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Abstract

According to the official statistics published by the National Institute of Statistics of Rwanda, the country registered a decline in poverty from 46 percent in 2010/11 to 39 percent in 2013/14. This declining poverty trend was broadly debated and repeatedly questioned in national and international forums, which provided the primary motivation for this study. Using data from the third and fourth rounds of the Integrated Household Living Conditions Surveys, this paper revisits the national poverty numbers and corroborates the poverty rates published by the National Institute of Statistics of Rwanda. Underlying the paper's conclusions is a detailed theoretical and analytical framework for making poverty comparisons over time. Furthermore, the paper shows that after adjusting for spatial and temporal price differences, the poverty rate based on the international poverty line of $1.90 per day per capita shows that there was a reduction in poverty between 2010/11 and 2013/14.

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Revisiting the Poverty Trend in Rwanda: 2010/11 to 2013/14

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I. Introduction

Since 2000/01, the NISR (National Institute of Statistics of Rwanda) has conducted five rounds of the Integrated Household Living Conditions Surveys (EICV surveys), with which the poverty trend has been monitored officially. The poverty estimation methodology used in the first three rounds of EICV (EICV1, EICV2, and EICV3) was modified when estimating poverty rates for the fourth round of the survey, EICV4 (see NISR 2015 for details). Due to the methodological change, there has been a debate around the poverty trend between EICV3 and EICV4.

According to the NISR statistics published in 2015, the incidence of poverty declined between EICV3 (2010/11) and EICV4 (2013/14). That said, some researchers, like Reyntjens (2015), argue against it, claiming that poverty had been stagnant or even increased during this period. NISR reviewed these claims and published a detailed report in the following year, NISR (2016), whereby the declining poverty trend was corroborated using global best practices. Nevertheless, the debate continued, and unfounded claims about stagnation in poverty were published in online blogposts and media websites, creating confusion and muddying the primary purpose of welfare estimation and poverty monitoring, limiting timely and relevant policy making. This paper is an attempt to provide theoretical and empirical evidence to help take the next steps in resolving this ongoing debate.

To do this, we first describe the official poverty estimation methodology used in EICV3 and EICV4 in section II. Section III examines the comparability of these estimates using a detailed theoretical framework, which provides the 'necessary' conditions for making robust poverty comparisons over time. Applying the framework to EICV data shows a decline in poverty based on the international poverty line. Section IV discusses the poverty trend based on the international poverty line of $1.90 per day per capita. Section V discusses the importance of the various price indices used to arrive at comparable poverty estimates, and section VI revisits the debate on the poverty trend. Section VII concludes.

II. Official poverty estimation methodology in Rwanda

Poverty measurement essentially hinges on two main decisions; (i) choosing a *welfare indicator*, and (ii) setting a *poverty line*, which is the minimum value of the welfare indicator that households (or individuals) must have to fulfill their basic food and non-food needs. In most developing countries monetary poverty is measured using absolute poverty lines, which are based on a fixed welfare standard. To make welfare comparisons over time, these poverty lines are updated using price data such that they represent the *same* purchasing power year after year (Ravallion 1998).

II.1. The Welfare Indicator

Welfare indicators are either based on income or consumption.[2] In Rwanda, as in most developing countries, the welfare indicator is based on aggregate consumption expenditure obtained from EICV surveys. The

[2] In most developing countries, consumption expenditure is used as a proxy for income, since income is difficult to measure due to the size of the informal economy, large agricultural sectors and seasonality in the measurement of income (see http://siteresources.worldbank.org/INTPRS1/Resources/383606-1205334112622/5467_chap1.pdf).

consumption aggregate has three main components: (i) The Aggregate Nominal Consumption Expenditure: which includes all food and non-food expenditures of the household converted into the same time unit, for instance annual, monthly or weekly expenditures, (ii) The Cost of Living Index (COLI): a price index used to adjust for the cost of living differences across space and time, and (iii) The Equivalence Scale: to adjust for differences in the size and age composition of households.

- Aggregate Nominal Consumption Expenditure

The consumption aggregate includes all food and non-food expenditures that are incurred on a recurrent basis, converted to annual expenditures. NISR elicits both cash and in-kind expenditures for food items directly purchased in the market, self-produced and consumed, received as wages or salaries, or received as gifts or assistance. The monetary value of all these expenditures is converted to a common time unit (year) and then aggregated to arrive at total consumption expenditure. Prior to aggregation, outliers in consumption are removed using region-level mean and standard deviation. In that, all observations that are 3.5-standard deviations above the mean are considered outliers and are replaced by the 'mean' value. These 'adjusted' values are then used to arrive at final annual consumption expenditure (NISR 2015).

The key non-food items included in the consumption aggregate include expenditures on clothing, footwear, housing, education, health, fuel, utilities, transport, recreation, and communication. Payments received by employees in kind and subsidized housing benefits are also included. Another important component of non-food expenditures is house rent, where the actual rent for renters and self-reported rent for owners is included. Lastly, estimated consumption flows derived from durable goods (based on their current value and rate of depreciation) is added to the consumption aggregate (NISR 2015).

- Cost of Living Index

As the cost of basic food and non-food needs varies across regions within a country, the aggregate nominal expenditure needs to be adjusted for spatial price differences. Moreover, temporal price adjustments need to be done to account for seasonality of consumption and price variation within survey months. A common way to do this is to construct a cost of living index (COLI). COLI is a numeric factor which describes price deviations over the survey period across regions from national average prices of a 'selected' basket of goods as recorded in the 'base month'. NISR uses January as the base month for welfare estimation, thus EICV3 adjusts all expenditures to January 2001 prices, and EICV4 uses January 2014 prices as reference.

The Rwandan COLI can best be described as a poor's price index. This means that the index is based on a selected 'basket' of food and non-food items according to their relative weight in the budget share of the poorest households.[3] To adjust the nominal consumption aggregate in EICV3, NISR uses the consumption patterns of the bottom 60 percent of the households. In EICV4, the choice is restricted to the bottom 40 percent of households. This is because the poverty headcount was estimated at 45 percent in EICV3, and being a poor price index, COLI was restricted to households strictly below the poverty threshold. The final

[3] The availability of price data throughout the survey period is also a factor in the determination of the goods that make it into the COLI basket.

basket used in the estimation of EICV4 COLI consisted of 42 food items and 84 non-food items, where the selected food items accounted for 86 percent of household consumption expenditure on food (NISR 2015).

Taking the budget shares from EICV surveys, NISR uses CPI price data to first come up with region level food and non-food indices. These indices are then aggregated at the national level using population shares of each region. Finally, the food and non-food indexes are aggregated using budget weights from the survey. The weight of the total 'food index' and the total 'non-food index' is the share of food and non-food consumption in the reference group, which in the case of EICV4 includes households in the bottom 40 percent.[4]

- Equivalence Scale

Households of different sizes and age composition have differing consumption needs. Thus, adjustments are made to the welfare aggregate to reflect the age, and sometimes the gender distribution of household members. This is also done to account for the fact that larger households may be able to purchase goods in bulk at cheaper rates to economize on the purchase of certain items, reducing their expenditure on food. Adjusting the welfare aggregate using equivalence scales can address these concerns. Rwanda uses the adult equivalence scale presented below.

Age range	Gender	
	Male	Female
Less than 1 year	0.41	0.41
1 to 3 years	0.56	0.56
4 to 6 years	0.76	0.76
7 to 9 years	0.91	0.91
10 to 12 years	0.97	1.08
13 to 15 years	0.97	1.13

Age range	Gender	
	Male	Female
16 to 19 years	1.02	1.05
20 to 39 years	1.00	1.00
40 to 49 years	0.95	0.95
50 to 59 years	0.90	0.90
60 to 69 years	0.80	0.80
More than 70 years	0.70	0.70

The final welfare aggregate used for poverty measurement in Rwanda is thus the *spatially and temporally adjusted annual per-adult equivalent consumption expenditure at January prices.*

II.2. The Poverty Line

A monetary poverty line expresses peoples' basic needs in monetary terms, allowing to track the number of households (or individuals) that are not able to attain a minimum acceptable standard of well-being within the country. Rwanda uses an absolute poverty line, which is best thought of as one that is fixed in terms of living standards and fixed over the entire domain of the poverty comparisons (Ravallion 1998). There are three key decisions involved in setting a poverty line: (i) the choice of the reference group; which provides the basket of food and non-food items deemed necessary to escape poverty, (ii) a normative

[4] Data from EICV4 show that the bottom 40 percent spend almost 70 percent of their budget on food. The resulting COLI therefore gives a weight of 0.7 to the food index and 0.3 to the non-food index (NISR 2015). Ultimately, this has two implications. First, the overall index should display a similar spatial and temporal pattern as the 'COLI food index'. Second, because a higher proportion of households in the bottom 40 percent are rural households, COLI also closely imitates the country's rural price index.

welfare standard widely accepted to ensure a minimum standard of well-being, and (iii) the estimation methodology.

- The Reference Group

The 'reference group' represents a group of households whose expenditure patterns provide an adequate description of what is required to *escape* poverty in the given country context. Thus, it typically includes households that are neither among the poorest nor the wealthiest in a country, ideally reflecting the needs of those who are 'around' the existing poverty level. One way to ensure this is to select from among households in the lower 'middle' of the distribution of expenditure. In practice, this implies excluding households in the bottom decile and sometimes the bottom quintile of the expenditure distribution. Similarly, it is not recommended in practice to include households that are much above the median expenditure level. That said, the choice of a reference group is ultimately subjective and relies heavily on the subjective notions of poverty in the country.

In Rwanda, the 2001 poverty line was based on the expenditure patterns of households in the bottom three quintiles of the distribution of consumption expenditure. This was done because poverty headcount in 2001 was between 60-65 percent. Similarly, in 2014 NISR used households in the bottom two quintiles as the reference group—as the poverty rate from the last available survey at the time (EICV3) was around 45 percent.

Including the bottom decile or sometimes the bottom quintile in the reference group is tricky as the tail has a lot more noise than the lower middle of the distribution. As mentioned earlier, it is best to choose a reference group that is around the poverty line, reducing sensitivity to measurement error in extreme values.

- The Normative Standard – a Caloric Threshold

Absolute poverty lines supplement the consumption basket of the chosen reference group with a normative standard of well-being. The use of an externally established minimum standard of well-being helps to anchor the poverty line such that it becomes consistent with the country's subjective standards of consumption adequacy. These standards are typically based on thresholds of nutritional adequacy provided by the Food and Agriculture Organization (FAO), and defined in terms of the minimum daily caloric intake of an individual.

The relevant FAO standard for a country like Rwanda, for example, is about 2,100-2,500 calories per adult equivalent per day. In the estimation of the 2001 poverty line, Rwanda uses a caloric threshold of 2,500 calories per adult equivalent per day which is at the higher end of the regional established minimum (NISR 2015). Ultimately, the decision to choose the final standard is the country's decision, and despite the 2,500 calorie standard being more aspirational than the usual minimum for the region, Rwanda decided to keep the caloric threshold unchanged from the one used previously. The final 2014 poverty line is therefore based on a caloric threshold of 2,500 calories per adult equivalent per day.

- The Estimation Methodology: Cost of Basic Needs (CBN) method

The CBN method defines a poverty line as the cost of a basket of goods deemed to be sufficient for satisfying the basic food and non-food needs of the 'reference' population. It first determines the cost of basic food needs, aligns them to the normative minimum standard of well-being, and then adds a provision for basic non-food needs. This method is in most common use in a majority of the developing countries, and the application of CBN to EICV4 to arrive at the 2014 poverty line in Rwanda is detailed below.

The food component

The food component of the poverty line is almost universally anchored to nutritional requirements for good health, as established by the Food and Agriculture Organization (FAO). This does not necessarily generate a unique monetary poverty line, since many bundles of food goods can potentially yield the same nutrition. In practice, a diet is chosen which accords with 'prevailing' consumption patterns of a certain reference group considered to be appropriate in defining poverty. Ravallion (1998) asserts that the idea of respecting consumer choice in the definition of a poverty line is extremely important to arrive at a more objective and relatable poverty measure. Early attempts to determine the minimum cost of achieving the basic-needs vector at given prices ignored preferences. In that case, the resulting poverty lines can sometimes be so alien to consumer behavior that their relevance as a basis for policy becomes doubtful. Instead, current practices aim to anchor the choice more firmly to existing demand behavior. Among the (infinite number of) consumption vectors that could yield any given set of basic needs, a vector is chosen which is consistent with choices ***actually made*** by some relevant reference group. Poverty is then measured by comparing actual expenditures to the CBN. A person is not deemed poor who consumes less food (say) than the stipulated basic needs but could consume it on rearranging her budget allocation. This helps in avoiding any possible disagreements that might arise when choosing the basket more normatively (Ravallion 1998).

Rwanda uses a semi-normative approach to compute the food component of the poverty line. For the poverty line based on EICV4 data, the estimation is done in three steps. In the first step, focusing on the consumption patterns of the reference group (bottom 40 percent), quantities consumed for all items are backed out using survey reported prices and total expenditure. These quantities are then converted to a common unit, quantities in kilograms—consumed per adult equivalent per day. Using the standard FAO calorie table, these quantities are then converted to calories consumed per adult equivalent per day to obtain the average calorie consumption in the reference group. This equates to 1,335 calories per adult equivalent per day, which corresponds to an average total quantity of 1 kilogram of uncooked food per adult equivalent per day (NISR 2015).

In the second step, NISR studies the resulting food basket, as determined by the actual consumption patterns of the reference group and finds that the basket is dominated by low calorie food items (sweet potatoes, Irish potatoes and cassava root), very little cereals, and some items that are not necessarily of relevance to the poor. This is where the normative part of the approach comes in. In a 'revealed preference' approach, the reference group's food basket is taken as given and is converted to calories and then scaled up to arrive at the final food poverty line. In this case, any changes to the food poverty line can only come from changing the choice of the reference group or the caloric threshold. Once the reference group is fixed, the quantities of each item in the food basket are taken as is. In contrast, NISR takes a more normative approach and

adjusts the quantities in the reference food basket to make it more relevant to what the poor are more likely to consume. First, they exclude some items that are not of relevance to the poor. Second, they exclude items for which calorie contents or unit prices are harder to obtain. Third, they remove items that contribute very little to the overall food basket; all items with less than 0.1 percent share in the total weight (in kilograms) of the basket are excluded. These adjustments result in a final basket of 42 food items, that account for 88 percent of the original basket weight composition and provide 1,206 kcal per adult equivalent per day (see NISR 2015 for a detailed justification of the adopted approach).

In the third step, the average caloric intake (and in turn item-quantities represented by the semi-normative 'reference' basket) is scaled up to the minimum caloric threshold of 2,500 Kcal per adult equivalent per day. This is done by multiplying the quantities in the basket with a factor of 2.07 (2500/1206). Note that if the 'reference' basket was directly derived from the reference group, the scale factor would have been 1.87 (2500/1335).

In the fourth step, all retained food items are grouped into 10 meta food categories, namely, cereals and products, eggs, fish, fruits and products, meat, milk and cheese, pulses, roots and tubers, tree nuts/oil crops, and vegetables. In the last step, to arrive at the 'minimum' cost of obtaining the 'defined' basket, higher cost per calorie items are replaced by lower cost per calorie items in their respective meta food category. The final basket mainly consists of roots, tubers and products (basically sweet potatoes, cassava and its products); these together make up 52 percent of the food basket. In addition, beans are included as the main source of proteins, with certain weight given to fish and meats (NISR 2015).

To arrive at the final food component of the poverty line, the basket is then costed using survey reported January 2014 prices. This gives a food poverty line (FPL) of RWF 105,064 per adult equivalent per year (around RWF 288 per adult equivalent per day) in January 2014 prices.

The non-food component

The next step is to account for non-food basic needs. In theory, the provision for non-food needs is guided by the expenditure patterns of households for which the average food expenditure is equal to the food poverty line. In practice, the non-food component of the poverty line is indirectly estimated by taking the food budget share, s_f, of households whose food expenditure is 'close' to the food poverty line and scaling up the FPL by this food budget share (Ravallion and Bidani 1994).

For the 2014 poverty line, s_f was estimated using the median food expenditure of all households whose food consumption was within 10 percent (plus or minus) of the food poverty line. This provided a food share of 0.66, and a total poverty line of RWF 159,375 per person per year in January 2014 prices.[5]

[5] Note that the allowance for non-food goods is completely consistent with demand behavior and is focused at (or in a region around) the food poverty line. No normative assumptions are made in terms of what is required for satisfying basic non-food needs. This is different from the food component of the poverty line in two ways, which (i) uses a more normative approach in defining the final food basket; and (ii) includes the consumption patterns of the poorest households in picking up the initial reference basket.

III. Poverty Trends

III.1. Poverty headcount rates at a point in time

- The 2001 poverty line

In Rwanda, the 2001 poverty line was defined using data from EICV1, with a reference group including the bottom three deciles of the expenditure distribution. The COLI used to spatially and temporally deflate the consumption aggregate also used the consumption patterns of the bottom 60 percent. This generated a poverty threshold of RWF 64,000 in January 2001 prices, yielding a poverty headcount rate of 58.9 percent.

For two subsequent surveys, EICV2 (2005/06) and EICV3 (2010/11), poverty was estimated using the 2001 poverty line derived from EICV1, after deflating the nominal consumption expenditure in EICV2 and EICV3 to January 2001 prices and comparing them to the poverty threshold of RWF 64,000 per adult equivalent per year. Thus mathematically, poor households in EICV3 for instance were identified using the following inequality:

$$\frac{e_{im10/11}}{\pi_{J2001}^{rm10/11}} < 64{,}000 \qquad (1)$$

where $e_{im10/11}$ denotes nominal consumption expenditure per adult equivalent of household i in month m of EICV3, and $\pi_{J2001}^{rm10/11}$ is the price index used to deflate nominal consumption expenditure from EICV3 survey months to January 2001 prices (see NISR, 2012). This method yielded a poverty rate of 44.9 percent in 2010/11. Going forward, the government decided to update the poverty line. This was done using EICV4 data.

- The 2014 poverty line

Typically, rapidly changing consumption patterns in a globalized world, combined with improvements in social and economic indicators of well-being warrant a periodic update of the monetary threshold established to evaluate changes in welfare. This is particularly true for developing countries, where the 'relevance' of a poverty threshold tends to erode with increasing access to markets, new product varieties and overall economic growth. This was also true in the case of Rwanda, where significant changes in the socio-economic structure of the country as measured by EICV4, necessitated an update of the poverty line.

In Rwanda, changes in consumption patterns between 2000-2014 were primarily reflected through a reduction in the share of food consumed by the poorest households (Engel's law), decreases in household size (reflected in reduced fertility rates and falling dependency ratios), increases in asset ownership (ownership of more expensive assets like televisions and mobile phones increased in the bottom quintile), and improvements in child and maternal health (reduced stunting, wasting, infant and maternal mortality).[6] In addition, per capita GDP growth remained positive, and education and labor market outcomes also improved over time. All these changes that were reflected in the consumption patterns captured by EICV4 needed to be incorporated in a poverty measure intended for evidence-based policy making going forward.

[6] See Rwanda Poverty Profile Report (2015).

Thus, a new poverty line was estimated based on the poverty estimation methodology outlined in Section II.

As mentioned earlier, the new poverty line was set at RWF 159,375 per adult equivalent per year in January 2014 prices, and poor households in 2013/14 were identified using the following inequality:

$$\frac{e_{im13/14}}{\pi_{J2014}^{rm13/14}} < 159{,}375 \qquad (2)$$

where $e_{im13/14}$ denotes nominal consumption expenditure per adult equivalent in EICV4, and $\pi_{J2014}^{rm13/14}$ is the price index (COLI) used to deflate nominal consumption expenditure within EICV4 to January 2014 prices. This yielded a poverty rate of 39.1 percent in January 2014 (see NISR 2015).

III.2. Comparability of poverty rates over time

Welfare comparisons based on absolute poverty lines are only valid if the poverty lines represent the 'same purchasing power' over time. This can be accomplished by adjusting a 'given' poverty line and welfare aggregate for changes in prices/purchasing power, and then comparing them against each other to arrive at poverty headcount rates.

III.2.1 Theoretical framework

Theoretically then, poverty rates estimated from household surveys conducted at two different points in time are comparable when both the welfare aggregate and the poverty threshold from these time periods are appropriately adjusted for price variations between the two survey rounds. The following is an illustration of how the expenditure data and poverty lines need to be updated for robust poverty comparisons over time.

- Estimation of poverty rates in round t_0:

Suppose we start with a poverty line ($z_{m_0t_0}$) that is estimated using a household survey conducted in year t_0, and is adjusted to prices in month m_0 of the same year (t_0). Similarly, the consumption aggregate from year t_0 is expressed in terms of month m_0 of year t_0 prices. Then the poor in t_0 are simply identified by:

$$\frac{e_{imt_0}}{\pi_{m_0t_0}^{rmt_0}} < z_{m_0t_0} \quad (3)$$

Where e_{imt_0} is household i's nominal consumption expenditure per adult equivalent in month m of year t_0, $\pi_{m_0t_0}^{rmt_1}$ is the inflation rate derived from a region-specific COLI valued in terms of month m_0 of year t_0 prices, and $z_{m_0t_0}$ is the poverty line, also valued in terms of month m_0 of year t_0 prices.[7]

[7] The theoretical example mentions the per adult equivalent consumption expenditure and region-specific cost-of-living index normalized to a certain month to reflect the Rwanda case more closely.

- Estimation of comparable poverty rates in round t_1:

In the next period, say t_1, household i's nominal consumption expenditure per adult equivalent (e_{imt_1}) is collected in month m of year t_1. To estimate a poverty rate in year t_1 that is comparable to the poverty rate based on the poverty line set in year t_0, the welfare aggregate from year t_1 has to be adjusted to the same base as the poverty line, i.e., m_0t_0. This means that household expenditure from t_1 must be adjusted using an inflation rate derived from a region-specific COLI $\{\pi_{m_0t_0}^{rmt_1}\}$ with m_0t_0 as the base. Poor households at time t_1 can then be identified using the following inequality:

$$\frac{e_{imt_1}}{\pi_{m_0t_0}^{rmt_1}} < z_{m_0t_0} \quad (4)$$

Now, the poverty rate derived from eq (4) is comparable to the one derived from eq (3).

- Estimation of comparable poverty rates in round t_2:

Similarly, to obtain a comparable poverty headcount rate for a subsequent round of the household survey, say year t_2, nominal household expenditure per adult equivalent in year t_2 (e_{imt_2}) has to be adjusted by the inflation rate derived from a region-specific COLI $\{\pi_{m_0t_0}^{rmt_2}\}$ that can be used to express year $t_2's$ expenditures in terms of month m_0 of year t_0 prices. Then, poor households in year t_2 can be identified using the following inequality:

$$\frac{e_{imt_2}}{\pi_{m_0t_0}^{rmt_2}} < z_{m_0t_0} \quad (5)$$

Proposition 1. Comparability of poverty headcount rates estimated from inequalities (4) and (5). *Poverty rates estimated from inequalities (4) and (5) are comparable if and only if (i) the welfare aggregates in survey rounds t_1 and t_2, i.e., e_{imt_1} and e_{imt_2}, are constructed the same way, and (ii) the COLIs used to derive the respective inflation rates ($\pi_{m_0t_0}^{rmt_1}$ and $\pi_{m_0t_0}^{rmt_2}$) are constructed using the same methodology in both rounds. Condition (ii) requires that the price data and the item weights used to construct the two indices are the same.*

Proposition 1 is a necessary condition for the comparability of poverty estimates derived from inequalities (4) and (5). This is because these inequalities use a poverty line evaluated at month m_0 of year t_0 prices ($z_{m_0t_0}$), compared against household expenditures from future time periods (t_1 and t_2) that are also expressed in terms of month m_0 of year t_0 prices.[8] However, if the inequalities (4) and (5) use poverty lines expressed in terms of different time periods, Proposition 1 cannot be used to evaluate the comparability of poverty rates. Using the previous example for instance, if poverty rates at time t_2 are estimated from the following inequality:

[8] We use this proposition to evaluate the comparability of poverty rates in NISR (2016) where the same poverty lines are used for estimating poverty rates of EICV3 and EICV4.

$$\frac{e_{imt_2}}{\pi_{m_0t_2}^{rmt_2}} < z_{m_0t_2} \quad (5')$$

, then Proposition 1 cannot be used to test the comparability of poverty rates estimated from inequalities (4) and (5′) because the poverty line used in inequality (5′) is different from that of inequality (4). This limits the usefulness of Proposition 1 because most countries including NISR (2015) use different poverty lines when estimating poverty rates for different rounds of household surveys. For example, NISR (2015) uses a poverty line of RWF 64,000 (January 2001 prices) when estimating poverty rates in EICV3 and a poverty line of RWF 159,375 (January 2014 prices) when estimating poverty rates in EICV4. To examine the comparability of poverty rates estimated with different poverty lines for different rounds of household surveys, we need to modify Proposition 1.

What are the circumstances under which poverty rates estimated from inequality (5′) are comparable to those derived from inequality (4)? To answer this question, we first identify the conditions where inequality (5′) can produce the same poverty rates as inequality (5), and combine these conditions to the ones needed for the comparability of poverty estimates derived from inequalities (4) and (5).

By comparing inequalities (5) and (5′), it is straightforward to show that poverty rates from inequality (5′) are the same as those of inequality (5) if the following conditions are satisfied:

$$\pi_{m_0t_0}^{rmt_2} = \pi_{m_0t_0}^{m_0t_2} * \pi_{m_0t_2}^{rmt_2} \qquad (5.1)$$

and

$$z_{m_0t_0} * \pi_{m_0t_0}^{m_0t_2} = z_{m_0t_2} \qquad (5.2)$$

where $\pi_{m_0t_0}^{m_0t_2}$ is the inflation factor (1+inflation rate) between month m_0 of year t_0 and month m_0 of year t_2.

Since poverty rates from inequalities (5) and (4) are comparable only if the conditions in Proposition 1 are satisfied, poverty rates from inequalities (5′) and (4) are comparable only if both the conditions in Proposition 1 and the above equalities are satisfied. This is summarized in Proposition 2.

Proposition 2. Comparability of poverty headcount rates estimated from two rounds of household surveys.

Poverty rates estimated from two rounds of the household surveys—inequalities (4) *and* (5′)*–are comparable if and only if the following three conditions are satisfied:*

- *(i)* *Household expenditures in the two rounds are constructed in the same way;*
- *(ii)* *COLIs in both rounds use the same budget weights and source price data, and satisfy condition* (5.1)*;and*
- *(iii)* *Poverty lines satisfy condition* (5.2).

Since Proposition 2 shows a necessary condition under which poverty rates estimated from inequalities based on different poverty lines are comparable, it can be used to evaluate the comparability of poverty rates estimated in NISR (2015).

III.2.2 Comparability of the official poverty trend between EICV3 and EICV4

Here we explore the comparability of the poverty rates estimated in NISR (2015). The three conditions of proposition 2 need to be satisfied. Since both EICV3 and EICV4 use the same approach for constructing nominal household expenditures and adopt the same adult equivalent scale, condition (i) holds. Condition (ii) – comparability of COLIs – and condition (iii) – the update of poverty lines, however, *may not* hold.

In the case of condition (ii), there are three main differences. First, the base months to which the two COLIs are normalized are different. For EICV3, the food COLI uses January 2001 as the base month, while EICV4 uses January 2014 as the base month.[9] Second, the weights of the COLIs differ. For EICV3, the weights for the food COLI are derived from EICV1 (2001) data, while those of the nonfood COLI come from EICV3 data. In contrast, for EICV4, the weights of both food and nonfood COLIs are derived from EICV4 data. Third, the price data used for constructing the COLIs are different. For EICV3, NISR (2015) uses MINAGRI data to estimate the food COLI, and the official CPI data to estimate the non-food COLI. For EICV4, NISR (2015) uses CPI price data for both food and non-food COLIs. It is therefore difficult to guarantee that condition (ii) is satisfied.

As for (iii), the poverty line used for estimating poverty rates in EICV3 is based on EICV1 data and valued at January 2001 prices (RWF 64,000), while the poverty line used for estimating poverty rates in EICV4 is based on EICV4 data and valued at January 2014 prices (RWF 159,375). Thus, condition (iii) will hold if the two poverty lines satisfy the following equation:

$$64{,}000 * \pi_{J2001}^{J2014} = 159{,}375 \quad (5.2')$$

To check whether this is the case, we need an estimate of the inflation rate between January 2001 and January 2014, i.e. π_{J2001}^{J2014}. This is not directly available from the data. We therefore split this into two components; the inflation rate between January 2001 and January 2011 and the inflation rate between January 2011 and January 2014, i.e.

$$\pi_{J2001}^{J2014} = \pi_{J2001}^{J2011} * \pi_{J2011}^{J2014}$$

There are two sources of data available for each of these inflation rates. In the case of π_{J2001}^{J2011}, we can either use the COLI estimated in NISR (2015) or the WDI (World Development Indicators) 2018 data. In case of the former, we take a population weighted average of the COLIs across all regions for January 2011, and approximate $\pi_{J2001}^{J2011} = \{\pi_{J2001}^{rJ2011}\}_{r=1}^{5}$. Using EICV3 data, this comes out to be 2.05 (see Appendix table A1). Interestingly, this number is the same as the inflation rate from WDI.

[9] Strictly speaking, the non-food COLI for EICV3 is first estimated for January 2011 as the base month and then adjusted to January 2001 as the base month when aggregating it with the food COLI (NISR 2012).

We then estimate the inflation rate between January 2011 and January 2014 in two ways. From the CPI data, $\pi_{J2011}^{J2014} = 1.23$. According to NISR (2016), $\pi_{J2011}^{J2014} = 1.047$. [10] If we substitute these inflation rates into $(5.2')$, using approximation (6), the poverty line of January 2014 can either be:

$$64{,}000 * \pi_{J2001}^{J2011} * \pi_{J2011}^{J2014} = 64{,}000 * 2.05 * 1.23 = 161{,}376 \qquad (6)$$

OR

$$64{,}000 * \pi_{J2001}^{J2011} * \pi_{J2011}^{J2014} = 64{,}000 * 2.05 * 1.047 = 137{,}366 \qquad (6')$$

In the case of (6), headcount poverty in EICV4 is estimated at 40 percent, and based on $(6')$, the poverty rate is 30 percent.

Note that the re-estimated official poverty line of January 2014 (RWF 159,375) is closer to the poverty line estimated in (6). Thus, the analysis shows that the 2014 poverty line reflects the inflation rate between January 2001 and January 2014 reasonably well if it is estimated based on CPI data between January 2011 and January 2014, and COLIs of NISR (2015) between January 2001 and January 2011.

In summary, the methodology used in NISR (2015) satisfies conditions (i) and, to a lesser extent, (iii), but there is not enough evidence to guarantee it satisfies condition (ii); and therefore, we cannot guarantee that poverty rates of EICV3 and EICV4 as reported in NISR (2015) are comparable.

III.2.3 Evaluating the comparability of poverty rates of EICV3 and EICV4 in NISR (2016)

The previous section shows that we do not have enough evidence to guarantee the comparability of the poverty rates in NISR (2015). Thus, we go on to examine whether the official poverty rates presented in NISR (2016) are comparable. NISR (2016) estimates poverty rates using the following inequalities:

For EICV3 (2010/11) data:

$$\frac{e_{imEICV3}}{\pi_{J2014}^{rmEICV3}} < 159{,}375 \qquad (7)$$

For EICV4 (2013/14) data:

$$\frac{e_{imEICV4}}{\pi_{J2014}^{rmEICV4}} < 159{,}375 \qquad (8)$$

[10] π_{J2011}^{J2014} based on survey data is not directly available. We therefore estimate it using the following equality $\pi_{J2011}^{J2014} = \pi_{J2011}^{J2011}/\pi_{J2014}^{J2011}$. To estimate the denominator, we use a population weighted average of 5 regional monthly price indices, i.e. $\pi_{J2014}^{J2011} \approx \{\pi_{J2014}^{J2011}\}_{r=1}^{5}$, which equates to 0.955. As $\pi_{J2011}^{J2011} = 1$, π_{J2011}^{J2014} = 1/0.955 = 1.0471.

Note that since inequalities (7) and (8) use the same poverty line, we can use Proposition 1 to test the comparability of poverty rates derived from them. Indeed, inequalities (7) and (8) satisfy the conditions of Proposition 1. First, the NISR (2016) approach is based on nominal household expenditure, which is constructed the same way in EICV3 and EICV4. Second, the COLI used for deflating consumption expenditure in EICV3 ($\pi_{J2014}^{rmEICV3}$) is fully consistent with the index used for deflating consumption expenditure in EICV4 ($\pi_{J2014}^{rmEICV4}$), i.e., the base month, the source price data, and the budget weights for the two indices are the same. Therefore, poverty rates estimated from inequalities (7) and (8) satisfy the necessary conditions of comparability, corroborating that the official poverty trend, where headcount poverty declined from 46 percent to 39 percent between EICV3 and EICV4, is credible.

III.3. Establishing robustness of the declining poverty trend

To substantiate the credibility of the poverty trend based on the NISR (2016) approach, they conducted further analysis using a survey-to-survey imputation method (S2S). When consumption data from two rounds of a household survey are deemed non-comparable, the survey-to-survey imputation approach, as in Christiaensen et al. (2012), is often used to restore the comparability of consumption data and poverty rates. The methodology creates consumption models in a household survey where both consumption and non-consumption data are reliable, and then imputes household consumption expenditures using the models in a different survey where only non-consumption data are reliable. The consumption models use household and individual characteristics such as educational attainment and employment status of household members, household composition and the like. This S2S approach is useful if price adjustments or poverty lines are not comparable over time, but non-consumption data are comparable. Given some key assumptions are satisfied, Christiansen et al. (2012) and Ahmed et al. (2013) corroborate the reliability of this approach using data from various countries.

NISR (2016) estimates a poverty trend between 2010/11 and 2013/14 using the S2S approach and compares it with the official poverty trend between 2010/11 and 2013/14 in NISR (2015). Following Tarozzi (2002), NISR (2016) estimates a logistic regression model to predict the probability of being poor from non-consumption data using EICV4, predicts a poverty rate from a model using EICV4, and applies it to non-consumption data in EICV3. Using this approach, they find that the poverty rate of EICV3 is 44.6 percent, which is almost the same as the official poverty estimate for EICV3, i.e., 44.9 percent. NISR (2016) also estimates the poverty rate of EICV4 using this approach (39.0 percent), which is almost identical to the official estimate of EICV4 (39.1 percent). The S2S analysis, therefore, also confirms that the official trend is reliable.

In Rwanda, the reduction in food budget shares over time also corroborates the poverty decline. Typically, increases in income are strongly associated with a declining share of the budget spent on food (Engel's law). We examine if this is true in the case of Rwanda. We estimate real food budget shares, expressed in January 2014 prices, for 2010/11 and 2013/14 and find that the real food share declines from 64 percent in EICV3 to 61 percent in EICV4. We also find that these differences are statistically significant.[11]

[11] The real food budget share is estimated by deflating food expenditures (numerator) with an inflation rate calculated from the food CPI and total expenditures (denominator) with an inflation rate calculated from the overall CPI.

III.4. Which approach is better, NISR (2015) or NISR (2016)?

Both NISR (2015) and NISR (2016) produce a similar poverty trend (and more or less similar rates). But NISR's (2016) approach is the one that produces comparable poverty estimates, using a common poverty line and a consistent COLI, one which uses the same budget weights, source data on prices, and base month.

IV. Poverty trend based on International Poverty Lines

Rwanda's poverty rates measured at the $1.90 poverty line are 60.3 percent in EICV3 and 60.4 percent in EICV4 (Povcalnet as of March 2018). In contrast, Rwanda's official poverty rate declined from 46 percent to 39 percent between the two surveys. This section explores the reasons behind these differences.

As mentioned earlier, poverty measurement typically hinges on the estimation of a nominal welfare aggregate, adjustment for spatial and temporal price differences, further adjusted for household composition differences. When comparing national and international poverty measurement, we find that both estimates are based on the same nominal consumption expenditure. Thus, any differences in national and international poverty trend are driven by differences in the price index used for spatial and temporal deflation, and the adjustments made for household age and size composition. In the case of Rwanda, we find three key differences in the latter two adjustments.

First, the international measure uses household expenditure per capita while the national measure uses household expenditure per adult equivalent. Second, the international poverty measure uses an average inflation rate for each of the EICV surveys and deflates household expenditure with this average inflation rate derived from survey-weighted monthly CPIs. In contrast, the national poverty measure first deflates household expenditure by a price index that adjusts for spatial and monthly price variations *within* a survey year, and then adjusts for inflation *between* survey years. Third, the two aggregates are deflated to different base periods. The international measure uses 2011 as the base period while NISR (2016) uses January 2014 as the base period.

IV.1. Estimating international poverty rates for Rwanda using the World Bank's methodology

To estimate the international poverty rates, we first convert the $1.90 per day per capita line to an annual per capita poverty line expressed in local currency units (LCUs), and then compare it to a welfare aggregate also expressed in annual per capita terms.

We do this by first expressing the international poverty line (IPL) in annual terms (multiplying it by 365). We then convert the annual line to local currency units (LCUs) using the 2011 Purchasing Power Parities (PPPs), and finally adjust the resulting poverty line to reflect average 2011 prices. This is done by multiplying the annual PPP adjusted line with the inflation rate between the 2011 average and the EICV survey month average. Thus, the IPL for EICV3 can be written as:

$$IPL^{LCU}_{Avg\ EICV3} = \$1.90 * 365 * 2011PPP * \pi^{Avg\ EICV3}_{Avg\ 2011} \qquad (9)$$

, where $\pi_{Avg\ 2011}^{Avg\ EICV3}$ is the inflation rate between annual average CPI of 2011 calendar months and an average CPI for the EICV3 survey months. The latter is a weighted average of monthly CPIs for EICV3 survey months, where the weights are equal to the share of households surveyed in each month. Substituting 2011 PPPs and $\pi_{Avg\ 2011}^{Avg\ EICV3}$ in (9):

$$IPL_{Avg\ EICV3}^{LCU} = 1.90 * 365 * 246.8344 * 0.99$$

Thus, poor households can be identified by the following inequality:

$$epc_{iEICV3} < IPL_{Avg\ EICV3}^{LCU} = 1.90 * 365 * 246.8344 * 0.99 = 169{,}468$$

where epc_{iEICV3} is household i's nominal consumption expenditure per capita in EICV3, and the poverty line is RWF 169,468 per capita per year. This yields a poverty rate of 60.3 percent.

Similarly, the IPL for EICV4 can be written as:

$$IPL_{Avg\ EICV4}^{LCU} = \$1.90 * 365 * PPP * \pi_{Avg\ 2011}^{Avg\ EICV4} \qquad (10)$$

, where $\pi_{Avg\ 2011}^{Avg\ EICV4}$ is an inflation rate between annual average CPI for 2011 calendar months, and an average CPI for EICV4 survey months. According to our estimates, $\pi_{Avg\ 2011}^{Avg\ EICV4}$ is equal to 1.14. Thus, poor households can be identified using the following inequality:

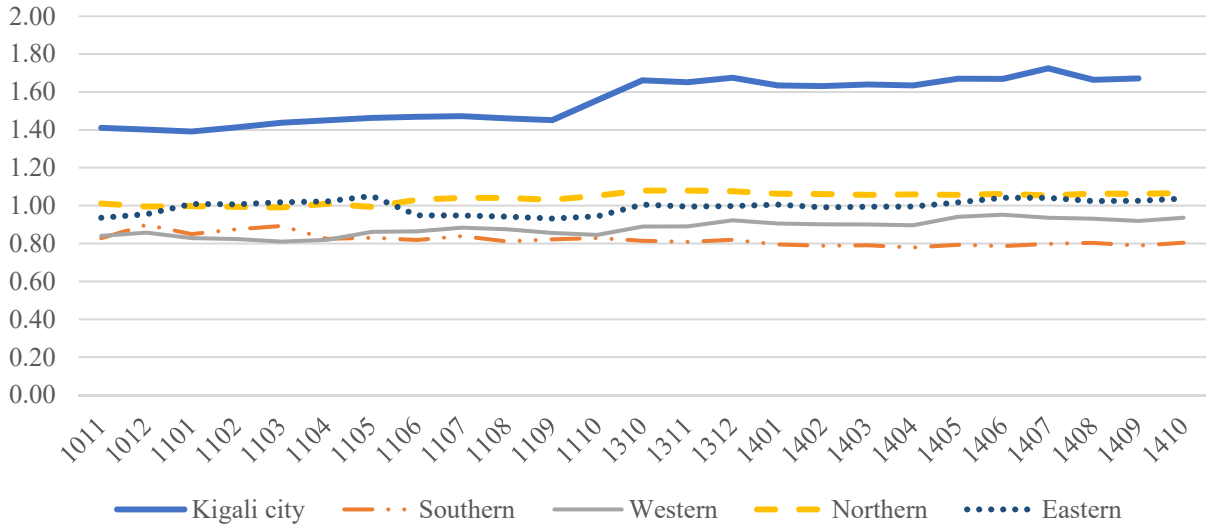
$$epc_{iEICV4} < IPL_{Avg\ EICV4}^{LCU} = 1.90 * 365 * 246.8344 * 1.14 = 195{,}145$$

where epc_{iEICV4} is household i's nominal consumption expenditure per capita in EICV4, and the poverty line is RWF 195,145 per capita per year. This yields a poverty rate of 60.4 percent.

IV.2. Adjustments for spatial and monthly price variations using NISR (2016)'s COLI

One of the major flaws of the global monitoring is that it does not adjust household expenditure to spatial and monthly price variations. In Rwanda, spatial prices and inflation rates differ largely across provinces. Figure 1 shows the trends in province level inflation rates derived from survey-based COLI. The figure shows that not only is the COLI in Kigali city much higher than in other provinces, Kigali City's COLI has been increasing at a much faster rate as compared to other regions. Thus, ignoring spatial price differences, as reflected in province level inflation rates, can cause a huge bias in poverty estimation.

Figure 1. Inflation rates based on NISR (2016) by province



To use COLIs derived in NISR (2016) to allow for spatial and temporal price adjustment in the estimation of international poverty rates, we first need to convert the IPL in local currency units (LCU) to January 2014 prices, which is the base month of the COLIs.

Recall that the NISR approach to estimating poverty trends is to update the welfare aggregate to the year in which the poverty line was set and compare the two to identify poor households. Moreover, Section III showed that the only way to get poverty estimates that are inter-temporally consistent is to use the same price indices to adjust nominal consumption expenditure and the poverty line. This is why the official estimates of national poverty in 2011 based on the EICV3 welfare aggregate expressed in January 2014 prices were being compared to the poverty line set in January 2014 prices. Following the same approach for international poverty measurement, the international PL converted in annual LCUs, expressed in January 2014 prices is given by:

$$IPL_{J2014}^{LCU} = \$1.90 * 365 * 2011PPP * \pi_{J2014}^{Avg\ 2011} \qquad (11)$$

The first three components on the RHS of eq (11)— $\$1.90 * 365 * 2011PPP$—convert the $1.90 line to annual RWF in 2011 PPPs, and the last term converts this line to January 2014 prices. We do this by first converting the 2011 line ($\$1.90 * 365 * 246.8344 = 171{,}180$) to an annual average of 2014 prices using an inflation rate between a 2011 average of monthly CPIs and that of 2014, $\pi_{Avg\ 2011}^{Avg\ 2014}$, and then converts the 2014 average line to the poverty line of January 2014 using the inflation rate between the 2014 annual average and January 2014 based on NISR (2016), $\pi_{Avg\ 2014}^{J2014}$. As a result, the IPL in January 2014 prices can be written as:

$$IPL_{J2014}^{LCU} = \$1.90 * 365 * 2011PPP * \pi_{Avg\ 2011}^{Avg\ 2014} * \pi_{Avg\ 2014}^{J2014} \qquad (11')$$

Since $\pi_{Avg\ 2011}^{Avg\ 2014} = 1.196$ and $\pi_{Avg\ 2014}^{J2014} = 1/1.09$, IPL_{J14}^{LCU} =RWF 187,827.

We now can use COLIs to adjust for spatial and monthly price variations:

The poor in EICV3 can be identified using:

$$\frac{epc_{iEICV3}}{\pi^{rmt}_{J2014}} < IPL^{LCU}_{J2014} = 187{,}827 \quad (12)$$

and the poor in EICV4 can be identified using:

$$\frac{epc_{iEICV4}}{\pi^{rmt}_{J2014}} < IPL^{LCU}_{J2014} = 187{,}827 \quad (12')$$

Inequalities (12) and (12') give a poverty rate of 62.4 percent in EICV3, and 56.9 percent in EICV4. Therefore, if spatial price variations and region level monthly inflation rates are properly controlled, the international poverty rates also show a significant reduction between EICV3 and EICV4.[12]

V. Comparison of Price Indices

The above analysis clearly shows the centrality of adequate price adjustments in poverty measurement, especially when establishing the comparability of poverty statistics over time and across space/regions. In Rwanda, two different sets of price data are potential candidates for poverty measurement – the price data used in the estimation of the official CPI, and the price index developed through household survey data, for instance the COLI in NISR (2016).

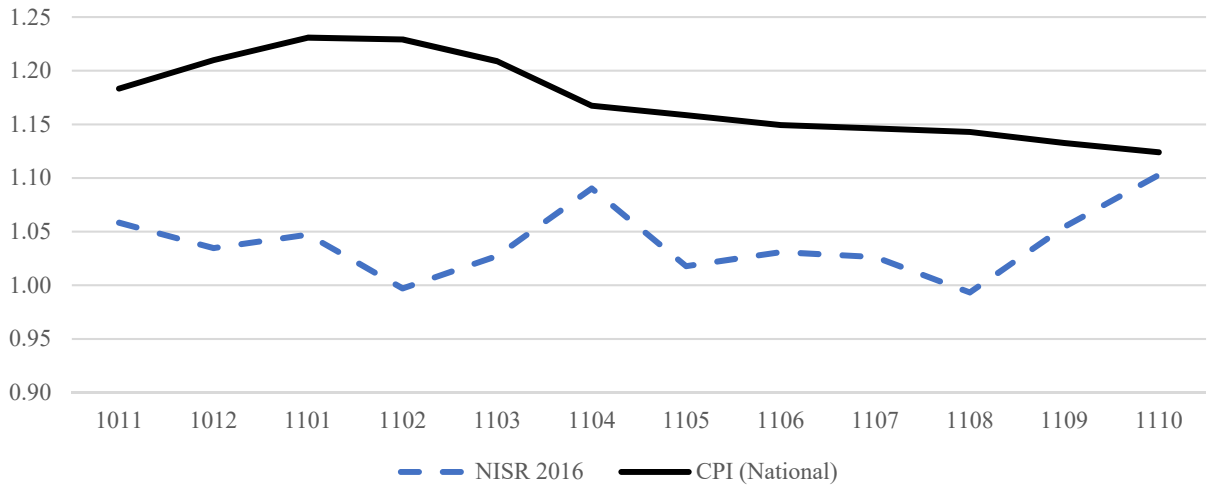
Figure 2 shows monthly inflation rates from EICV3 survey months to January 2014 for each of these price indices. The dotted line is a population weighted average of inflation rates calculated from COLI of NISR (2016) for each month from November 2010 (1011) to October 2011 (1110) while the solid line is calculated from monthly CPI (national) data. It is evident that CPI data show much higher inflation rates for almost all survey months. Below we provide some possible explanations underlying these differences.

The first major difference in CPI and COLI comes from the data sets and the reference group used to get item budget shares. A typical price index is made up of item budget weights and prices. In Rwanda, price data for the selected food items included in the NISR (2016) COLI are the same as CPI price data. The budget weights used for the two indices however, differ in two ways. First, in the year 2014, the official CPI base year was set at 2011 and CPI item weights were derived from EICV3 data. In contrast, item weights for the COLIs came from EICV4 data. Second, CPI item weights were computed using all survey households, while COLI used only the bottom 40 percent of households. Thus, both the year and the reference group used to obtain item weights for the two price indices are different.

The second major difference in CPI and COLI relates to the level of aggregation of the two indices. The CPI is estimated for national, rural and urban regions, while the COLI is estimated for 5 provinces.

[12] Inequalities (12) and (12') use a unique poverty line expressed in January 2014 prices. But as shown above, the global poverty line uses a poverty line expressed in prices of an average month of a household survey, i.e., $IPL^{LCU}_{Avg\ EICV3}$ for EICV3 survey (2010/11) and $IPL^{LCU}_{Avg\ EICV4}$ for EICV4 (2013/14). Appendix 2 shows how inequalities (12) and (12') can be modified so that (i) poverty rates do not change but (ii) $IPL^{LCU}_{Avg\ EICV3}$ and $IPL^{LCU}_{Avg\ EICV4}$ are used as the poverty line for EICV3 and EICV4, respectively.

Figure 2. Inflation rates between months in EICV3 and January 2014



The third major difference is the overall weight given to the food index and the non-food index used for the CPI and COLI calculations. Food CPI gets a weight of 44 percent in total national CPI, 53 percent in rural CPI, and 70 percent in COLI.[13] Ceteris paribus, when food inflation is higher than non-food inflation (as was the case in Rwanda), then, giving a higher weight to the food index (as in COLI) should lead to higher inflation. This however, was not the case in Rwanda; the overall CPI presents a higher inflation rate as compared to the inflation rate based on COLI. This primarily owes to the item selection for COLI. The 42 food items and 84 non-food items in COLI registered lower price increases than the full-CPI food and non-food basket, and these differences were enough to offset the effect of a higher weight on food in the estimation of COLI.

It is also important to note that COLI uses a subset of items from the CPI (126 out of 1,022 in the full CPI), which are more relevant for the poor. Thus, both the overall food and non-food inflation, as well as the item level budget shares 'for the same items' in the COLI and CPI basket can prove to be very different. This represents one the key differences between the national CPI for Rwanda and the COLI used in poverty estimation.

Lastly, it is not clear as to whether the calculation/aggregation methods used in COLI and CPI are similar.[14]

VI. Revisiting the debate on the poverty trend

Results from Rwanda's fourth Integrated Household Living Conditions Survey (the 2013/14 EICV4) were published in September 2015. It showed a continued reduction in poverty and extreme poverty between 2011 and 2014. Soon after the launch, a debate on the comparability of poverty estimates from EICV3 and EICV4 to the previous series ensued. For instance, Reyntjens (2015) questioned the comparability of poverty rates between EICV3 and EICV4 in NISR (2015) as mentioned below.

. [13] The corresponding shares are 47 and 55 percent for national and rural CPIs if the category of 'restaurants and hotels' is included.

[14] NISR states that the official CPI uses a Modified Laspeyres formula (NISR, CPI 2016).

Reyntjens (2015) stated that "we can do this by starting from the 2010/11 poverty figure of 45%, but then adapting the 2010/11 poverty line in the same proportion (-19 points) as the 2013/14 adjustment. Based on the EICV3 micro data and lowering the poverty line (of the 2013/14) by 19%, the actual poverty figure is then 33% in 2010/11. There is nothing wrong in principle with a working out a new poverty line for EICV4 – as "many changes in the socio-economic structure of the country have taken place [since the first EICV in 2000/1]" – but even if the change is accepted, the 2013/14 report should measure change in poverty using a comparable poverty figure in 2010/11, namely 33% instead of 45%." cited from Reyntjens (2015).

We now apply Propositions 1 and 2 to examine the claims made in Reyntjens (2015), asking whether the poverty rates (33 percent in EICV3 and 39 percent in EICV4) are comparable. Since Reyntjens (2015) uses a different poverty line for EICV3 and EICV4, we apply Proposition 2 for the comparability assessment.

First, condition (i) of Proposition 2 seems satisfied. Although it is not clear from the blog, we can safely assume that he uses nominal expenditure data available in EICV3 and EICV4, as released by NISR, and if so, we can say that household expenditure data are comparable. Second, condition (iii) is roughly satisfied. He discounts the poverty line of the 2013/14 by 19 percent, which is close to the inflation rate between January 2011 and January 2014 calculated from the monthly CPI published by NISR (monthly CPI provides an inflation rate of 23 percent). It is not however clear whether condition (ii) is satisfied. The problem here is that it is not clear from the blog as to what COLIs are used. If he is using the COLI of NISR (2015) for estimating poverty rates in EICV3, then the national poverty rate in 2010/11 should be close to 45 percent. If the COLI is not used and nominal expenditures are used, the national poverty rate should be close to 39.7 percent. In both cases, we cannot replicate his result. Since we cannot identify what COLIs he used, we cannot guarantee that condition (ii) is satisfied. In conclusion, we cannot confirm his poverty estimates of 33 percent for EICV3 are comparable with 39 percent for EICV4.

VII. Conclusion

This paper revisits the declining poverty trend published in NISR (2015) and NISR (2016). Findings from this analysis support the official trend published in NISR (2016). We also compare the methodology adopted by NISR (2015) and NISR (2016) and although both produce similar poverty trends, it shows several methodological advantages of the latter. Moreover, we show that poverty rates for Rwanda measured at an international poverty line, $1.90 per day per capita, also show a declining poverty trend if the international measure properly adjusts for spatial price variations across regions and temporal price variations during survey data collection. Given the significance of spatial and temporal price variations, we recommend that the international poverty statistics be updated by properly adjusting for these. Finally, this paper presents possible reasons behind the significant differences between national CPIs and NISR (2016) COLIs. It is important to continue research on these differences to establish a common understanding and agreement on the price index deemed most appropriate for poverty monitoring over time.

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Appendix 1.

Table A1: Price index in EICV3 with January 2001 prices as reference

Survey month-year	Index
Oct-10	2.0545
Nov-10	2.1798
Dec-10	2.1249
Jan-11	2.0539
Feb-11	2.0895
Mar-11	2.1914
Apr-11	2.3314
May-11	2.4584
Jun-11	2.4311
Jul-11	2.4292
Aug-11	2.4563
Sep-11	2.4160
Oct-11	2.4438
Average of 2010 months	2.1504
Average of 2011 months	2.3272
Average of EICV3	2.2901

Source: NISR data

Appendix 2.

As discussed before, the poverty rates measured at the international poverty line of $1.90 per day per capita should be estimated by the following inequalities:

The poor in EICV3 can be identified using:

$$\frac{epc_{iEICV3}}{\pi_{J2014}^{rmt}} < IPL_{J2014}^{LCU} = 187{,}827 \quad (12)$$

and the poor in EICV4 can be identified using:

$$\frac{epc_{iEICV4}}{\pi_{J2014}^{rmt}} < IPL_{J2014}^{LCU} = 187{,}827 \quad (12')$$

Both identification conditions of the poor use the unique poverty line expressed in January 2014 prices, IPL_{J2014}^{LCU}. But, the global poverty monitoring uses the poverty line expressed in prices of an average month of each household survey. For EICV3, the global poverty monitoring uses $IPL_{Avg\ EICV3}^{LCU}$. while for EICV4, it uses $IPL_{Avg\ EICV4}^{LCU}$. Here we show how inequalities (12) and (12') can be modified so that (i) poverty rates

do not change but (ii) $IPL^{LCU}_{Avg\ EICV3}$ and $IPL^{LCU}_{Avg\ EICV4}$ are used as the poverty line for EICV3 and EICV4, respectively.

For the identification condition of the poor in EICV3, we first divide both sides of inequality (12) with an inflation rate between an average month of EICV3 and January 2014, say $\pi^{J2014}_{Avg\ EICV3}$.

$$\frac{epc_{iEICV3}}{\pi^{rmt}_{J2014} * \pi^{J2014}_{Avg\ EICV3}} < \frac{IPL^{LCU}_{J2014}}{\pi^{J2014}_{Avg\ EICV3}}$$

Since $\frac{IPL^{LCU}_{J2014}}{\pi^{J2014}_{Avg\ EICV3}} = IPL^{LCU}_{Avg\ EICV3}$ and $\pi^{rmt}_{J2014} * \pi^{J2014}_{Avg\ EICV3} = \pi^{rmt}_{Avg\ EICV3}$, inequality (12) is equivalent to

$$\frac{epc_{iEICV3}}{\pi^{rmt}_{Avg\ EICV3}} < IPL^{LCU}_{Avg\ EICV3} \quad (13)$$

We can do a similar derivation to show inequality (12') is equivalent to

$$\frac{epc_{iEICV4}}{\pi^{rmt}_{Avg\ EICV4}} < IPL^{LCU}_{Avg\ EICV4} \quad (13')$$