Inference on poverty indicators for Ghana

Dioggban Jakperik[1,4*], Romanus Otieno Odhiambo[1,3], and George Otieno Orwa[1,2]

[1]Pan African University, Institute for Basic Sciences, Technology and Innovation
[2]Department of Statistics and Actuarial Science, Jomo Kenyatta University of Technology and Agriculture, Nairobi, Kenya
[3] Meru University of Science and Technology, P. O. Box 972-60200, Meru, Kenya
[4]Department of Statistics, Faculty of Mathematical Sciences, University for Development Studies, Tamale, Navrongo Campus, Box 24, Ghana

[*]To whom correspondence should be addressed; E-mail: jdiogban@uds.edu.gh.

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Abstract

Poverty indicators are the fundamental statistics used to optimally determine the standards of living of people in any country. These are used for policy planing and analysis. Poverty indicators were estimated using linearization techniques with a fourth-order multiplicative semiparametric bias reduction density estimator based on the Ghana Living Standards Survey Round 6 data. The study revealed that the Western Region has the highest At-Risk-of-Poverty Threshold ($GHC3,935.67$) with the Upper East having the least value of $GHC1,003.79$. Poverty levels were high among the three Northern Regions. The highest percentage of persons living below the poverty threshold was found in the Upper West Region whilst the lowest percent was found in the Western Region. Poverty levels were observed to be high in the rural areas compared to the urban centers. Therefore, to combat poverty in Ghana requires a multifaceted approach with good political will and much concentration on the youth since they are the major source of labour to feed the largely agrarian economy. There is the need to intensify education among the youth on capacity building in all endeavors to enhance productivity, hence improving their standards of living.

keywords

poverty indicators, linearization technique, Living standards, density estimator, Quantile

1 Estimation of poverty indicators

Poverty indicators are mostly estimated in recent times by means of linearization techniques. This is highly preferred to the resampling methods because it is less labour intensive and time consuming (Chauvet and Goga, 2018; Goga et al., 2009) without sacrificing the gain in precision. Previously, linearization techniques were implemented especially for poverty and inequality indicators using the normal kernel density, this was shown to generate strong bias (Graf and Tillé, 2014; Karlis, 2016). Graf and Tillé (2014) then proposed using the uniform and the k-nearest neighbor with logarithmic transformation to mitigate the bias. The reduction of the bias was substantial after their methods were implemented, but leaves much to be desired. In this study, a fourth-order multiplicative semiparametric density estimator is used, which significantly reduces the bias. This density estimator, reduces both bias and variance, or at worst preserves the variance of the ordinary kernel estimator and therefore makes it suitable for practical applications such as estimating poverty indicators. The definitions of these poverty indicators considered in this study are stated below.

1.1 Quantile

According to the fourth definition of Hyndman and Fan (1996), the quantile is defined as

$$Q_\alpha = y_{k-1} + (y_k - y_{k-1})\left[\alpha N - (k-1)\right] \tag{1}$$

where $\alpha N < k \leq \alpha N + 1$. The sample estimate of the quantile is

$$\hat{Q}_\alpha = y_{k-1} + (y_k - y_{k-1})\left(\frac{\alpha\hat{N} - \hat{N}_{k-1}}{w_k}\right) \tag{2}$$

The linearized variable of an α-order quantile is given by

$$\hat{z}_k^{Q_\alpha} = -\frac{1}{f\left(\hat{Q}_\alpha\right)}\frac{1}{\hat{N}}\left[1_{\left[y_k \leq \hat{Q}_\alpha\right]} - \alpha\right] \tag{3}$$

(Graf and Tillé, 2014).

The quantile estimates (2) and (3) was used in estimating the poverty indicators.

1.2 Median income and at-risk-of-poverty threshold

Suppose $\hat{m} = \hat{Q}_{0.5}$ is the estimated median income of the sample. The At Risk of Poverty Threshold $(ARPT)$ is defined as 60% of the median income:

$$ARPT = 0.6F^{-1}(0.5) \tag{4}$$

estimated by

$$\widehat{ARPT} = 0.6\hat{Q}_{0.5} = 0.6\hat{m}$$

This is an absolute measure that is scale-dependent. The linearized variable of the $ARPT$ is proportional to that of the median income given by

$$\begin{aligned} \hat{z}_k^{ARPT} &= I(ARPT)_k \\ &= 0.6I(MED)_k \\ &= -\frac{0.6}{f(\hat{m})}\frac{1}{\hat{N}}\left[1_{[y_k \leq \hat{m}]} - 0.5\right] \end{aligned} \tag{5}$$

(Graf and Tillé, 2014).

1.3 At Risk of Poverty Rate

The At Risk of Poverty Rate $(ARPR)$, where $ARPR \in [0,1]$ defines the share of the population with an income below the $ARPT$: $ARPR = F(ARPT)$. It is also scale-dependent. The sample estimate is given by

$$\widehat{ARPR} = \frac{\sum_{y_k < \widehat{ARPT}} w_k}{\hat{N}} \tag{6}$$

(Graf and Tillé, 2014).

Osier (2009) defined the linearized variable of the $ARPR$ as

$$\begin{aligned} \hat{z}_k^{ARPR} &= \frac{1}{N}\left(1_{\left[y_k \leq \widehat{ARPT}\right]} - \widehat{ARPR}\right) - \frac{f\left(\widehat{ARPT}\right)}{f(\hat{m})}\frac{0.6}{\hat{N}}\left(1_{[y_k \leq \hat{m}]} - 0.5\right) \\ &= \frac{1}{\hat{N}}\left(1_{\left[y_k \leq \widehat{ARPT}\right]} - \widehat{ARPR}\right) + f\left(\widehat{ARPT}\right)\hat{z}_k^{ARPT} \end{aligned} \tag{7}$$

1.4 Median income of individuals below the ARPT

The median income of individuals below the $ARPT$ is $m_p = F^{-1}(1/2F(ARPT))$. It is estimated in the same way like any other quantile but the exact definition may differ (Graf and Tillé, 2014). Osier (2009) defined the linearized variable of m_p in terms of the $ARPR$ as

$$\hat{z}_k^{m_p} = \frac{1}{f(\hat{m}_p)}\frac{\hat{z}_k^{ARPR}}{2} - \frac{1}{\hat{N}}\left(1_{[y_k \leq \hat{m}_p]} - F(\hat{m}_p)\right) \tag{8}$$

1.5 Relative Median Poverty Gap

The relative median poverty gap ($RMPG$) is the relative difference between the $ARPT$ and the median income of individuals below the $ARPT$. If $RMPG = 0$, then the income of all "poor" individuals is equal to the $ARPT$, and $RMPG = 1$ if the income of all "poor" individuals is zero. It measures the extent to which "poor" individuals are poor;

$$RMPG = \frac{ARPT - m_p}{ARPT} \tag{9}$$

(Graf and Tillé, 2014; Verma and Betti, 2010). The linearized variable of the $RMPG$ as defined by Osier (2009) is

$$\hat{z}_k^{RMPG} = \frac{\hat{m}_p \hat{z}_k^{ARPT} - \widehat{ARPT}\, \hat{z}_k^{m_p}}{\widehat{ARPT}^2} \tag{10}$$

Here, the estimated income density function is involved four times: once in the estimation of $\hat{z}_k^{ARPT}$ and three times in the estimation of $\hat{z}_k^{m_p}$.

2 Multiplicative semi-parametric bias reduction density estimator

In this study, a multiplicative semi-parametric biased reduction density estimator is proposed to effectively mitigate the challenge of bias in the estimation of poverty indicators. The approach is to start with a parametric density estimate and multiply by a nonparametric kernel estimate. The general form of the density is

$$\begin{aligned} \hat{f}(x) &= f\left(x, \hat{\theta}\right) \hat{r}(x) \\ &= \frac{1}{n} \sum_{i=1}^{n} K_h (X_i - x) \frac{f\left(x, \hat{\theta}\right)}{f\left(X_i, \hat{\theta}\right)} \end{aligned} \tag{11}$$

where the nonparametric correction function is

$$\hat{r}(x) = \frac{1}{n} \sum_{i=1}^{n} \frac{K_h (X_i - x)}{f\left(X_i, \hat{\theta}\right)} \tag{12}$$

Details and properties of this estimator can be found in Jakperik et al. (2018).

3 Source of Data for Analysis

The study used data from the Ghana Living Standards Survey Round 6 for the analysis and estimation of designated poverty indicators (Service, 2014).

4 Estimates of National Poverty Indicators for Ghana

From table 1, it can be seen that the median income of all poor Ghanaians differ from the *ARPT* by 28.36% whilst the *ARPT* is $GHC2,429.11$. A whooping 38% of the population falls below the *ARPT*, with a median income of $GHC688.90$.

Table 1: **Estimates of Poverty Indicators for Ghana**

Poverty indicator	**Estimate(GHC)**	**se**
ARPT	2,429.11	0.264321
ARPR	0.3755	0.281975
RMPG	71.64	1.286352
MEDP	688.90	0.310781

This presents a worrying phenomenon as the units represents households and the actual number of affected individuals both in absolute numbers and percentages could be much higher with its attendant consequences on the prospects of national development and standards of living.

4.1 Regional estimates of poverty indicators for Ghana

At the Regional level, as can be seen from table 2, Upper East Region has the least *ARPT* of $GHC1003.79$ whilst Western Region has the highest *ARPT* of $GHC3,935.67$. The Greater Accra Region has the smallest *ARPR* of 28% followed by the Asante Region with a value of 31%. Clearly, the three Northern Regions are lagging behind in almost all the poverty indicators, consolidating their positions as the poorest Regions of Ghana. Interestingly, a lot of Government and Non-Governmental Organizations(*NGO*) support have gone into these Regions without much improvements being realized over the years. Maybe the mode and approach of investments as well as targeted groups must be changed together with a strong political will. Also, whilst the Central Region has a high *ARPT* of GHC 1,594.77, it has one of the largest *RMPG* of 80.53% only next to the Volta Region which an *RMPG* of 83.14%. This puts the Central Region in a good position as the standard of living in the Central is perceived to be one of the best following this results.

4.2 Sex-based poverty indicators for Ghana

Furthermore, from table 3, the analysis revealed that whilst the households with male heads have higher $ARPT\,(GHC2,885.00)$ than their female counterparts $GHC1,529.00$, the median income of household whose heads are females below the $ARPT$ is $GHC719.69$ higher than their male counterparts, $GHC651.69$. The households with female heads also have a lower $RMPG\,(70.37)$ than their males counterparts $GHC73.17$ but has a $ARPR\,(49\%)$ than their corresponding males counterparts 33%.

Table 2: **ESTIMATES OF REGIONAL POVERTY INDICATORS FOR GHANA**

Region	Poverty Indicator	Estimate	se
Western	*ARPT*	3,935.67	0.02312
	ARPR	0.29	0.00324
	RMPG	70.81	0.03151
	MEDP	709.00	0.01564
Central	*ARPT*	1,594.77	0.12861
	ARPR	0.48	0.00532
	RMPG	80.53	0.02541
	MEDP	473.05	0.06231
Greater Accra	*ARPT*	2,923.92	0.07092
	ARPR	0.31	0.00214
	RMPG	77.36	0.03081
	MEDP	550.00	0.00352
Volta	*ARPT*	1,599.55	0.07260
	ARPR	0.48	0.09126
	RMPG	83.14	0.00186
	MEDP	409.56	0.03571
Eastern	*ARPT*	2,094.00	0.00542
	ARPR	0.40	0.00158
	RMPG	74.68	0.00643
	MEDP	614.97	0.00921
Ashanti	*ARPT*	3,509.54	0.00721
	ARPR	0.28	0.00422
	RMPG	62.22	0.00735
	MEDP	917.72	0.01139
Brong Ahafo	*ARPT*	2,061.76	0.00036
	ARPR	0.41	0.00865
	RMPG	65.15	0.01093
	MEDP	846.60	0.00231
Northern	*ARPT*	1,779.48	0.00022
	ARPR	0.45	0.00071
	RMPG	64.07	0.00103
	MEDP	872.67	0.00091
Upper East	*ARPT*	1,003.79	0.00528
	ARPR	0.60	0.00729
	RMPG	71.87	0.00913
	MEDP	683.42	0.00576
Upper West	*ARPT*	1,018.06	0.00104
	ARPR	0.57	0.00208
	RMPG	79.62	0.00199
	MEDP	495.03	0.00138

Table 3: **ESTIMATES OF POVERTY INDICATORS FOR GHANA BY SEX**

Poverty indicator	Male	se	Female	se
ARPT	2,885.00	0.0033	1,529.00	0.0026
ARPR	0.33	0.0019	0.49	0.0041
RMPG	73.17	0.0132	70.37	0.0025
MEDP	651.69	0.0019	719.69	0.0031

5 Discussion of Results

The quest of the government and people of Ghana to achieve a higher middle income status can only be achieved if conducive environment is provided to reduced the poverty gap between the rich and the poor. This will consequently improve the standard of living and productivity in the country. The current situation in the country according the *GLSS*6 data presents a daunting picture, and does not seem the country is in a good position to achieve this feet in the near future. According to the latest world poverty clock report, any person who lives on a daily amount less than \$1.99 (*GHC*8.96) is poor (Mills, 2018). This is far higher than that in Ghana as the *ARPT* yields *GHC*6.66 whilst the median income of individuals with income below the *ARPT* gives *GHC*1.89. Even more worrying is the fact that these figures represent household income that has to cater for many people. In spite of numerous interventions from various stakeholders, the situation in the country seems to be stagnating without much improvements (Mills, 2018). According to Castro-Leal et al. (1999), public spending or interventions hardly benefits the poor but rather the rich. Mills (2018) contends that, this persistent failure of African nations purely rests on failed leadership. Thus, the Ghanaian situation may be due to wrong interventions approach or interventions are misdirected to the wrong people. This really seems to be the case in Ghana because since the attainment of a lower middle income status in 2010 (Demery and Squire, 1996), there has been a steady increasing growth rate of about 7% since 2005 but the inequality rate is still on the high side with an *RMPG* of 71.64%. Although poverty levels has seen a drastic reduction in recent times compared to the experiences of the early 1990s, there is still much to be done if the MDGs are to be achieved (Adams, 2006; Cooke et al., 2016; Mills, 2018). The growing inequality and high poverty levels often force the youth to move to the urban centers in such of non-existent jobs, thus becoming internal and international migrants with the mindsets of making money to enhance their family fortunes (Black et al., 2003). Movements such as these adversely affects other essential aspects of the economy such as agriculture among others, since the migration of the youth leads to

labour loss and hence low productivity (Adams, 2006). Poverty and ill-health are linked with poorer countries mostly having bad health outcomes whilst better-off countries have good health outcomes (Cooke et al., 2016; Hong, 2007). This resonates to the household and individual level as poor households and individuals usually have poor health conditions and mostly worse-off than their rich counterparts. Poverty breeds ill-health and keeps the poor persons poor (Cooke et al., 2016). This always leads to impoverishment and increases income inequality with its attendance challenges. It has implications on all facets of human health including infant and maternal mortality (Wagstaff, 2002), which are basic measures of standard of living in any country.

On the regional analysis, the Western Region has the highest *ARPT* value of $GHC3,935.67$ which translates into $GHC10.67$ per day for each household in the Region. This amount is only slightly higher than the designated poverty line value by the world bank of \$1.99 $(GHC8.96)$ a day per person. The lowest *ARPT* value is that of the Upper East Region, $(GHC1003.79)$ with a daily household sustenance amount of $(GHC2.75)$. Unfortunately, this amount is too small to cater for an individual need and far less than the minimum amount set by the world bank (Mills, 2018). Almost over a decade, the Upper East and by extension the three Northern Region have always been the poorest of the ten administrative Regions of Ghana with cases of severe starvation and malnutrition despite various interventions made in those Regions by *NGOs* and government alike. It may be necessary to vary the nature of interventions made in those areas to improve their livelihood and hence enable them to contribute in nation building and gain self-actualization. Beyond these observations, the analysis presents an improvement in the lives of the people than those they experience in the early 2000*s* and even in somewhere in 2006 six where a world bank reported an endemic poverty prevalence in the area that three out of every four persons in the Upper East Region was poor (Adams et al., 2008; Novignon et al., 2012; Palmer et al., 2007). Another Region worthy of notice is the Central Region. It has an *ARPT* of $GHC1,594.77\,(4.37)$ and *ARPR* of 0.48 implying about 48% of the people are poor. It has one of high *RMPG* values of 80.53 and the lowest $MEDP$ value of $GHC473.05$. By these statistics, although it has high *ARPT* value than the three Northern Regions, the standard of living in the Central Region is poorer than the three Northern Regions, It would be interesting to find out what really causes those disparities and seek formidable solutions for same to better the lives of the people there. The Eastern Region had similar characteristics of relatively high *ARPT* value and low $MEDP$ value and high *RMPG* value with about 40% of the people falling below the poverty line. That may partly be due to the discovery of the oil in the Region with the influx of the people and its attendance increase in cost of living. This naturally will put the indigenous people who are not employed in the oil industry at a disadvantageous position. The Brong Ahafo Region

once again is the best in terms a place to be in Ghana with relatively high *ARPT* $(GHC2,061.76)$ and high *MEDP* $(GHC846.60)$ values. However, the percentage of persons below the *ARPT* of 41% should be a source of worry to government and other stakeholders in charge of the Region. Also, the households headed by males in the country tend t have a higher *ARPT* $(2,885.00)$ than those headed by females *ARPT* $(1,529.00)$. This seems to mean that standards of living in male headed households are better-off than the female headed households (Wodon and Blackden, 2006). Also the percentage of households headed by males and whose income is less than the *ARPT* is lower than those in the female category. However, these households whose heads are females have lower *RMPG* and higher *MEDP* values than their male counterparts. This means, the households whose heads are females seem to have higher income disparities than those whose heads are males. In all, the poverty situation in Ghana is not excessively bad but there is the need for all hands on desk by all stakeholders to minimize the effect of this dreadful societal challenge in the country.

6 Conclusion

Poverty levels are high in the three Northern Regions but their standards of living have significantly improved over the years. Generally, over the whole country, rural dwellers has high incidence of poverty but the median income of people below poverty threshold in the rural areas indicates that their living standards are encouraging. There is therefore the need to empower the youth through skills development and intensive education to harness their potential.

References

Adams, R. H. J. (2006). *Remittances and poverty in Ghana*. The World Bank.

Adams, R. H. J., Cuecuecha, A., and Page, J. (2008). *The impact of remittances on poverty and inequality in Ghana*. The World Bank.

Black, R., King, R., and Tiemoko, R. (2003). Migration, return and small enterprise development in ghana: A route out of poverty. In *International Workshop on Migration and Poverty in West Africa, University of Sussex, United Kingdom*, volume 13. Citeseer.

Castro-Leal, F., Dayton, J., Demery, L., and Mehra, K. (1999). Public social spending in africa: do the poor benefit? *The World Bank Research Observer*, 14(1):49–72.

Chauvet, G. and Goga, C. (2018). Linearization versus bootstrap for variance

estimation of the change between gini indexes. *Survey Methodology*, pages 17–42.

Cooke, E., Hague, S., and McKay, A. (2016). The ghana poverty and inequality report: Using the 6th ghana living standards survey. *University of Sussex*.

Demery, L. and Squire, L. (1996). Macroeconomic adjustment and poverty in africa: an emerging picture. *The World Bank Research Observer*, 11(1):39–59.

Goga, C., Deville, J.-C., and Ruiz-Gazen, A. (2009). Use of functionals in linearization and composite estimation with applications to two-sample survey data. *Biometrika*, 96(3):691 – 709.

Graf, E. and Tillé, Y. (2014). Variance estimation using linearization for poverty and social exclusion indicators. *Survey Methodology*, 40(1):61–79.

Hong, R. (2007). Effect of economic inequality on chronic childhood undernutrition in ghana. *Public Health Nutrition*, 10(4):371–378.

Hyndman, R. J. and Fan, Y. (1996). Sample quantiles in statistical packages. *The American Statistician*, 50(4):361–365.

Karlis, D. (2016). Integrated systems of european social surveys - generalization of the existing framework to cover longitudinal and other complex aspects. resreport, EUROSTAT.

Mills, G. (2018). Why is africa poor? In *Culture and Civilization*, pages 52–62. Routledge.

Novignon, J., Nonvignon, J., Mussa, R., and Chiwaula, L. S. (2012). Health and vulnerability to poverty in ghana: evidence from the ghana living standards survey round 5. *Health economics review*, 2(1):11.

Osier, G. (2009). Variance estimaton for complex indicators of poverty and inequality using linearization techniques. *Survey Research Methods*, 3(3):167 – 195.

Palmer, R., Wedgwood, R., Hayman, R., and of African Studies, E. C. (2007). *Educating out of poverty?: a synthesis report on Ghana, India, Kenya, Rwanda, Tanzania and South Africa*. DFID.

Service, G. S. (2014). *Ghana Living Standards Survey Round 6 (GLSS 6).: Poverty profile in Ghana (2005-2013)*. Ghana Statistical Service.

Verma, V. and Betti, G. (2010). Taylor linearization sampling errors and design effects for poverty measures and other complex statistics. *Journal of Applied Statistics*.

Wagstaff, A. (2002). Poverty and health sector inequalities. *Bulletin of the world health organization*, 80:97–105.

Wodon, Q. and Blackden, C. M. (2006). *Gender, time use, and poverty in sub-Saharan Africa*. The World Bank.