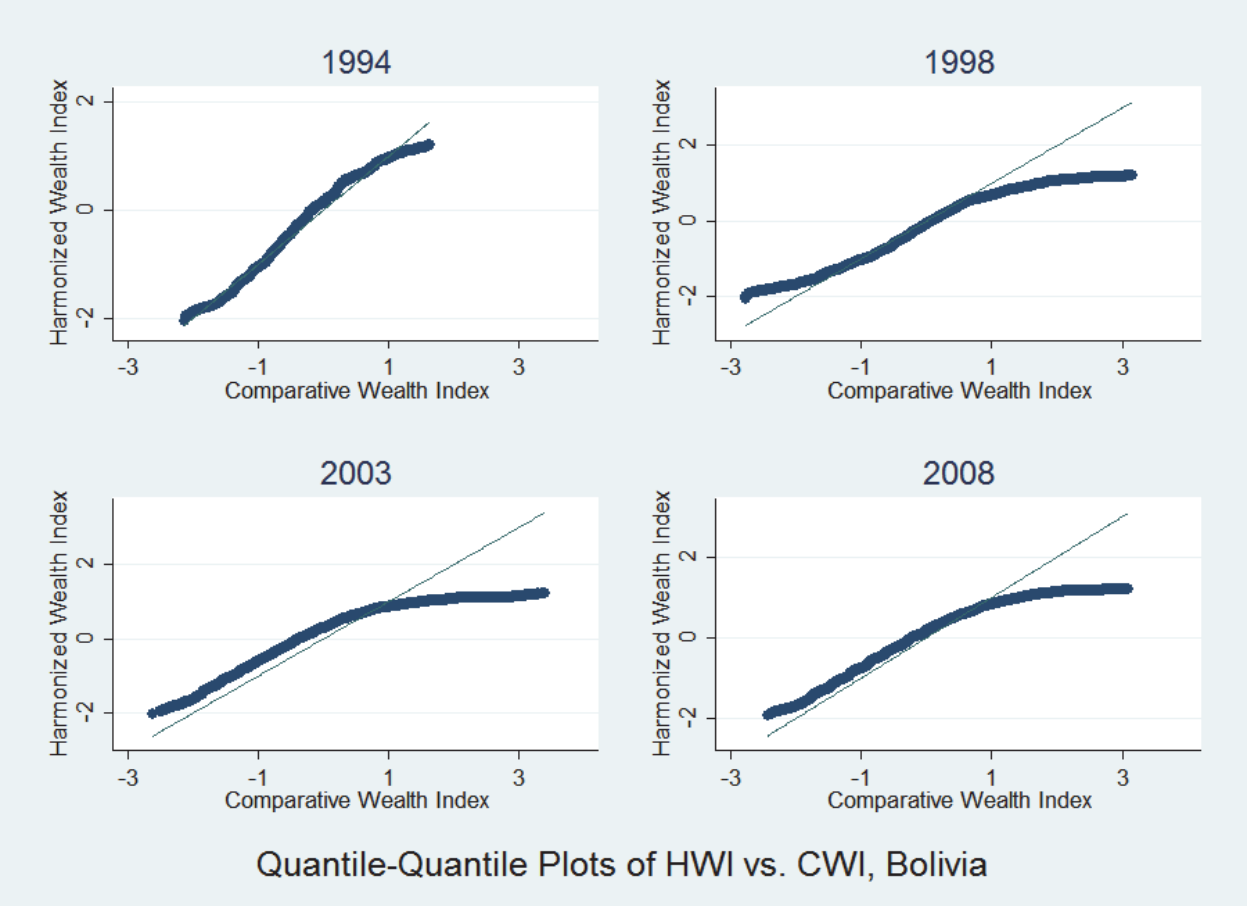


Table 6, which compares joint quintile classification, shows a fairly strong correspondence between categories on both measures. Overall, 72 percent of household members were categorized into the same quintile in both metrics; this is higher than any other case study country except Egypt. Nearly all of the remaining household population was classified within one step of the pooled quintile on either metric.

Table 6. Correspondence between pooled CWI and HWI quintiles in Bolivia, 1994-2008

Proportion of household members in pooled CWI and pooled HWI quintile

	CWI Quintile					
HWI Quintile	**lowest**	**second**	**third**	**fourth**	**highest**	**Total**
lowest	17	3	0	0	0	20
second	3	14	3	0	0	20
third	0	3	13	4	0	20
fourth	0	0	4	12	4	20
highest	0	0	0	4	15	20
Total	20	20	20	20	20	100
weighted n	50,312	50,308	50,311	50,376	50,242	251,548

3.3. Cameroon

Table 7 shows a varying range of minimum and maximum CWI scores in Cameroon. The maximum score of 3.15 in 1991 is higher than the maximum scores in subsequent years, including a maximum of 2.47 in 2011. Additionally, the minimum score declined from -1.63 to -1.82 over the 20-year period. Analysis of these patterns reveals that these aberrant cases are only a small share (<2 percent) of household members in any given survey.

Table 7. Summary of CWI and HWI in Cameroon, 1991-2011

		Comparative Wealth Index (CWI)				Harmonized Wealth Index (HWI)				
	weighted n	mean	sd	min	max	mean	sd	min	max	correlation CWI-HWI
1991	19,783	-0.48	1.07	-1.63	3.15	-0.12	0.97	-1.25	3.27	0.966
1998	25,757	-0.54	1.10	-1.78	2.88	-0.10	0.94	-1.23	3.27	0.960
2004	49,758	-0.45	0.91	-1.51	2.33	0.04	0.99	-1.27	3.27	0.947
2011	70,882	-0.33	0.82	-1.82	2.47	0.18	1.02	-1.28	3.30	0.945

Cameroon suffered an economic crisis in the late 1990s, which reduced GDP per capita by at least 10 percent. CWI showed a small average decline, while HWI stagnated. The trends in subsequent years are similar to each other and to GDP per capita.

Figure 9. Mean CWI and HWI versus GDP per capita (PPP), Cameroon

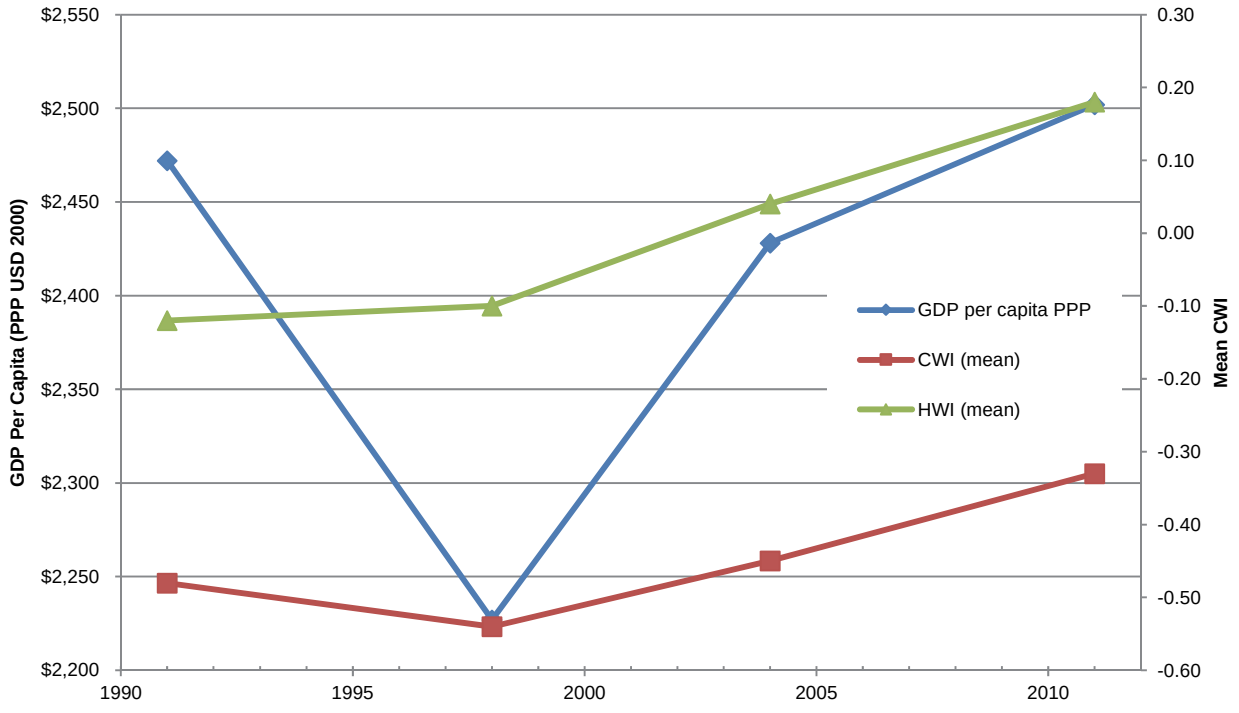


Figure 10, which shows the distribution of CWI scores among the household population in each survey year, reveals a nearly L-shaped distribution of wealth, with a high peak toward the left (bottom) end of the distribution. By 2011, however, the distribution begins to plateau around the middle, suggesting an emerging lower/middle class in the country. The distribution of HWI scores shown in Figure 11 reveals a similar, though lumpier, clustering of HWI scores toward the left side of the distribution with a long right tail. In 2004 and 2011 there appears to be not just a plateau in HWI but a slightly bimodal distribution, with wealth peaking toward the middle of the spectrum.

Figure 10. Distribution of comparative wealth index (CWI) in Cameroon by year

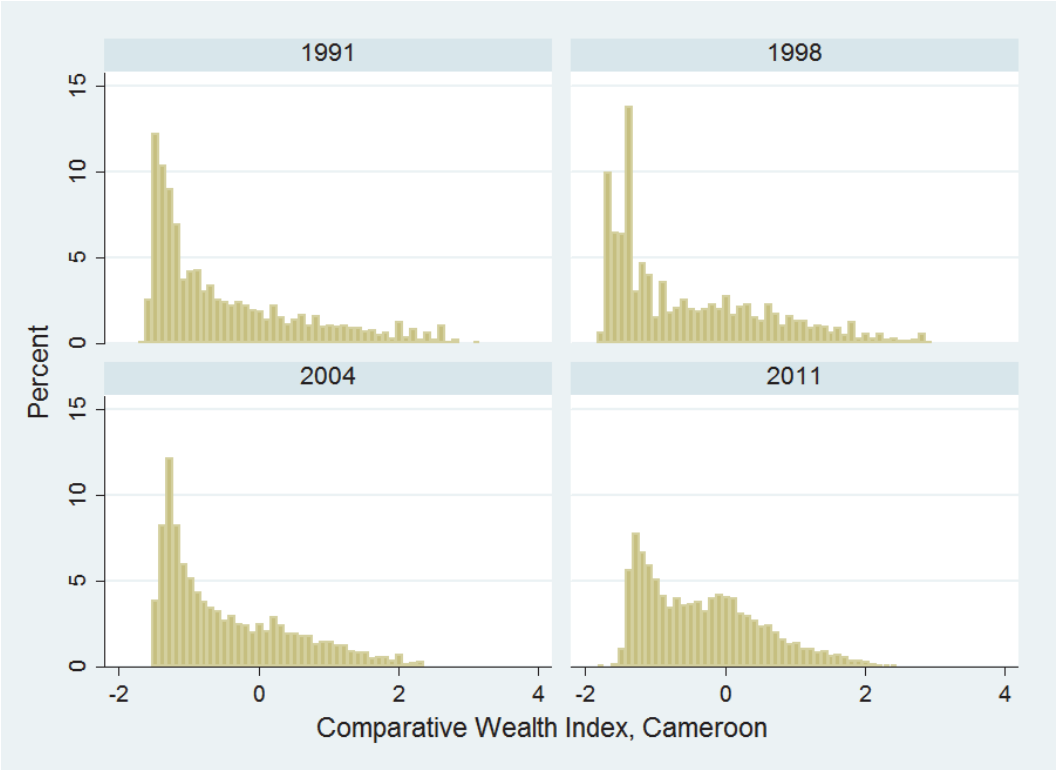
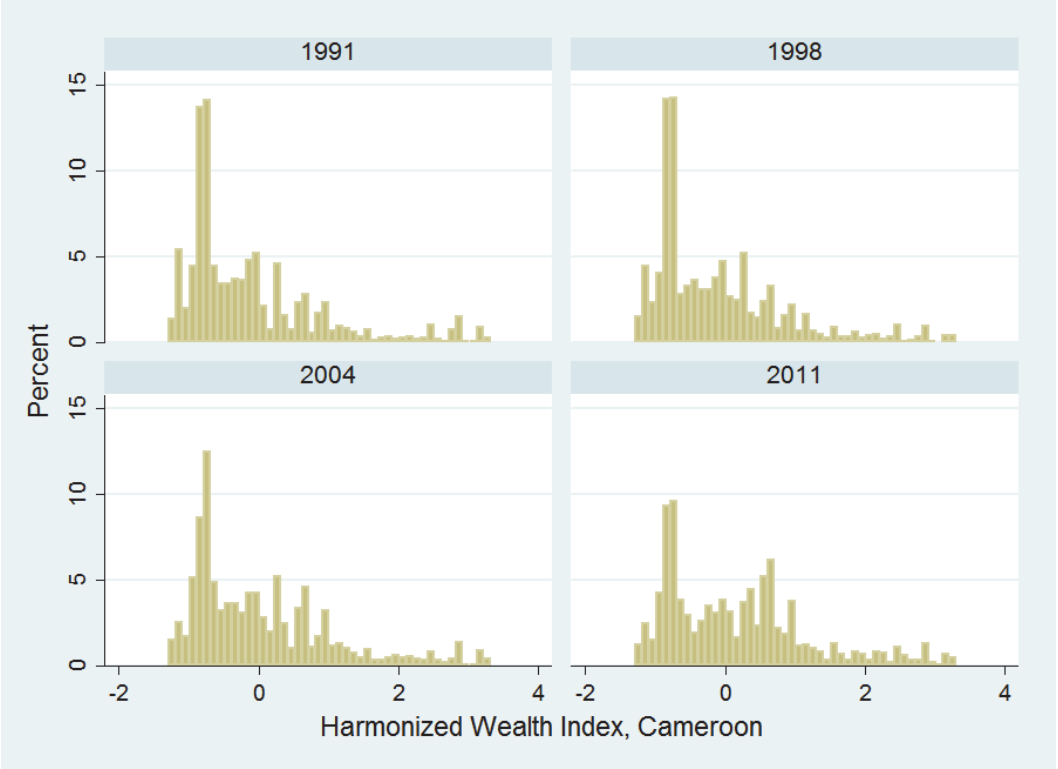


Figure 11. Distribution of harmonized wealth index (HWI) in Cameroon by year



The Q-Q plot of HWI versus CWI scores shown in Figure 12 reveals relatively little compression of scores except at the top end of the distribution in later years. Table 8, which shows the proportion of household members in each combination of CWI and HWI scores, indicates that more than two-thirds are in the same category in both metrics.

Figure 12. Quantile-Quantile plots of HWI versus CWI, Cameroon

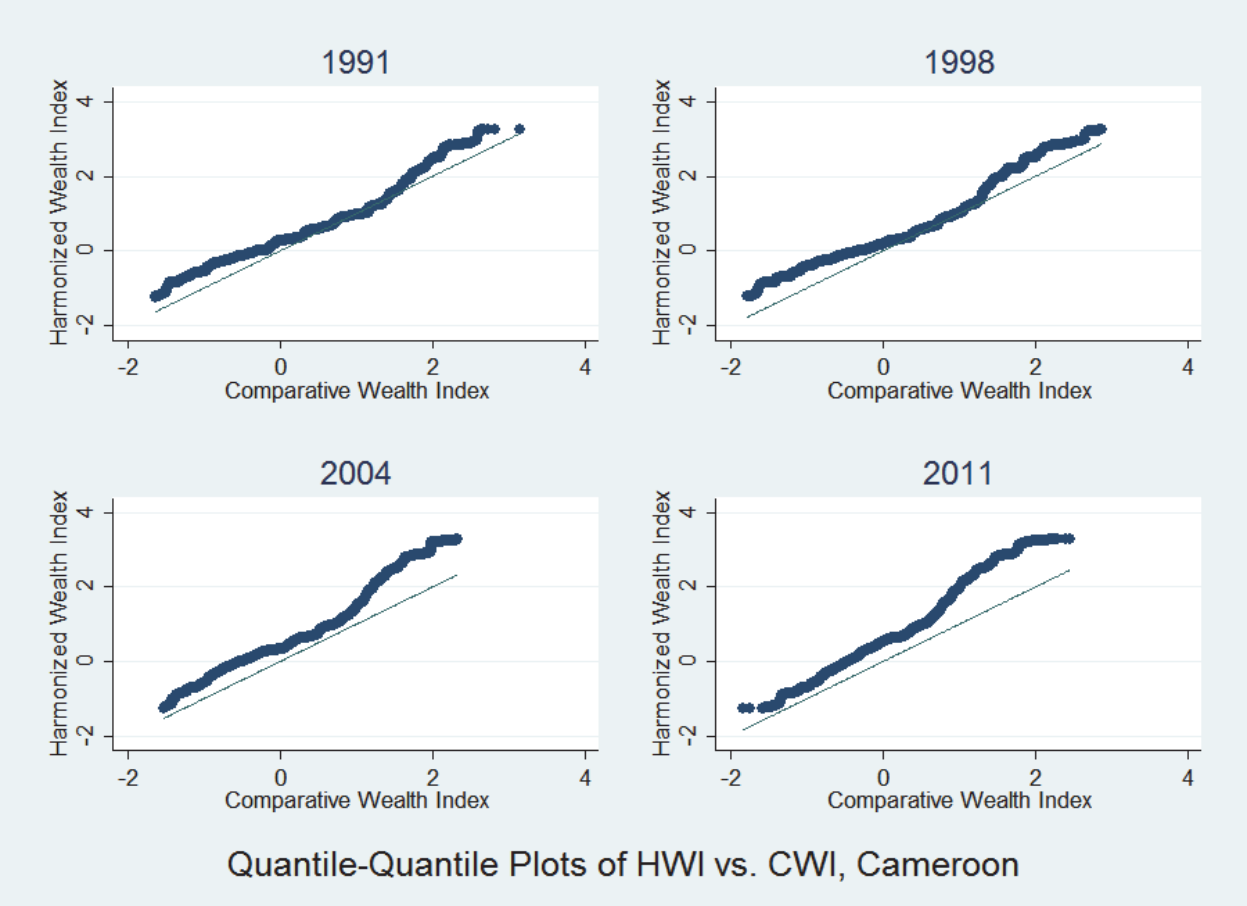


Table 8. Correspondence between pooled CWI and HWI quintiles in Cameroon, 1991-2011

Proportion of household members in pooled CWI and pooled HWI quintile

	CWI Quintile					
HWI Quintile	**lowest**	**second**	**third**	**fourth**	**highest**	**Total**
lowest	14	6	1	0	0	20
second	6	11	4	0	0	20
third	1	4	13	3	0	20
fourth	0	0	3	13	4	20
highest	0	0	0	3	17	20
Total	20	20	20	20	20	100
weighted n	33,239	33,234	33,243	33,238	33,225	166,179

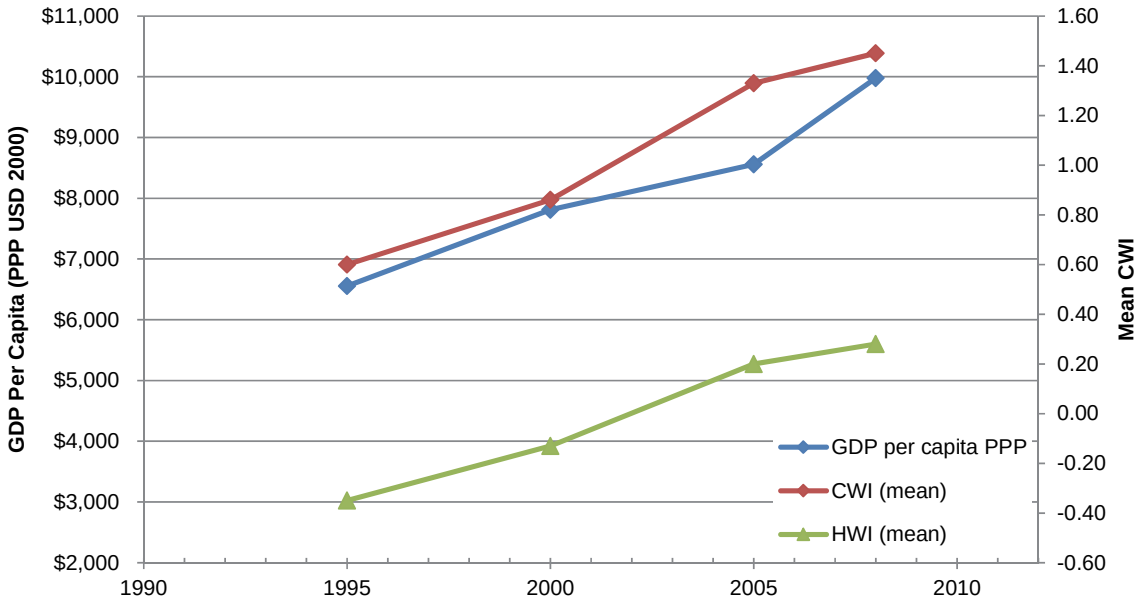
3.4. Egypt

Egypt, the focal country with the largest number of harmonized assets (16), has a higher average correlation between the HWI and the CWI (and, by extension, between the HWI and the DHS Wealth Index) than any other case study country, consistently above 95 percent (Table 9). The mean CWI and HWI scores track closely to each other and to GDP per capita, which increased over the course of the survey years.

Table 9. Summary of CWI and HWI in Egypt, 1995-2008

		Comparative Wealth Index (CWI)				Harmonized Wealth Index (HWI)				
	weighted n	mean	sd	min	max	mean	sd	min	max	correlation CWI-HWI
1995	82,826	0.60	1.33	-2.68	3.42	-0.35	1.15	-3.06	2.07	0.970
2000	88,865	0.86	1.10	-2.20	3.16	-0.13	1.01	-3.08	2.07	0.961
2005	107,300	1.33	0.98	-2.15	4.05	0.20	0.84	-2.90	2.04	0.959
2008	87,480	1.45	0.94	-1.60	4.32	0.28	0.80	-2.90	2.01	0.954

Figure 13. Mean CWI and HWI versus GDP per capita (PPP), Egypt 1995-2008



The distribution of wealth among household members using CWI (Figure 14) and HWI (Figure 15) is nearly identical, except that HWI is somewhat more uneven than CWI. Figure 16, the Q-Q plot of HWI and CWI, reveals a fairly linear relationship with relatively little compression of HWI, except toward the top of the distribution in 2005 and 2008.

Figure 14. Distribution of comparative wealth index (CWI) in Egypt by year

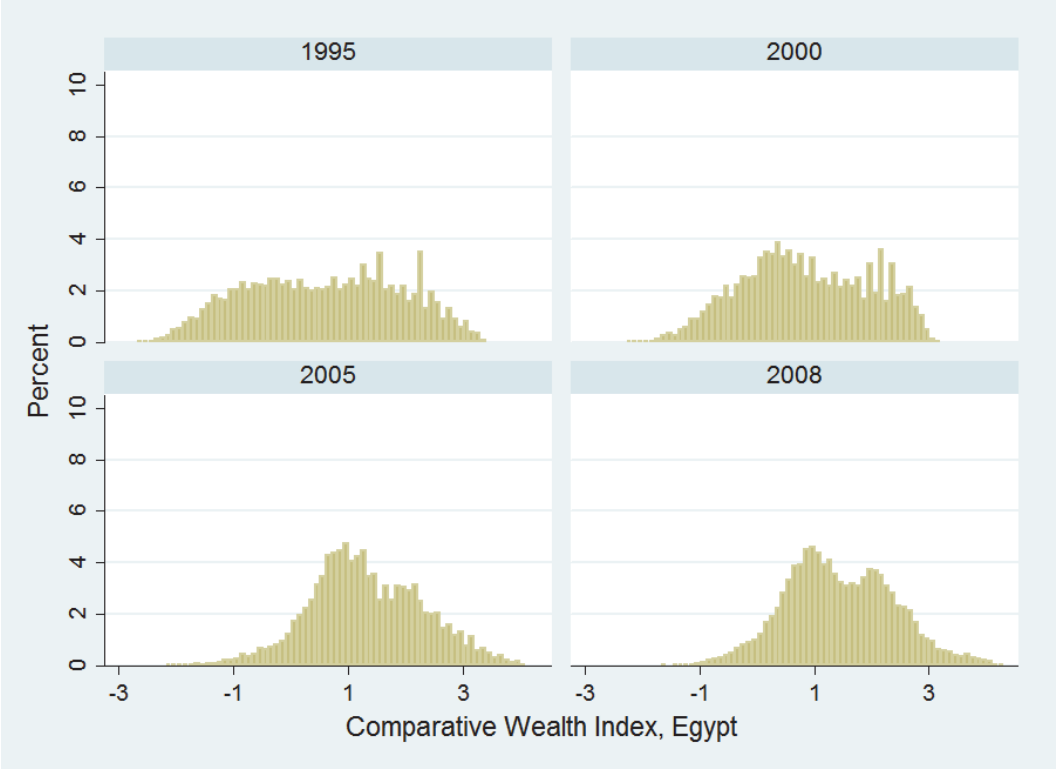


Figure 15. Distribution of harmonized wealth index (HWI) in Egypt by year

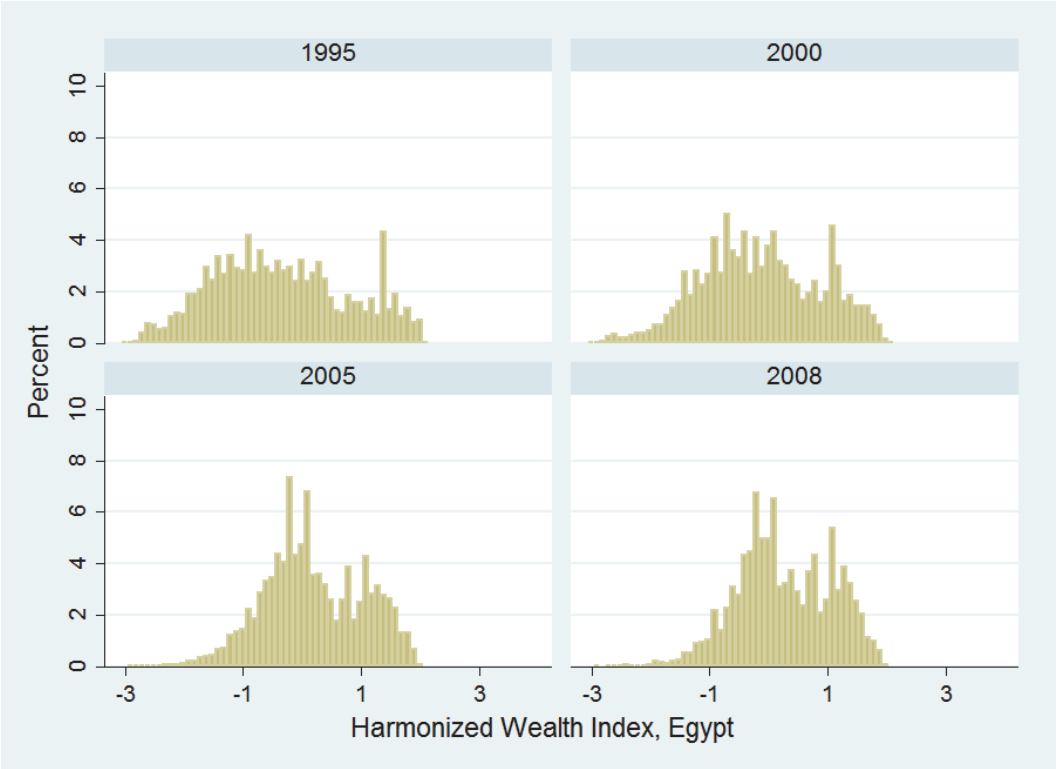


Figure 16. Quantile-Quantile plots of HWI versus CWI, Egypt

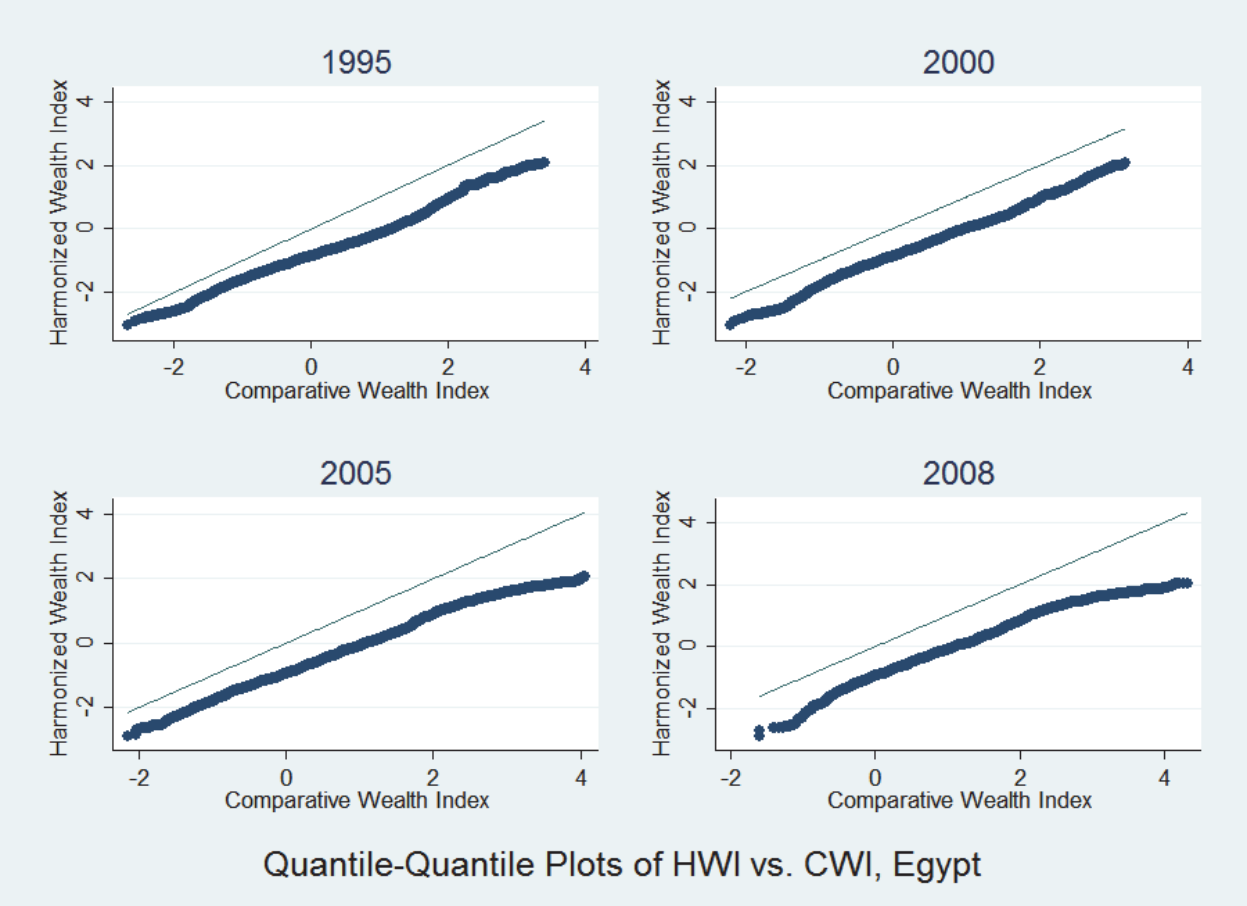


Table 10, which shows the proportion of household members in each combination of CWI and HWI scores, shows the largest share of household members of any focal country, 75 percent, classified in the same quintile for CWI and HWI.

Table 10. Correspondence between pooled CWI and HWI quintiles in Egypt, 1995-2008

Proportion of household members in pooled CWI and pooled HWI quintile

	CWI Quintile					
HWI Quintile	**lowest**	**second**	**third**	**fourth**	**highest**	**Total**
lowest	17	3	0	0	0	20
second	3	13	4	0	0	20
third	0	4	13	3	0	20
fourth	0	0	3	15	2	20
highest	0	0	0	3	17	20
Total	20	20	20	20	20	100
weighted n	73,304	73,285	73,299	73,752	72,831	366,471

3.5. Ghana

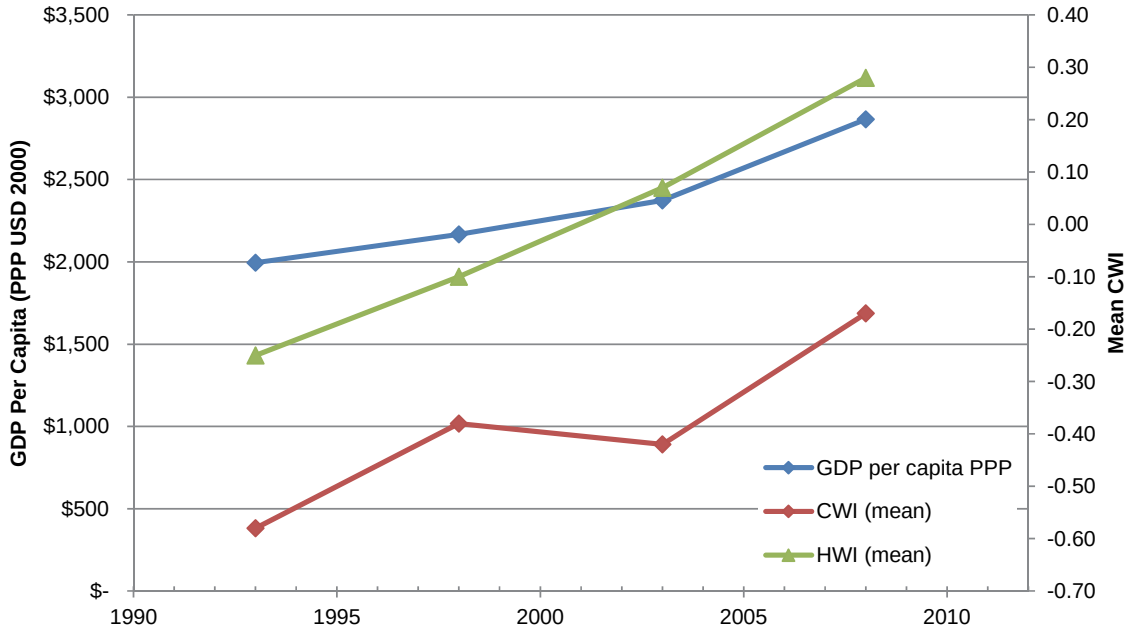
Table 10 shows that in Ghana the 2008 survey has a minimum CWI score of -2.45, whereas earlier surveys have a minimum of -1.39. As discussed earlier, 12.7 percent of the household population in Ghana in 2008 was scored as poorer than the poorest household members in 1993, a finding that suggests some problem in the displacement of CWI scores.

Table 11. Summary of CWI and HWI in Ghana, 1993-2008

		Comparative Wealth Index (CWI)				Harmonized Wealth Index (HWI)				
	weighted n	mean	sd	min	max	mean	sd	min	max	correlation CWI-HWI
1993	21,900	-0.58	0.90	-1.27	4.25	-0.25	0.86	-0.97	3.56	0.990
1998	21,665	-0.38	0.83	-1.37	2.29	-0.10	0.94	-0.97	3.51	0.971
2003	25,154	-0.42	0.95	-1.39	2.88	0.07	1.04	-0.97	3.51	0.969
2008	44,080	-0.17	0.98	-2.45	3.55	0.28	1.04	-0.98	3.88	0.936

Both the HWI and the CWI in Ghana are strongly correlated with GDP per capita, but the HWI tracks slightly better with GDP, revealing no decline in average economic status from 1998 to 2003 (Figure 17).

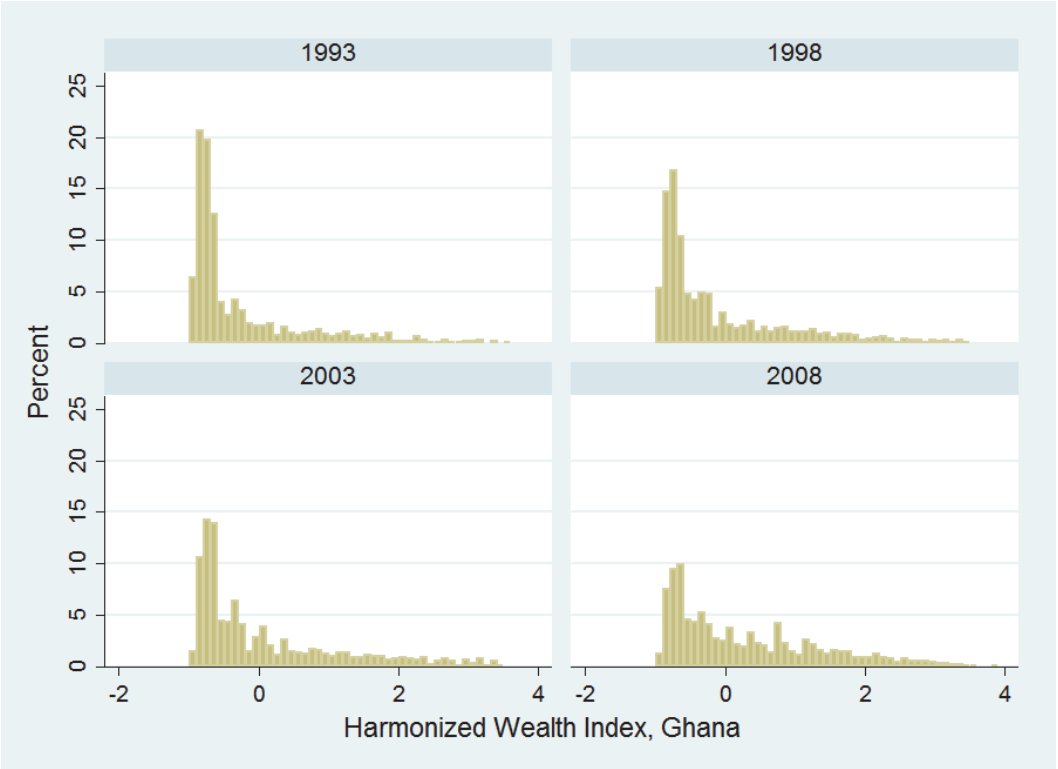
Figure 17. Mean CWI and HWI versus GDP per capita (PPP), Ghana 1993-2008



In Figures 18 and 19, the distribution of wealth among the household population appears similar in both metrics in the three earlier surveys, 1993, 1998, and 2003. In 2008, however, the CWI scores are centralized and are more of a plateau shape than in prior years, whereas the shape of the distribution of the HWI in 2008 is similar to that of prior years. One possible explanation is that additional assets measured in the 2008 survey provided a more complete picture of household living standards. At the same time, the share of variance explained by the pooled HWI in Ghana (14.1 percent, Table 2) was higher than the share of variance explained by the 2008 wealth index in Ghana (10.3 percent, not shown here).

Figure 18. Distribution of comparative wealth index (CWI) in Ghana by year

Figure 19. Distribution of harmonized wealth index (HWI) in Ghana by year



The Q-Q plot of HWI versus CWI (Figure 20) indicates little compression in HWI scores relative to CWI until the 2008 survey, when scores are compressed at both the upper and lower ends of the wealth distribution. Overall, however, both metrics classify more than two-thirds of the household population into the same CWI and HWI quintile (Table 12).

Figure 20. Quantile-Quantile plots of HWI versus CWI, Ghana

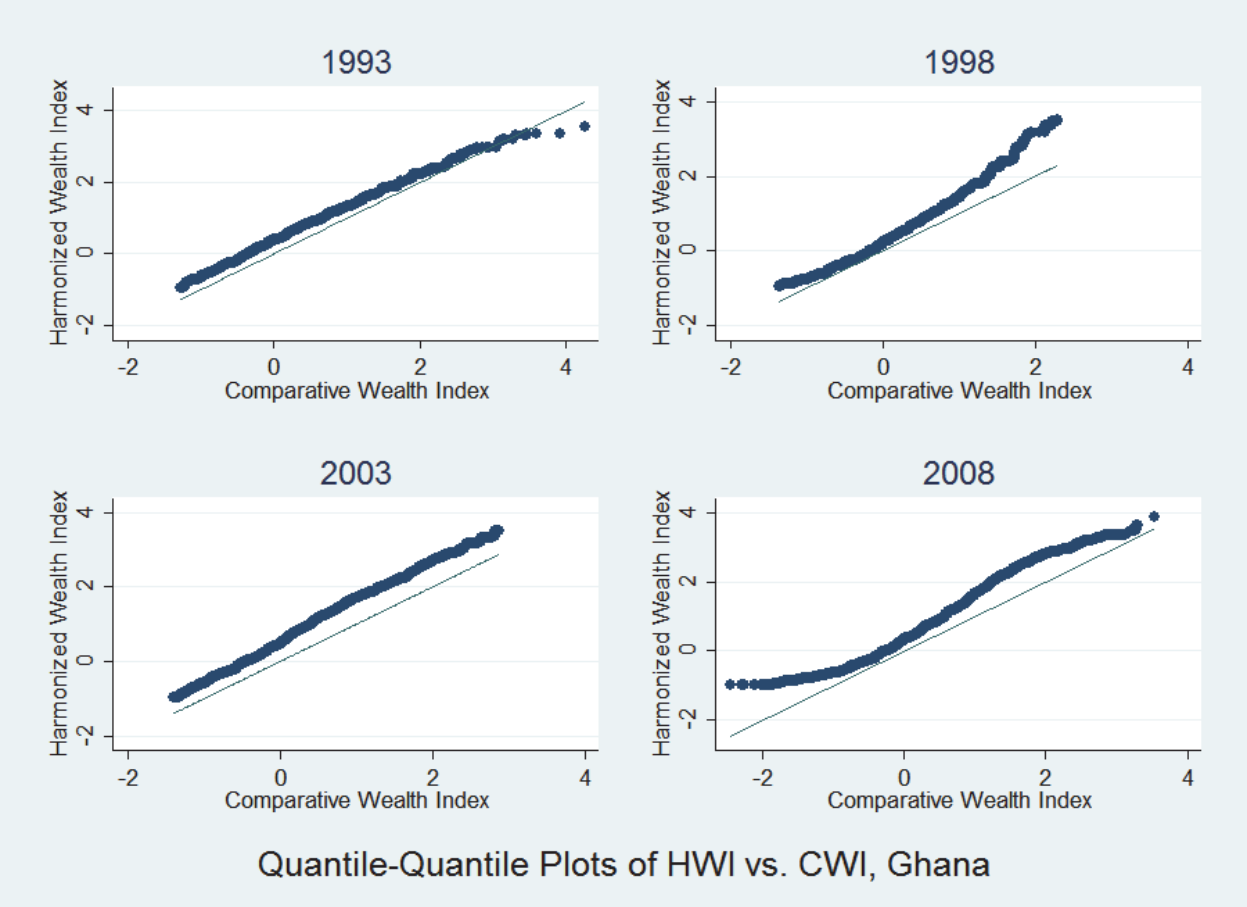


Table 12. Correspondence between pooled CWI and HWI quintiles in Ghana, 1993-2008

Proportion of household members in pooled CWI and pooled HWI quintile

	CWI Quintile					
HWI Quintile	**lowest**	**second**	**third**	**fourth**	**highest**	**Total**
lowest	14	6	1	0	0	20
second	6	11	4	0	0	21
third	1	3	12	4	0	19
fourth	0	0	4	14	2	20
highest	0	0	0	2	18	20
Total	20	20	20	20	20	100
weighted n	22,595	22,630	22,439	22,516	22,545	112,725

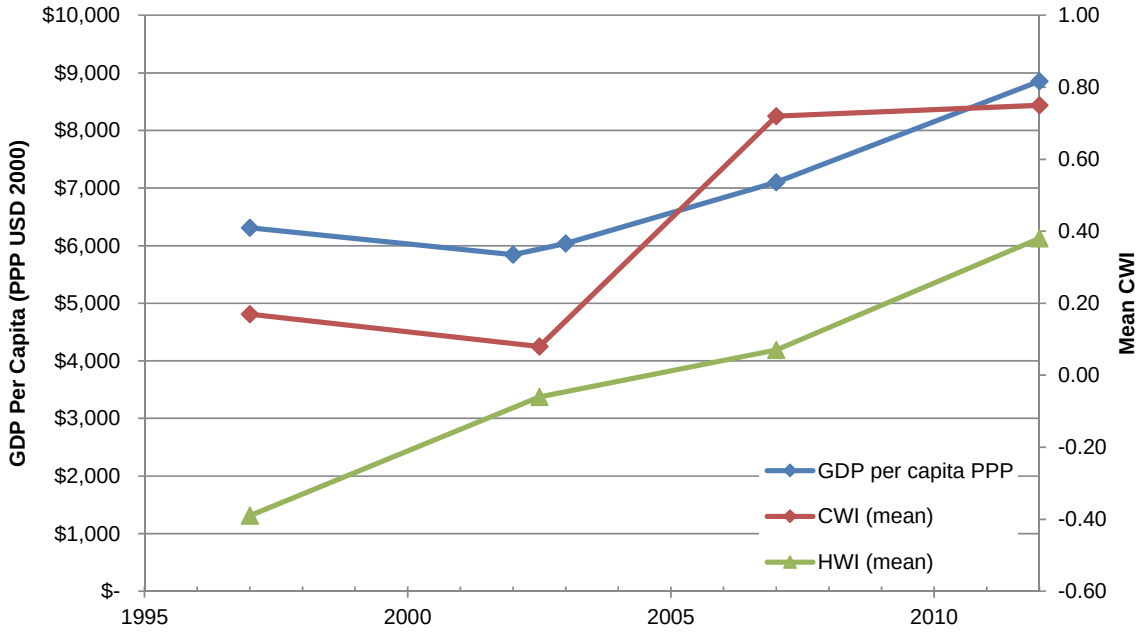
3.6. Indonesia

Despite a relatively high number of harmonized assets (12), Indonesia exhibits the weakest correlation between CWI and HWI of any of the focal countries studied (Table 13). Even so, the correlation between the two indices is above 92 percent. The mean HWI tracks quite closely to GDP, whereas CWI has a sharper increase in 2007 and levels off in 2012 (Figure 21).

Table 13. Summary of CWI and HWI in Indonesia, 1997-2012

		Comparative Wealth Index (CWI)				Harmonized Wealth Index (HWI)				
	weighted n	mean	sd	min	max	mean	sd	min	max	correlation CWI-HWI
1997	147,673	0.17	1.15	-2.20	3.26	-0.39	0.92	-2.65	1.74	0.920
2002-03	142,861	0.08	1.24	-2.71	3.45	-0.06	0.97	-2.65	1.84	0.933
2007	167,002	0.72	1.05	-2.17	2.56	0.07	1.00	-2.65	1.84	0.961
2012	174,977	0.75	0.88	-2.16	3.65	0.38	0.93	-2.65	1.84	0.942

Figure 21. Mean CWI and HWI versus GDP per capita (PPP), Indonesia



In Indonesia, the distribution of wealth in the household population appears similar in the CWI and the HWI (Figures 22 and 23, respectively). Household member wealth initially follows a nearly normal distribution before tending to skew leftward. The Q-Q plot shown in Figure 24 indicates some compression of the HWI in 2002-03 and a moderate degree of compression in 2012.

Figure 22. Distribution of comparative wealth index (CWI) in Indonesia by year

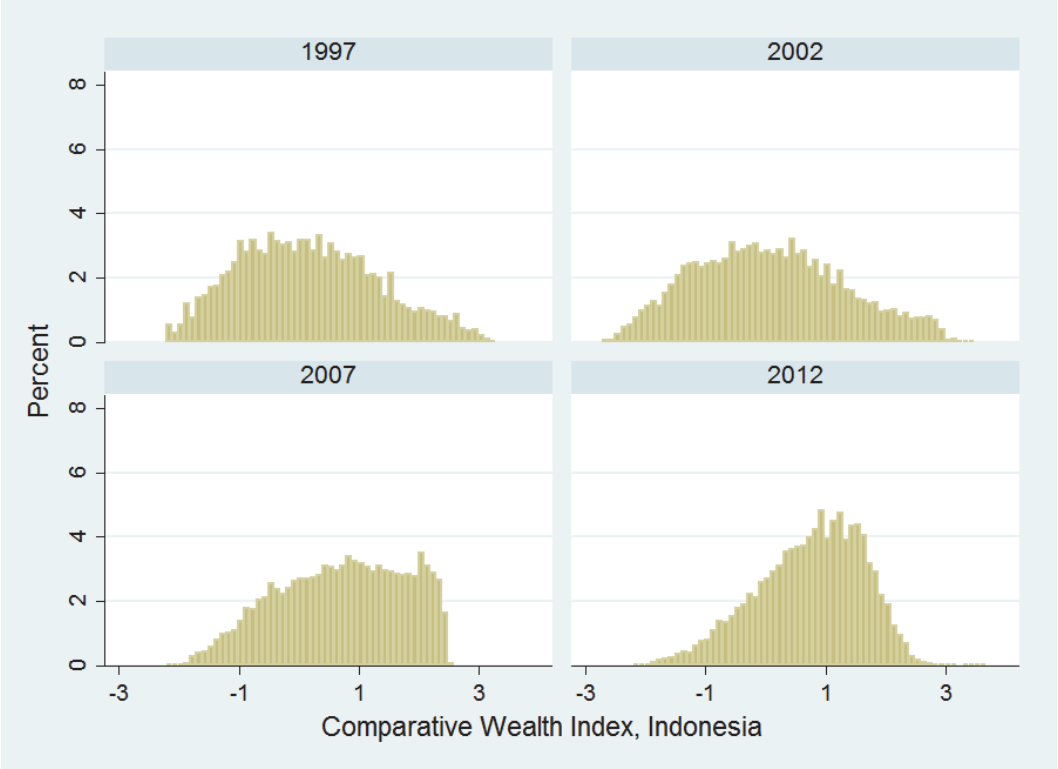


Figure 23. Distribution of harmonized wealth index (HWI) in Indonesia by year

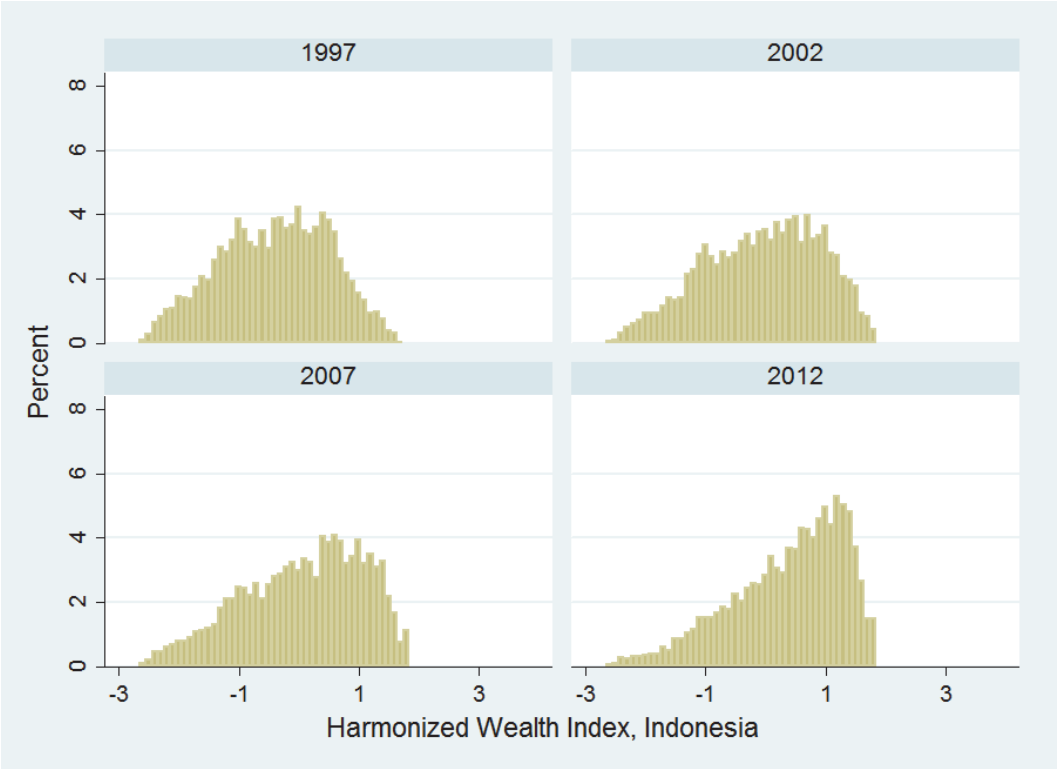


Figure 24. Quantile-Quantile plots of HWI versus CWI, Indonesia

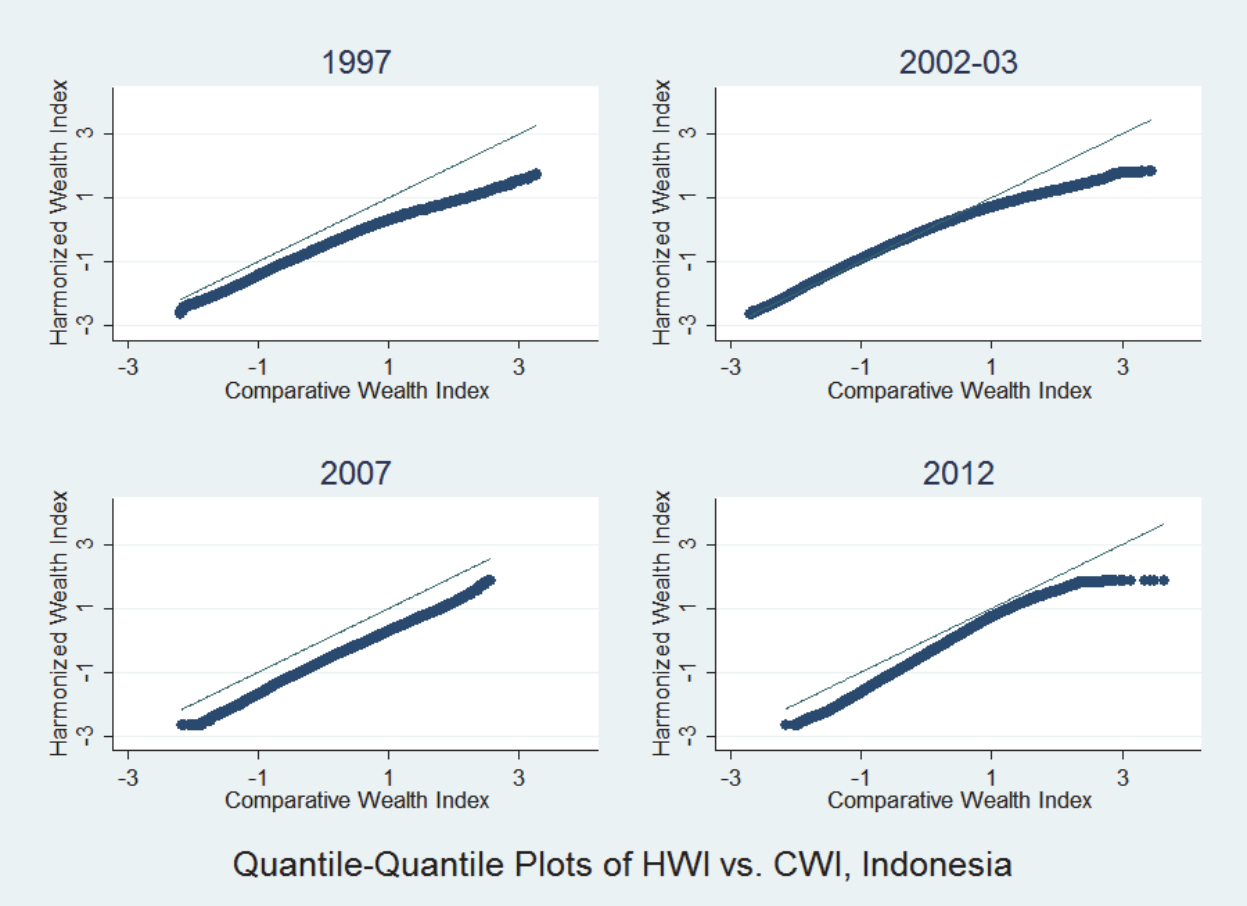


Table 14 shows that the cross-classification of wealth quintiles between HWI and CWI in Indonesia is weaker than in most other countries (62 percent of the household population). An additional 36 percent are within one quintile of cross-classification.

Table 14. Correspondence between pooled CWI and HWI quintiles in Indonesia, 1997-2012

Proportion of household members in pooled CWI and pooled HWI quintile

	CWI Quintile					
HWI Quintile	**lowest**	**second**	**third**	**fourth**	**highest**	**Total**
lowest	16	4	0	0	0	20
second	4	11	5	1	0	20
third	0	5	10	5	0	20
fourth	0	1	5	10	4	20
highest	0	0	0	5	15	20
Total	20	20	20	20	20	100
weighted n	126,505	126,503	126,555	126,473	126,476	632,513

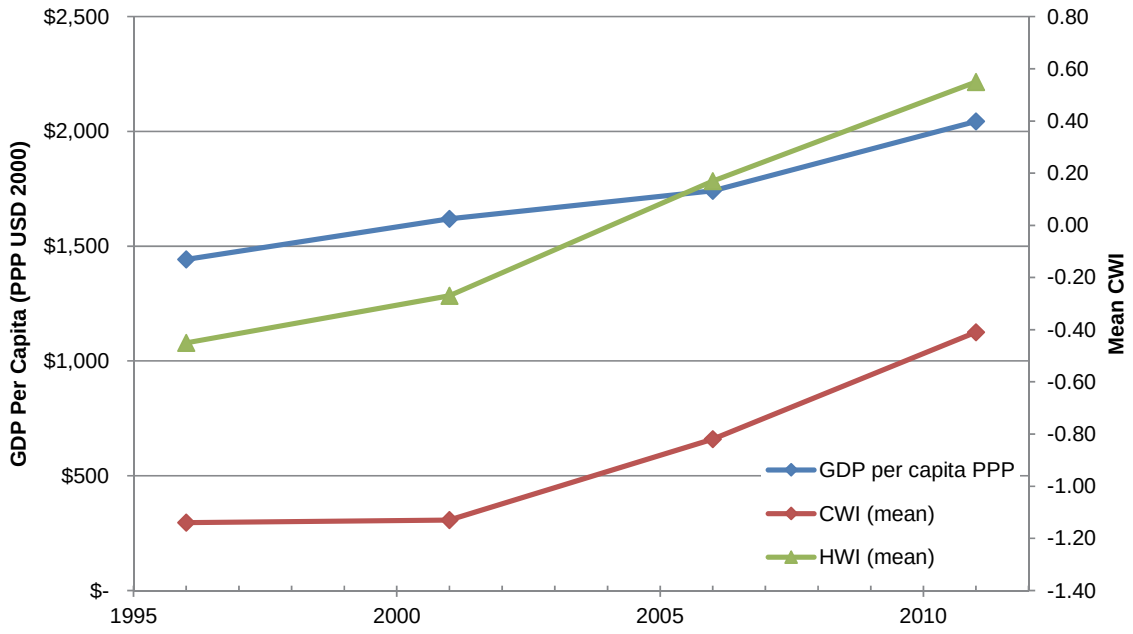
3.7. Nepal

In Nepal, the focal country with the fewest harmonized assets (8), there is a fairly consistent minimum CWI, and an increasing maximum over the course of the 15-year period (Table 15). The correlation between CWI and HWI ranges from 92.9 to 97.4 percent across the four surveys. The trends in the mean CWI and HWI scores are almost perfectly parallel to each other (Figure 25) and to GDP per capita over the course of the survey years.

Table 15. Summary of CWI and HWI in Nepal, 1996-2011

		Comparative Wealth Index (CWI)				Harmonized Wealth Index (HWI)				
	weighted n	mean	sd	min	max	mean	sd	min	max	correlation CWI-HWI
1996	44,559	-1.14	0.43	-1.69	0.86	-0.45	0.69	-1.18	2.86	0.948
2001	45,511	-1.13	0.62	-1.59	1.47	-0.27	0.85	-1.18	2.88	0.974
2006	42,256	-0.82	0.84	-1.68	2.56	0.17	1.01	-1.18	2.88	0.935
2011	48,123	-0.41	0.98	-1.96	2.32	0.55	1.07	-1.18	2.88	0.929

Figure 25. Mean CWI and HWI versus GDP per capita (PPP), Nepal 1996-2011



The distribution of wealth scores across the household population is fairly similar in 1996, 2001, and 2006 across the two measures (Figure 26 and 27)—an L-shaped distribution with a long right tail. The distribution of wealth in 2011 is much more evenly plateaued in both metrics. The distribution of the HWI appears somewhat lumpy in later surveys, particularly in 2011, where it shows a slight bimodality toward the right (upper) end of the distribution.

Figure 26. Distribution of comparative wealth index (CWI) in Nepal by year

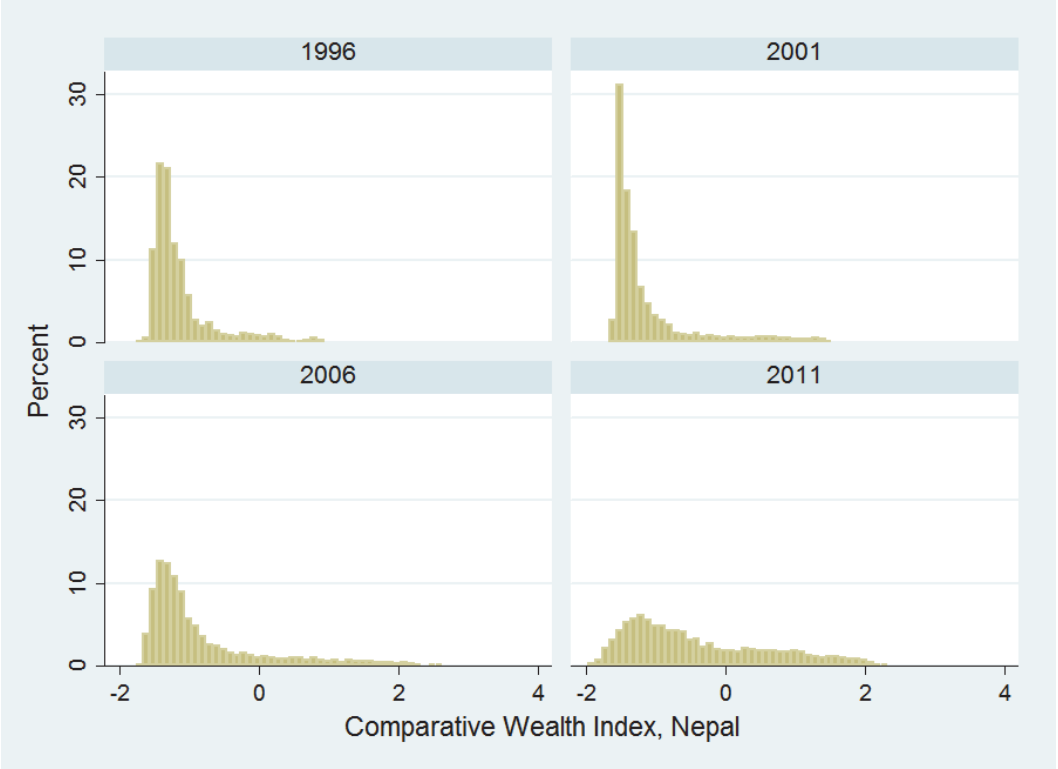


Figure 27. Distribution of harmonized wealth index (HWI) in Nepal by year

The Q-Q plots of wealth in Nepal (Figure 28) suggest that the only major compression of HWI is in 2006 at the top end of the distribution. The cross-classification of wealth quintiles between CWI and HWI (Table 16) finds the lowest identical classification of the focal countries, at 60 percent.

Figure 28. Quantile-Quantile plots of HWI versus CWI, Nepal

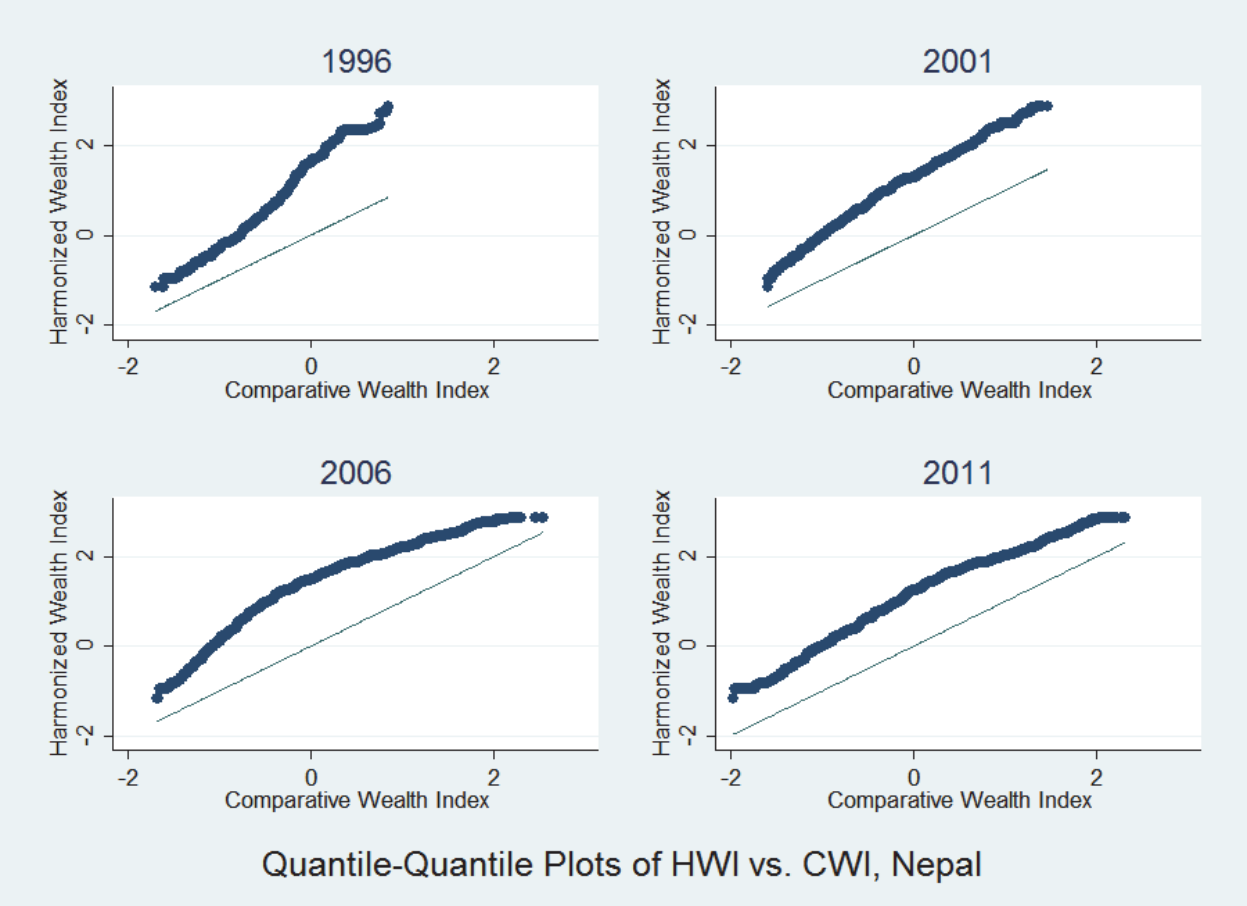


Table 16. Correspondence between pooled CWI and HWI quintiles in Nepal, 1996-2011

Proportion of household members in pooled CWI and pooled HWI quintile

HWI Quintile	CWI Quintile: lowest	second	third	fourth	highest	Total
lowest	15	9	2	0	0	26
second	3	6	5	1	0	14
third	1	5	9	5	0	21
fourth	0	1	4	12	2	20
highest	0	0	0	2	18	20
Total	20	20	20	20	20	100
weighted n	36,267	35,935	36,075	36,082	36,090	180,448

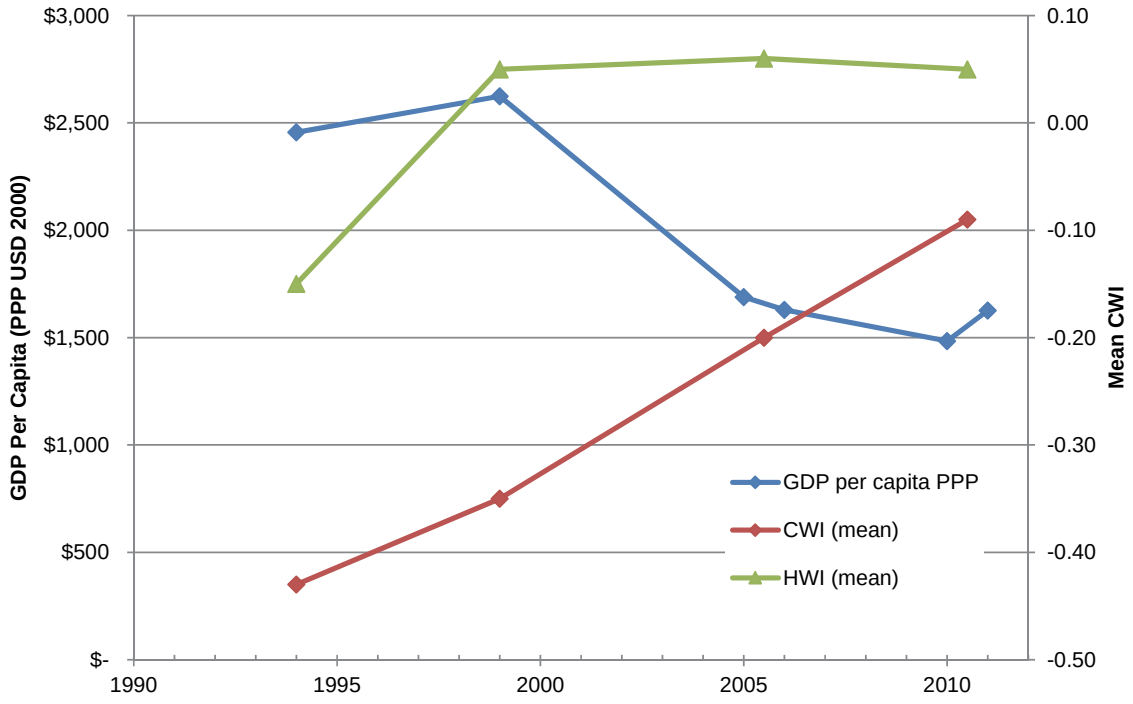
3.8. Zimbabwe

During the first decade of this century, Zimbabwe experienced a severe economic crisis and hyperinflation. GDP per capita declined by more than 40 percent. Meanwhile, as Table 17 shows, the mean value of asset-based measures of living standards stagnated or increased. Figure 29 shows the mean value of each index against GDP per capita. The trends go in opposite directions, which underscores the difference between expenditure- and income-based measures of economic standing, versus asset-based measures of wealth. There tends to be an inherent momentum in asset accumulation. For example, existing houses do not become more poorly constructed during times of economic collapse.

Table 17. Summary of CWI and HWI in Zimbabwe, 1994-2011

		Comparative Wealth Index (CWI)				Harmonized Wealth Index (HWI)				
	weighted n	mean	sd	min	max	mean	sd	min	max	correlation CWI-HWI
1994	27,949	-0.43	1.09	-1.85	2.97	-0.15	0.97	-1.08	3.25	0.989
1999	26,666	-0.35	1.06	-1.81	2.26	0.05	0.99	-1.08	3.25	0.924
2005-06	41,323	-0.20	1.15	-1.78	2.05	0.06	1.03	-1.08	2.87	0.967
2010-11	40,401	-0.09	0.94	-1.55	4.64	0.05	0.96	-1.08	3.25	0.946

Figure 29. Mean CWI and HWI versus GDP per capita (PPP), Zimbabwe 1994-2011



The distributions of CWI and HWI in Zimbabwe are displayed in Figures 30 and 31, respectively. CWI indicates a bimodal distribution of wealth in 1994 and 1999, and a trimodal distribution in later years. Meanwhile the HWI echoes the bimodal trend in 1994 and 1999 and the trimodal trend in 2010-11. The HWI scores show a characteristic 'comb' pattern of unevenness throughout the distribution, indicating a smaller number of distinct values of the wealth index.

Figure 30. Distribution of comparative wealth index (CWI) in Zimbabwe by year

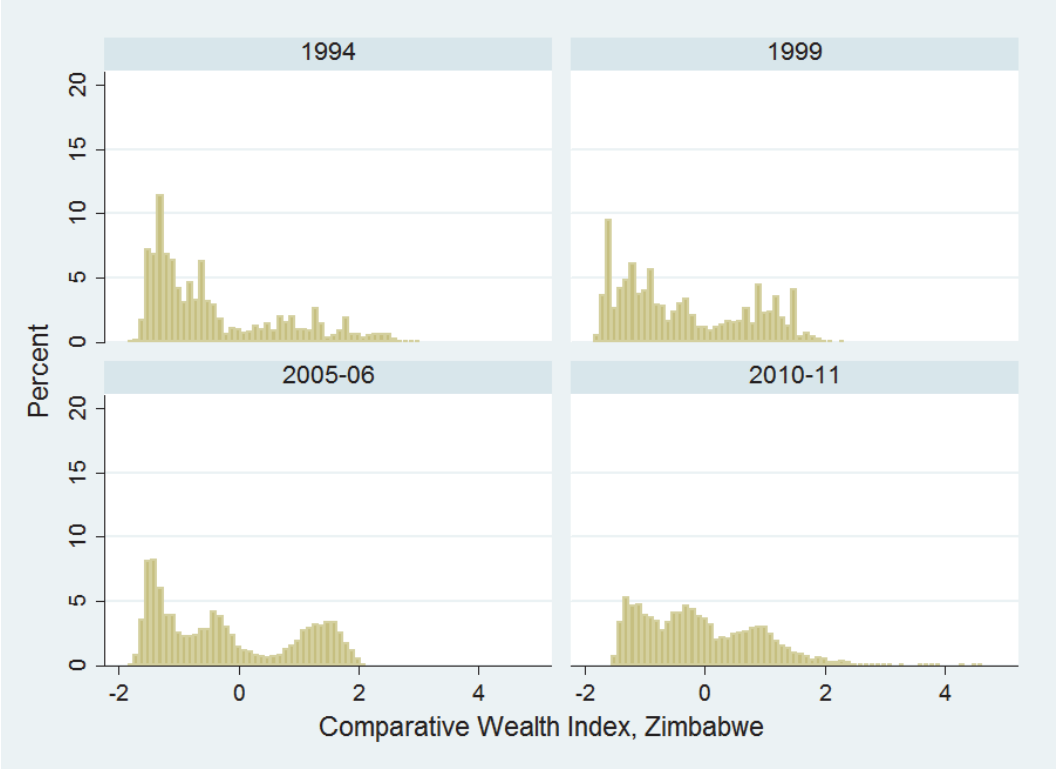
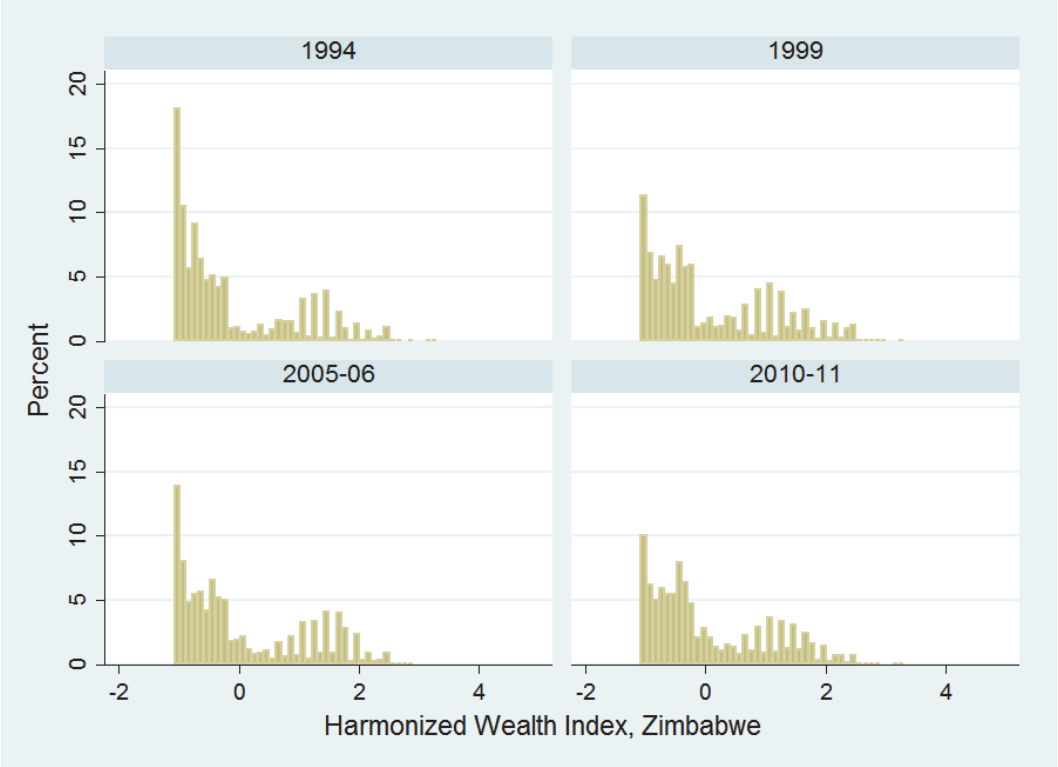


Figure 31. Distribution of harmonized wealth index (HWI) in Zimbabwe by year



The Quantile-Quantile plots of CWI versus HWI (Figure 32) suggest relatively little compression of the HWI until 2010-11, when the top of the range appears substantially compressed. Table 18 shows moderate correspondence between CWI and HWI quintile classifications.

Figure 32. Quantile-Quantile plots of HWI versus CWI, Zimbabwe

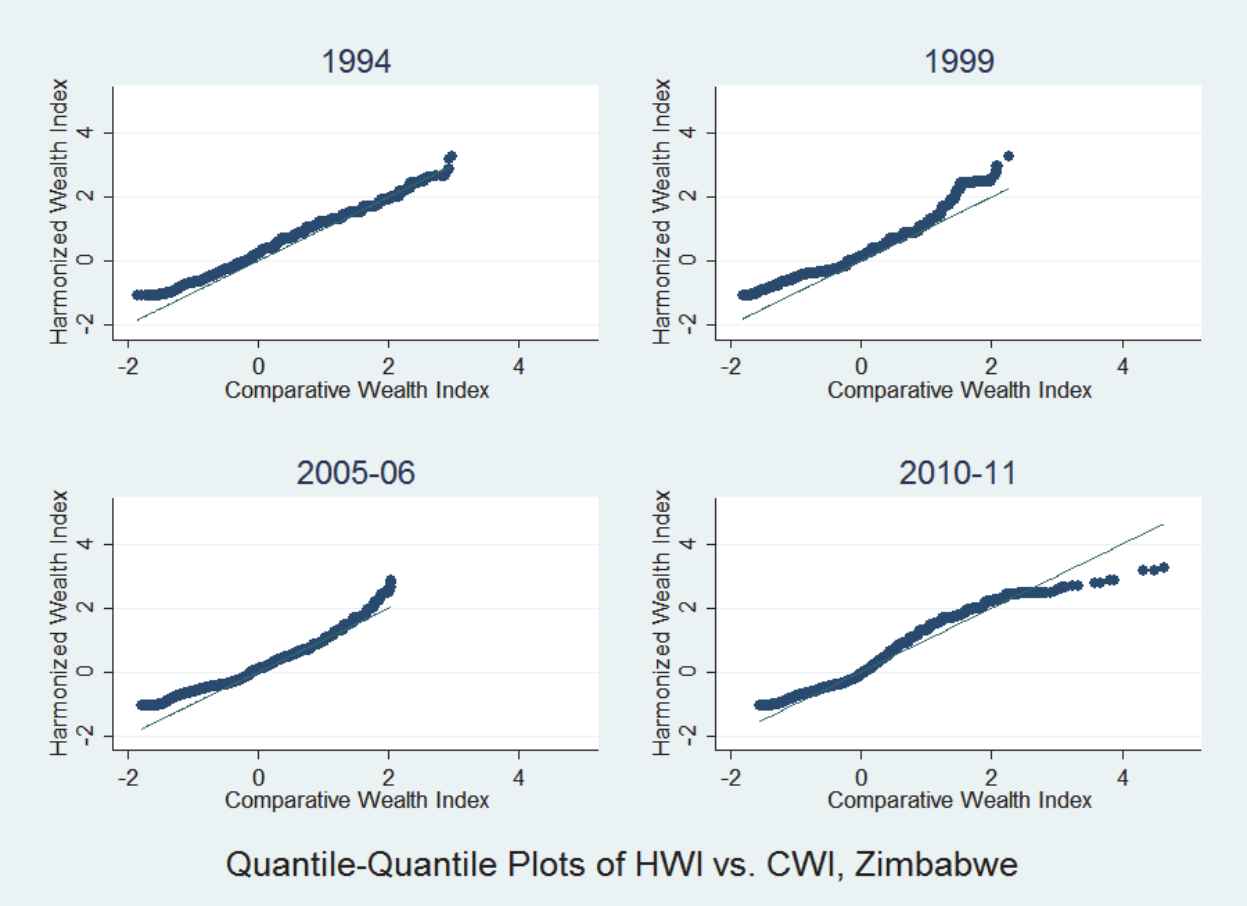


Table 18. Correspondence between pooled CWI and HWI quintiles in Zimbabwe, 1994-2011

Proportion of household members in pooled CWI and pooled HWI quintile

	CWI Quintile					
HWI Quintile	**lowest**	**second**	**third**	**fourth**	**highest**	**Total**
lowest	16	4	0	0	0	20
second	4	11	5	0	0	20
third	0	5	13	4	0	21
fourth	0	0	3	13	3	19
highest	0	0	0	3	17	20
Total	20	20	20	20	20	100
weighted n	27,268	27,269	27,268	27,266	27,267	136,339

4. Discussion and Conclusions

The Harmonized Wealth Index (HWI) approach described in this paper has promising applications for intertemporal analysis of health and poverty that combine data from the early- and mid-1990s with more recent data. It is particularly well suited to comparisons within a given country where a unique asset such as a solar heater or a sewing machine may have been considered salient even in earlier years when the DHS contained very few questions on household assets.

The analysis of eight focal countries finds that, as expected, the HWI produces a bounded range of wealth scores that is nearly constant across all surveys. This is in contrast to the CWI, where there appear to be some problematic distortions, for example in Ghana 2008 or Bangladesh 2011. This is because the HWI is inherently uniform. Households in any given survey with the same basic assets will, by definition, score exactly the same. Additionally, the HWI has the less obvious advantage of implementing the rural-urban adjustments to the wealth index in every survey rather than just in the most recent surveys.

But the HWI is not without its flaws. It requires analysts to compute based on the surveys selected for inclusion, and, if used to compare early and late DHS surveys it should be computed within a single or small number of countries; its reliability declines substantially when the number of harmonized assets is reduced. Harmonizing assets obviously leads to a loss of information that can differentiate households from one another. Histograms of the distribution of wealth across households reveal some degree of clustering in wealth categories in the HWI. The Q-Q plots show that the loss of information and compression of scores typically appears at the top of the distribution in more recent surveys. Non-focal countries had slightly fewer harmonized assets on average than focal countries, which may result in greater compression, but no country eligible for the study had fewer harmonized assets than Nepal (eight). To the extent that analysts use percentile categories of the wealth index as opposed to continuous scores, the compression of harmonized index scores should not be generally problematic.

Comparisons of harmonized asset-based wealth and poverty over time from DHS surveys cannot measure any increase in quality or quantity of particular assets— for example, the make of a car or truck and whether it is old or new. More recent surveys sometimes differentiate between black-and-white versus color televisions, for example, and—in countries such as Jordan may quantify the number of expensive assets—but earlier surveys did not. Yet, despite its name, the DHS Wealth Index was not intended to differentiate among the very wealthy, but rather to differentiate gradations of poverty. At the low end of the economic distribution in the focal countries studied, the Harmonized Wealth Index was not generally compressed relative to the CWI. The main exceptions were Bolivia in 1998 and Ghana in 2008.

The continuous HWI and CWI (and, by extension, the DHS Wealth Index) scores within each individual survey are highly correlated: without exception there was over 90 percent correlation between the scores in all 34 DHS surveys studied. The classification of quintiles of economic status was relatively consistent, with over 60 percent of household members cross-classified in the same quintile. Some variation is to be expected; if the two metrics of relative economic status overlapped perfectly then there would be no need to explore an alternative to the CWI. Moreover, when the two metrics differ, it is unclear which is more accurate.

One important lesson from this comparison for country stakeholders and survey managers is that countries should work to ensure consistency in asset categories and questions over time across household surveys. While new assets, particularly computers and Internet access, are salient markers of economic well-being, efforts should be made to ensure backward compatibility of categories and measures. In many countries it was not so much the earliest survey that lacked a relevant question, but middle surveys (for example, number of sleeping rooms in Bangladesh 1996-97 and 1999) that made it more difficult to produce a

harmonized wealth index. In other cases, assets that have become nearly ubiquitous have been phased out of recent surveys (for example, a watch or clock in Bangladesh) and thus could not be used to compare households over time.

The HWI approach is a promising avenue for analysts and policymakers interested in intertemporal comparisons of wealth and health. Based on initial results, compression of the index remains a concern, although in almost every country studied the compression occurred primarily among the wealthiest household members in the most recent survey. To the extent that most research uses quintile classifications, clustering of raw scores should not be unduly problematic; nonetheless, analysts are encouraged to review computed indices for compression.

This study has only evaluated the HWI method for the very particular challenge of comparing earlier and later DHS surveys with few harmonized assets. Applications of this method to a set of more recent surveys with a larger number of harmonized variables will yield an index that captures a greater degree of variations in household economic status than an HWI that includes earlier DHS surveys with relatively few asset questions.

Overall, the HWI methodology should prove useful for intertemporal analysis. However, additional research and validation are needed. Some researchers (Booysen et al. 2008; Sahn and Stifel 2000) have advocated the use of multiple correspondence analysis or factor analysis instead of principal component analysis to compute the asset index factor scores. The HWI retained principal component analysis for the sake of consistency with the existing DHS Wealth Index, but alternate computational methods could certainly be explored. Applications of the HWI to health indicators, alternate approaches to harmonizing asset categories (for example, using a quality index), and computations for additional countries should be explored further.

Appendix

Table A1. Example of Asset Harmonization Table, Bangladesh

	1993-94	1996-97	1999	2004	2007	2011	Harmonized variable
DRINKING WATER	**hv201 source of drinking water** 11. piped inside dwel 12. piped outside dwel. 21. tubewell 22. surface /other well 31. pond /tank/lake 32. river /stream 41. rainwater 96. other missing	**hv201 source of drinking water** 11. piped inside dwel. 12. piped outside dwel. 21. tubewell 22. surface /other well 31. pond /tank/lake 32. river /stream 41. rainwater 96. other missing	**hv201 source of drinking water** 11. piped inside dwel. 12. piped outside dwel. 21. tubewell 22. surface/other well 31. pond/tank/lake 32. river/stream 96. other missing	**hv201 source of drinking water** 11. piped inside dwelling 12. piped outside dwel. 21. tubewell 22. shallow tubewell 23. deet tubewell 24. surface well/other well 41. pond/tank/lake 42. river/stream 96. other missing	**hv201 source of drinking water** 11. piped into dwelling 12. piped to yard/plot 13. public tap/standpipe 21. tube well or borehole 31. protected well 32. unprotected well 41. protected spring 42. unprotected spring 43. river/dam/lake/ ponds/stream/canal/i 51. rainwater 62. cart with small tank 71. bottled water 96. other	**hv201 source of drinking water** 11. piped into dwelling 12. piped to yard/plot 13. public tap/standpipe 21. tube well or borehole 31. protected well 32. unprotected well 41. protected spring 43. river/dam/lake/ ponds/stream/canal/i 51. rainwater 61. tanker truck 62. cart with small tank 71. bottled water 96. other	**hv201_r source of drinking water** 11. piped into dwelling 12. piped to yard/plot 96. other 21. well 21. well 21. well 21. well 21. well 96. other 96. other 43. river/dam/lake/ ponds/stream/canal/ tank 43. river/dam/lake/ ponds/stream/canal/ tank 96. other 96. other 96. other 96. other 96. other missing
FLOOR	**hv213 main floor material** 11. earth 21. wood 31. cement/concrete 96. other missing	**hv213 main floor material** 11. earth /bamboo 21. wood 31. cement /concrete 96. other missing	**hv213 main floor material** 11. earth/bamboo 21. wood 31. cement/concrete 96. other missing	**hv213 main floor material** 11. earth/bamboo 21. wood 31. cement/concrete 96. other missing	**hv213 main floor material** 11. earth, sand 22. palm, bamboo 21. wood planks 31. parquet, polished wood 33. ceramic tiles 34. cement 35. carpet 96. other 99.00	**hv213 main floor material** 11. earth, sand 22. palm, bamboo 21. wood planks 31. parquet, polished wood 33. ceramic tiles 34. cement 35. carpet 96. other 99.00	**hv213_r main floor material** 11. earth, sand, palm, bamboo 11. earth, sand, palm, bamboo 21. wood 21. wood 96. other 31. cement 96. other 96. other missing

(Continued…)

Table A1. – *Continued*

	1993-94	1996-97	1999	2004	2007	2011	Harmonized variable
	hv214 main wall material	**hv214 main wall material**	**hv214 main wall material**	**hv214 main wall material**	**hv214 main wall material**	**hv214 main wall material**	**hv214_r main wall material**
					11. no walls	11. no walls	96. other
	11. jute /bamboo/mud	11. natural walls	11. natural walls	11. jute/bamboo/mud	13. dirt	13. dirt	11. jute/bamboo/mud
					22. bamboo with mud	21. bamboo with mud	11. jute/bamboo/mud
					12. cane / palm / trunks	12. cane / palm / trunks	11. jute/bamboo/mud
							21. rudimentary: wood, stone,
	21. wood	21. rudimentary walls	21. rudimentary walls	21. wood	23. stone with mud	22. stone with mud	cardboard
WALLS					24. plywood		21. rudimentary: wood, stone, cardboard
							21. rudimentary: wood, stone,
					25. cardboard	25. cardboard	cardboard
	32. tin	32. tin	32. tin	32. tin	31. tin	31. tin	31. tin
	31. brick /cement	31. brick /cement	31. brick/cement	31. brick/cement	32. cement	32. cement	32. brick/cement
					33. stone with lime / cement	33. stone with lime / cement	32. brick/cement
					34. bricks	34. bricks	32. bricks
					35. wood planks / shingles	36. wood planks / shingles	96. other or wood
	96. other	96. other	96. other	96. other	96. other	96. other	96. other or wood
	missing	missing	missing	missing	99	99	missing
	hv215 main roof material	**hv215 main roof material**	**hv215 main roof material**	**hv215 main roof material**	**hv215 main roof material**	**hv215 main roof material**	**hv215_r main roof material**
					11. no roof	11. no roof	96. other
	11. jute /bamboo/mud	11. natural roof	11. earth/bamboo	11. bamboo/thatch	12. thatch / palm leaf	12. thatch / palm leaf	11. earth
					23. bamboo	22. palm / bamboo	11. earth
		21. rudimentary roof					21. rudimentary roof
			21. wood			23. wood planks	21. rudimentary roof
					32. wood	32. wood	21. rudimentary roof
ROOF						24. cardboard	21. rudimentary roof
	21. tin			21. tin	31. tin	31. tin	21. rudimentary roof
		31. finished roof					31. Finished Roof
						36. roofing shingles	31. Finished Roof
				31. cement/			
	31. cement /concrete		31. cement/concrete	concrete/tiled	34. cement	35. cement	31. Finished Roof
					33. ceramic tiles	34. ceramic tiles	31. Finished Roof
	96. other	96. other	96. other	96. other	96. other	96. other	96. Other
	missing	missing	missing	missing	99.00	99	missing

(Continued…)

Table A1. – *Continued*

	1993-94	1996-97	1999	2004	2007	2011	Harmonized variable
TOILET	**hv205 type of toilet facility** 11. septic tank/ modern 21. water sealed /slab 22. pit latrine 23. open latrine 24. hanging latrine 31. no facility /bush 96. other	**hv205 type of toilet facility** 11. septic tank/toilet 21. water sealed/ slab la 22. pit latrine 23. open latrine 24. hanging latrine 31. no fac. /bush/field 96. other missing	**hv205 type of toilet facility** 11. septic tank/toilet 21. water sealed/slab la 22. pit latrine 23. open latrine 24. hanging latrine 31. no facility, bush 96. other missing	**hv205 type of toilet facility** 11. septic tank/modern toilet 21. water sealed/slab latrine 22. pit latrine 23. open latrine 24. hanging latrine 31. no facility/bush/field missing	**hv205 type of toilet facility** 11. flush - to piped sewer system 12. flush - to septic tank 13. flush - to pit latrine 14. flush - to somewhere else 15. flush - don't know where 21. ventilated improved pit latrine (vi 22. pit latrine - with slab 23. pit latrine - without slab / open p 43. hanging toilet/latrine 31. no facility/bush/field 42. bucket toilet 99.00	**hv205 type of toilet facility** 11. flush to piped sewer system 12. flush to septic tank 13. flush to pit latrine 14. flush to somewhere else 15. flush, don't know where 21. ventilated improved pit latrine (vi 22. pit latrine with slab 23. pit latrine without slab/open pit 43. hanging toilet/latrine 31. no facility/bush/field 41. composting toilet 42. bucket toilet 99	**hv205_r type of toilet facility** 11. flush toilet 11. flush toilet 11. flush toilet 11. flush toilet 11. flush toilet 21. pit latrine with slab 21. pit latrine with slab 22. pit latrine/open 22. pit latrine/open 22. pit latrine/open 23. hanging latrine 31. no facility, bush 96. other 96. other 96. other missing
SHARED TOILET	N/A	N/A	N/A	N/A	**hv225 share toilet with other households** 0. no 1. yes 9 missing	**hv225 share toilet with other households** 0. no 1. yes missing	**hv225_r share toilet with other households** Not usable
# SLEEP-ING ROOMS	**hv216 number of rooms for sleeping** 1 though 41 missing	**hv216 number of rooms for sleeping** n/a	**hv216 number of rooms for sleeping** n/a	**sh36 number of rooms for sleeping** 1 through 12 missing	**hv216 number of rooms for sleeping** 1 through 16 99	**hv216 number of rooms for sleeping** 1 through 11 99	**hv216_r number of rooms for sleeping** Not usable

(Continued…)

Table A1. – *Continued*

	1993-94	1996-97	1999	2004	2007	2011	Harmonized variable
OWNS LAND	**sh26i agricultural land** 0. no 1. yes	**sh25 hh owns agricultural land** 0. no 1. yes	**sh27a household owns any other land** 0. no 1. yes	**sh42 owns land** 0. no 1. yes missing	**hv244 own land usable for agriculture** 0. no 1. yes 9	**hv244 own land usable for agriculture** 0. no 1. yes	**hv244_r owns land** 0. no 1. yes 0. no
HECTARES	**N/A**	**N/A**	**sh28 amount of land owned (number)** 0 through 8100 9996 9998 missing	**sh43a amount of land owned (acres)** 0 through 50 missing	**hv245 hectares for agricultural land** 0 through 40 99 missing	**hv245 hectares for agricultural land** 0 through 40 999 missing	**hv245_r hectares for agricultural land** Not usable
ASSETS	hv206 has electricity 0. no 1. yes	hv206 has electricity 0. no 1. yes	hv206 has electricity 0. no 1. yes	hv206 has electricity 0. no 1. yes	hv206 has electricity 0. no 1. yes	hv206 has electricity 0. no 1. yes	**hv206_r has electricity** 0. no 1. yes
	hv207 has radio 0. no 1. yes	hv207 has radio 0. no 1. yes	hv207 has radio 0. no 1. yes	hv207 has radio 0. no 1. yes	hv207 has radio 0. no 1. yes	hv207 has radio 0. no 1. yes	**hv207_r has radio** 0. no 1. yes
	hv208 has television 0. no 1. yes	hv208 has television 0. no 1. yes	hv208 has television 0. no 1. yes	hv208 has television 0. no 1. yes	hv208 has television 0. no 1. yes	hv208 has television 0. no 1. yes	**hv208_r has television** 0. no 1. yes
	hv210 has bicycle 0. no 1. yes	hv210 has bicycle 0. no 1. yes	hv210 has bicycle 0. no 1. yes	hv210 has bicycle 0. no 1. yes	hv210 has bicycle 0. no 1. yes	hv210 has bicycle 0. no 1. yes	**hv210_r has bicycle** 0. no 1. yes
			hv211 has motorcycle	hv211 has motorcycle/ scooter	hv211 has motorcycle/ scooter hv212 has car/truck	hv211 has motorcycle/ scooter hv221 has telephone (land-line)	Not usable Not usable Not usable
			hv221 has telephone	hv221 has telephone hv226 type of cooking fuel	hv221 has telephone hv226 type of cooking fuel	hv226 type of cooking fuel	Not usable

(Continued…)

Table A1. – *Continued*

	1993-94	1996-97	1999	2004	2007	2011	Harmonized variable
					hv241 food cooked in the house/in separate building/outdoors	hv241 food cooked in the house/in separate building/outdoors	Not usable
						hv242 hh has a separate room for kitchen	Not usable
				sh39 type of cooking stove	sh111 food cooked on stove		Not usable
				sh40 place of cooking	sh113 place cooking usually done		Not usable
	sh26a almirah 0. no 1. yes	sh24a almirah 0. no 1. yes	sh22b almirah 0. no 1. yes	sh31b almirah (wardrobe) 0. no 1. yes	sh109g hh own a almirah or wardrobe 0. no 1. yes	sh110g has almirah/wardrc 0. no 1. yes	**hv211_r has almirah/wardrobe** 0. no 1. yes
ASSETS, Cont'd	sh26b table/chair/bench 0. no 1. yes	sh24b table, chair or bench 0. no 1. yes	sh22c table or chair 0. no 1. yes	sh31c table 0. no 1. yes	sh109h hh own a table 0. no 1. yes	sh110h has table or chair 0. no 1. yes	**hv212_r has a table or chair** 0. no 1. yes
						sh110j has electric fan	Not usable
						sh110k has dvd/vcd player	Not usable
						sh110 has water pumps	Not usable
						hs118 has autobike	Not usable
					sh109p hh own a rickshaw/van	sh118b has rickshaw	Not usable
	sh26c watch/clock	sh24c watch or clock	sh22e watch or clock	sh31e watch or clock			Not usable
	sh26d cot/bed	sh24d cot or bed	sh22f cot or bed	sh31f cot or bed			Not usable
			sh22k sewing machine	sh31k sewing machine			Not usable
			sh27 household owns homestead	sh41 owns any homestead	sh121 hh own any homestead	sh122a owns homestead	Not usable
					hv243a has a mobile telephone	hv243a has a mobile telephone	Not usable
					hv243b has a watch		Not usable

(Continued…)

Table A1. – *Continued*

	1993-94	1996-97	1999	2004	2007	2011	Harmonized variable
ASSETS, Cont'd					hv243c has an animal-drawn cart		Not usable
					hv243d has a boat with a motor		Not usable
					hv246 livestock, herd or farm animals	hv246 livestock, herd or farm animals	Not usable
					hv246b cows, bulls own	hv246b cows, bulls own	Not usable
						hv246g owns bulls/buffaloes	Not usable
					hv246g cs own goats/sheep	hv246h owns goats/sheep	Not usable
					hv246h cs own chickens/ducks	hv246i owns chickens/ducks	Not usable
						hv247 has bank account	Not usable

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