



# Improved Generalised Foster-Greer-Thorbecke Index In One-Dimensional Poverty

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## ABSTRACT

The use of income or expenditure as a measure of poverty is known as a one-dimensional study of poverty. This method relies largely on the use of a poverty line as a classification criterion to classify households into poor and non poor groups. The main issue with this approach is its sensitivity to extreme observations. Additionally, it ignores variability among the poor. These issues make the Foster-Greer-Thorbecke (FGT) generalized uni-dimensional poverty index to be restricted in its usage. Therefore, this study intends to access the suitability of a hybrid poverty line and an Improved Generalized Foster-Greer-Thorbecke (IGFGT) poverty index in a one-dimensional poverty study.

**Keywords:** Improved Head Count index, Improved poverty gap index, Improved square poverty gap index, Hybrid poverty line.

## INTRODUCTION

Poverty is everywhere though the extent may not be the same. Poverty alleviation and eradication is always a subject of focus of any government. In order to achieve this, the poor must be identified firstly and appropriate techniques should be developed to aggregate information on the poor to enable us obtain a precise index of poverty. Poverty has been said to be multi-dimensional manifesting in different forms with a myriad of causes and should therefore be looked at from different angles to ensure that proper intervention policies are made. Despite the clamour for multi-dimensional approaches, money metric approaches are still being used because they are simpler to apply and usually offer a quantitative approach. This research does not differ from the use of money-metric approach . It uses expenditure as a proxy for poverty.

Hunger is poverty. Lack of shelter is poverty. Being sick and unable to visit a doctor is poverty. Lack of access to education and literacy are two characteristics of poverty. Living day by day and not having a job are all signs of poverty. Losing a child to a sickness brought on by contaminated water is poverty. Poverty is a lack of freedom, representation, and power (World Bank, 2001).

According to the World Bank (2014), poverty has various dimensions and is defined as a lack of well-being. It involves having poor wages and being unable to afford the essential products and services required for a dignified existence.

Low levels of health and education, inadequate physical security, lack of voice, and limited opportunities to improve one's situation are all included in the definition of poverty (Wikipedia, 2014).Poverty is a state or condition in which a person or community lacks the financial resources and essentials for a minimum standard of living. Poverty means that the income level from employment is so low that basic human needs cannot be met (James, 2019).

Absolute poverty is a state in which a person or family is highly deprived of the basic needs making their livelihood difficult. Relative poverty is a condition when a person or family is unable to reach the minimum average living standard in the society (Surblin, 2019).Tejvan (2017),Teachoo (2022) and Wong (2017) also defined poverty in terms of relative and absolute. Decerf (2018), Labrindis et .al. (2019) and Mifsud (2021) researched sorely on Absolute poverty and Relative poverty respectively. Absolute Poverty defined by World Bank says rather than measuring poverty against the rest of the population, poverty is measured against a fixed standard of living. In October 2015 the World Bank set a new Global Poverty Line at \$1.90 a day (compassion, 2019) .Managhan (2022) and Dhyani (2022) majored their studies on the differences between Absolute and Relative Poverty.

**METHODOLOGY**

**Poverty line (Z)**

Poverty lines demarcate the poor from the non-poor. They can be monetary (e.g. a certain level of consumption) or non-monetary (e.g. a certain level of literacy). We can have more than one poverty line depending on the researcher’s work or interest. For example, different levels of poverty can be distinguished with the aid of multiple poverty lines.

Poverty lines vary in time and place and each country uses lines which are appropriate to its level of development, societal norms and values (World Bank, 2010). The poverty line is conceptualized as a minimum standard required by an individual to fulfill his or her basic food and non-food needs (Osowole, 2011).

According to Sen (1985) cited in Maxwell (1999), poverty can be either absolute or relative. Due to this, two types of poverty lines were created: absolute and relative poverty lines.

**Relative Poverty Line (Z<sub>r</sub>):** These are described in terms of the general income or consumption distribution in a nation. The poverty line, for instance, could be set at 50% of national income or consumption.

**Absolute Poverty Line (Z<sub>a</sub>):** These are attained in accordance with some unwavering standard of what households ought to be able to depend on in order to satisfy their fundamental needs. They frequently base their absolute poverty levels on estimations of the price of basic food requirements (i.e., the price of a nutritious basket considered necessary for a family's healthy existence), to which a provision is made for non-food needs (Thomas and Canagarajah, 2002). The World Bank used a figure of US\$1per day in 1985 (purchasing power dollars) for absolute poverty, \$1.25 and \$2 per day in 2005 and \$1.90 per day in 2015.

**Hybrid poverty line (Z<sub>H</sub>)**

Poverty line, a threshold for classing households into poor and non-poor is germane to one-dimensional poverty analysis.

For this study, the hybrid poverty line will be adopted. Hybrid poverty line was proposed by Foster (1998) to address the problems of sensitivity of the relative poverty line and that of subjectivity of the absolute Poverty line. Foster and levy (2013) also incorporated its use. This is a combination of relative and absolute poverty lines and given as;

$$Z_H = Z_r^\beta Z_a^{1-\beta} \quad \text{For } 0 < \beta < 1 \dots\dots\dots(1)$$

Where Z<sub>r</sub> = Relative poverty line, Z<sub>a</sub> = Absolute poverty line, and β is the elasticity of poverty line with respect to income/expenditure.

Note that when,

$$\beta = 0, \quad Z_H = Z_a \quad \text{and when } \beta = 1, \quad Z_H = Z_r \quad .$$

Thus the two extremes is avoided.

- Four relative poverty lines will be considered viz:

$$Z_{r1} = \text{Mean per capita household expenditure}$$

$$= \left[ \frac{1}{N} \sum_{i=1}^N y_i \right] \dots\dots\dots(2)$$

$$Z_{r2} = \frac{2}{3}$$

$$= \frac{2}{3} \left[ \frac{1}{N} \sum_{i=1}^N y_i \right] \dots\dots\dots(3)$$

$$Z_{r3} = \text{Median per capita household expenditure} \dots\dots\dots(4)$$

$$Z_{r4} = \frac{2}{3} = \text{Median per capita household expenditure} \dots\dots\dots(5)$$

$$Z_a = \$ 1.90 \text{ per day world bank, October 2015} \dots\dots\dots (6)$$

$y_i$  is the total per capital expenditure for household  $i$  and  $N$  is the number of households in the survey. A household is considered non poor if the household's per capita expenditure greater than the poverty line; otherwise they are said to be poor.

The hybrid poverty lines will be obtained using each relative poverty line ( $Z_r$ ) and the absolute poverty line ( $Z_a$ ) and denoted as  $ZH_{r1}, ZH_{r2}, ZH_{r3}$  for  $ZH_{r4}$   $0.1 \leq \beta \leq 0.9$  following the comment of Madden (2000).

**Poverty indices**

Poverty analysis generally involves aggregation of information on the poor. This aggregation informs the use of poverty indices like FGT, Sen & Watts, e.t.c.

Foster-Greer-Thorbecke (1984) proposed generalized poverty index as cited in Haughton *et al.* (2009) and is given as;

$$P_\alpha = \frac{1}{N} \sum_1^N \left( \frac{z-y}{y} \right)^\alpha I(y \leq z) \dots\dots\dots (7)$$

Where  $\alpha$  is a measure of the sensitivity of the index to poverty,  
 $P_0$ =Head count index when  $\alpha =0$  (incidence),  $P_1$ = Poverty gap index when  $\alpha =1$ (Measures poverty depth/intensity-how poor are the poor) and  $P_2$  = Square poverty gap index when  $\alpha=2$  (Measures Severity of poverty-distribution of income/expenditure among the poor),  $Z$ = Poverty line.

**Modified poverty levels**

According to poverty profile (NBS, 2005) two levels of poverty has been in use, due to the present economic recession in the country there is need to reclassify the poverty levels to three so as to aid the proper identification of the poor .To achieve this, the household expenditure was sub-divided as follows; ( $y < \frac{1}{3}Z$ ) to capture the households who are starving, ( $\frac{1}{3} Z \leq y < \frac{2}{3} Z$  ) to capture extremely poor households and ( $\frac{2}{3} \leq y \leq Z$ ) to capture the moderately poor households.

**Improved Foster-Greer-Thorbecke (FGT) Index**

$$P_{\alpha} = \frac{1}{N} \sum_1^N \left[ \frac{y - z}{z} \right]^{\alpha} I (y \leq z) \dots\dots\dots (8)$$

Foster-Greer-Thorbecke poverty index has been used extensively in literature by researchers and is still being used in Poverty Analysis. This is not unconnected with its mathematical appeal. It is observable in this definition of FGT Index that the indicators function  $I (y \leq z)$  treats the poor alike, the poor are not the same and should be treated differently. The poorer individuals should be given higher weights. We note that there are three major classifications for any given household, namely extremely (core) Poor, Moderately Poor and Non-poor (two levels of Poverty) i.e. the extremely (core) Poor and Moderately Poor (see the final report of Poverty Profile, Africa (2011). However, three levels of poverty will be considered in this work, viz Starvation, Extremely Poor and Moderately Poor and this will be incorporated into the FGT Index.

Based on the foregoing, we shall define the Improved FGT index as.

$$P_{\alpha}^* = \frac{1}{N} \sum_1^N \left| \frac{y - z}{z} \right|^{\alpha} I^* (y \leq z) \dots\dots\dots (9)$$

Where;

$$I^* (y \leq z) = \left. \begin{array}{ll} \frac{3}{6}, & y < \frac{1}{3} z \quad \text{(Starvation)} \\ \frac{2}{6}, & \frac{1}{3} z \leq y < \frac{2}{3} z \quad \text{(Extremely - Poor)} \\ \frac{1}{6}, & \frac{2}{3} z \leq y \leq z \quad \text{(Moderately - Poor)} \\ 0, & y > z \quad \text{(Non - Poor)} \end{array} \right\} \dots\dots (10)$$

**Improved FGT head count index**

$$P_0^* = \frac{1}{N} \sum_1^N \left| \frac{y - z}{z} \right|^0 I^* (y \leq z) \dots\dots\dots (11)$$

$$= \frac{1}{N} \sum_1^n I^* (y \leq z) \dots\dots\dots (12)$$

n is the number of the poor, N is the total number of households. Suppose there are n<sub>1</sub> (at starvation point), n<sub>2</sub> extremely poor household and n<sub>3</sub>, moderately poor households then equation (12) becomes:

$$P_0^* = \frac{3n_1}{6N} + \frac{2n_2}{6N} + \frac{n_3}{6N} \dots\dots\dots (13)$$

**Improved FGT poverty gap index**

$$P_1^* = \frac{1}{N} \sum_1^N \left| \frac{y-z}{z} \right| I^*(y \leq z) \dots\dots\dots (14)$$

$$= \frac{3}{6N} \sum_1^{n_1} \left| \frac{y_i - Z}{Z} \right| + \frac{2}{6N} \sum_{n_1+1}^{n_1+n_2} \left| \frac{y_i - Z}{Z} \right| + \frac{1}{6N} \sum_{n_1+n_2+1}^{n_1+n_2+n_3} \left| \frac{y_i - Z}{Z} \right| \dots (15)$$

Where  $n_1$ ,  $n_2$  and  $n_3$  are the number of poor persons in the three groups.

$n_1 + n_2 + n_3 = n$  (the total number of poor persons).

**Improved FGT square poverty gap index**

$$P_2^* = \frac{1}{N} \sum_1^N \left| \frac{y-z}{z} \right|^2 I^*(y \leq z) \dots\dots\dots (16)$$

$$= \frac{3}{6N} \sum_1^{n_1} \left| \frac{y_i - Z}{Z} \right|^2 + \frac{2}{6N} \sum_{n_1+1}^{n_1+n_2} \left| \frac{y_i - Z}{Z} \right|^2 + \frac{1}{6N} \sum_{n_1+n_2+1}^{n_1+n_2+n_3} \left| \frac{y_i - Z}{Z} \right|^2 \dots\dots\dots (17)$$

**Data:** A General Household Survey (GHS) data from the National Bureau of Statistics (NBS) was used.

**RESULTS OF ANALYSIS AND DISCUSSION**

**Table 1: Relative Poverty Lines and Hybrid Poverty Lines for Nigeria**  
N = 4536

B	Zr <sub>1</sub> = 10,984.90	Zr <sub>2</sub> = 73,989.93	Zr <sub>3</sub> = 85,906.95	Zr <sub>4</sub> = 57,271.30
(₦)				
0.1	36,427.56	34,980.09	35,506.39	34,095.52
0.2	116,401.00	107,334.09	110,588.40	101,974.50
0.3	371,949.20	329,348.90	344,439.50	304,990.00
0.4	1,188,530.00	1,010,587.00	1,072,793.00	912,177.80
0.5	3,797,841.00	3,100,924.00	3,341,327.00	2,728,182.00
0.6	12,135,653.00	9,514,991.00	1,046,910.00	8,159,566.00
0.7	38,778,372.00	29,196,156.00	32,413,405.00	24,403,986.00
0.8	124,000,000.00	89,586,577.00	101,000,000.00	72,988,507.00
0.9	396,000,000.00	275,000,000.00	314,000,000.00	218,297,211.00

In One-dimensional poverty analysis it is customary to use relative poverty lines (that is poverty lines derived from a fraction of an ideal measure of location) as seen above. Table 1 shows hybrid poverty lines for the whole country (Nigeria) when household size is 4536.

When elasticity is minimum ( $\beta=0.1$ ) hybrid poverty line is maximum for relative poverty line ( $Z_{r1}=\text{₦}110,984.90$ ) and least for relative poverty line ( $Z_{r4} = \text{₦}57,271.30$ ). When elasticity is maximum ( $\beta=0.9$ ) the hybrid poverty line is maximum for relative poverty line ( $Z_{r1} = \text{₦}110,984.90$ ) and least for relative poverty line ( $Z_{r4} = \text{₦}57,271.30$ ). For elasticity values ( $0.2 \leq \beta \leq 0.8$ ), the trend as discussed is noticeable. Also, for each of the relative poverty lines, their hybrid poverty lines values increased as  $\beta$  increased.

**Number of Households And Proportion Of Those Who Fall Under These Poverty Levels For The Relative Poverty Lines And Hybrid Poverty Lines.**

**Table 2: Poverty Levels and Their Proportions/Number of poor Households for Relative (Mean Per capita Exp) and Hybrid Poverty Lines( $Z_H$ ) for the Whole country.**

Z(code)	B	Z Value	Starvation (n <sub>1</sub> )	Extremely Poor (n <sub>2</sub> )	Moderately Poor (n <sub>3</sub> )
Z <sub>r1</sub>	-	110,984.90	0.6609 (389)	0.3175(1478)	0.2467 (1132)
	0.1	36,427.56	0.0011 (5)	0.0174 (79)	0.0628 (285)
	0.2	116,401.00	0.1027 (466)	0.3397 (1541)	0.2447 (1110)
	0.3	371,949.20	0.7198 (3265)	0.2172 (985)	0.0450 (204)
	0.4	1,188,530.00	0.9868 (4476)	0.0112 (51)	0.0013 (6)
	0.5	3,797,841.00	0.9998 (4533)	0.0004 (2)	0.0000 (0)
	0.6	12,135,653.00	0.9998 (4535)	0.0002 (1)	0.0000(0)
	0.7	38,778,372.00	1.0000 (4536)	0.0000 (0)	0.0000 (0)
	0.8	124,000,000.00	1.0000 (4536)	0.0000 (0)	0.0000 (0)
	0.9	396,000,000.00	1.0000 (4536)	0.0000 (0)	0.0000 (0)

Table 2 shows the poverty levels, number of households in each poverty level and their proportions for  $Z_{r1}$  and  $Z_H$  for Whole Country. The  $Z_{r1}$  was obtained as  $\text{₦}110,984.90$  conventionally with 389 starving households, 1478 extremely poor households and 1132 moderately poor households. At  $\beta = 0.1$ ,  $Z_H$  was obtained as  $\text{₦}36,427.56$  with 5 starving households, 79 extremely poor households and 285 moderately poor households. From  $\beta = 0.1$  to 0.7 an increase in the starving households is observed. Maximum number of household (4536) was attained at  $\beta = 0.7$  where all households are starving. For the extremely

and moderately poor poverty levels, the number of households in these categories decreased from  $\beta = 0.2$ . No extremely poor and moderately poor households were found for  $\beta = 0.7$  to  $\beta = 0.9$

**Table 3: Poverty Levels and Their Proportions/Number of poor Households for Relative (2/3 Mean Per Capital Exp) and Hybrid Poverty Lines( $Z_H$ ) for the Whole country**

Z(code)	$\beta$	Z Value	Starvation ( $n_1$ )	Extremely Poor ( $n_2$ )	Moderately Poor ( $n_3$ )
Zr <sub>2</sub>	-	73,989.90	0.0198 (90)	0.1704 (773)	0.2213 (1004)
	0.1	34,980.09	0.0009 (4)	0.0146 (66)	0.0549 (249)
	0.2	107,334.30	0.0772 (350)	0.3186 (1445)	0.2436 (1105)
	0.3	329,348.90	0.6568 (2979)	0.2575 (1168)	0.0573 (260)
	0.4	1,010,587.00	0.9742 (4419)	0.0227 (103)	0.0018 (8)
	0.5	3,100,924.00	0.9987 (4530)	0.0009 (4)	0.0002 (1)
	0.6	9,514,491.00	0.9998 (4535)	0.0002 (1)	0.0000 (0)
	0.7	29,196,156.00	1.0000 (4536)	0.0000 (0)	0.0000 (0)
	0.8	89,586,577.00	1.0000 (4536)	0.0000 (0)	0.0000 (0)
	0.9	275,000,000.00	1.0000 (4536)	0.0000 (0)	0.0000 (0)

Table 3 shows the poverty levels, number of households in each poverty level and their proportions for Zr<sub>2</sub> and Z<sub>H</sub> for Whole Country. The Zr<sub>2</sub> was obtained as ₦73,989.90 conventionally with 90 starving households, 773 extremely poor households and 1004 moderately poor households. At  $\beta = 0.1$ , Z<sub>H</sub> was obtained as ₦34,980.09 with 4 starving households, 66extremely poor households and 294 moderately poor households. From  $\beta = 0.1$  to 0.7 an increase in the starving households is observed. Maximum number of household (4536) was attained at  $\beta = 0.7$  where all households are starving. . For the extremely and moderately poor poverty levels, the number of households in these categories decreased from  $\beta = 0.2$ . No extremely poor and moderately poor households were found for  $\beta = 0.7$  to  $\beta = 0.9$ .

**Table 4: Poverty Levels and Their Proportions/Number of poor Households for Relative (Median Per Capita Exp) and Hybrid Poverty Lines ( $Z_H$ ) for Nigeria**

Z (Code)	$\beta$	Z Value	Starvation ( $n_1$ )	Extremely Poor ( $n_2$ )	Moderately Poor ( $n_3$ )
Zr3	-	85,906.95	0.0355 (161)	0.2315 (1050)	0.5377 (2439)
	0.1	35,506.39	0.0009 (4)	0.0163 (74)	0.0732 (332)
	0.2	110,588.40	0.0847 (384)	0.3256 (1477)	0.3093 (1403)
	0.3	344,439.50	0.6788 (3079)	0.2467 (1119)	0.0622 (282)
	0.4	1,072,793.00	0.9788 (4440)	0.0073 (33)	0.0132 (60 )
	0.5	3,341,327.00	0.9957 (4533)	0.0004 (2)	0.0000 (0)
	0.6	1,046,910.00	0.9998 (4535)	0.0002 (1)	0.0000 (0)
	0.7	32,413,405.00	1.0000 (4536)	0.0000 (0)	0.0000 (0)
	0.8	101,000,000.00	1.0000 (4536)	0.0000 (0)	0.0000 (0)
	0.9	314,000,000.00	1.0000 (4536)	0.0000 (0)	0.0000 (0)

Table 4 shows the poverty levels, number of households in each poverty level and their proportions for Zr3 and  $Z_H$  for Whole Country. The Zr3 was obtained as ₦85,906.95 conventionally with 161 starving households, 1050 extremely poor households and 2439 moderately poor households. At  $\beta = 0.1$ ,  $Z_H$  was obtained as ₦35,506.39 with 4 starving households, 74 extremely poor households and 332 moderately poor households. From  $\beta = 0.1$  to 0.7 an increase in the starving households is observed. Maximum number of households (4536) was attained at  $\beta = 0.7$  where all households are starving. For the extremely and moderately poor poverty levels, the number of households in these categories decreased from  $\beta = 0.2$ . No extremely poor and moderately poor households were found for  $\beta = 0.7$  to  $\beta = 0.9$



**Table 5: Poverty Levels and Their Proportions/Number of poor Households for Relative (2/3 Median Per Capita Exp) and Hybrid Poverty Lines ( $Z_H$ )for the Whole country.**

Z (Code)	$\beta$	Z Value	Starvation ( $n_1$ )	Extremely Poor ( $n_2$ )	Moderately Poor ( $n_3$ )
$Z_{r4}$	-	57,271.30	0.0075 (34)	0.0873 (396)	0.1722 (78)
	0.1	34,095.52	0.0009 (4)	0.0137 (62)	0.0518 (235)
	0.2	101,974.50	0.0641 (291)	0.3047 (1382)	0.2416 (1096)
	0.3	304,990.00	0.6083 (2759)	0.2881 (1307)	0.0686 (311)
	0.4	912,177.80	0.9985 (4529)	0.0000 (0)	0.0000 (0)
	0.5	2,728,182.00	0.9985 (4529)	0.0011 (5)	0.0002 (1)
	0.6	8,159,566.00	0.9998 (4535)	0.0002 (1)	0.0000 (0)
	0.7	24,403,986.00	1.0000 (4536)	0.0000 (0)	0.0000 (0)
	0.8	72,988,507.00	1.0000 (4536)	0.0000 (0)	0.0000 (0)
	0.9	218,297,211.00	1.0000 (4536)	0.0000 (0)	0.0000 (0)

Table 5 shows the poverty levels, number of households in each poverty level and their proportions for  $Z_r$  and  $Z_H$  for Whole Country. The  $Z_{r4}$  was obtained as ₦57,271.30 conventionally with 34 starving households, 396 extremely poor households and 78 moderately poor households. At  $\beta = 0.1$ ,  $Z_H$  was obtained as ₦34,095.52 with 4 starving households, 62 extremely poor households and 235 moderately poor households. From  $\beta = 0.1$  to 0.7 an increase in the starving households is observed. Maximum number of households (4536) was attained at  $\beta = 0.7$  where all households are starving. For the extremely and moderately poor poverty levels, the number of households in these categories decreased from  $\beta = 0.2$ . No extremely poor and moderately poor households were found for  $\beta = 0.7$  to  $\beta = 0.9$

**Estimates of Improved Head Count Index ( $P_0^*$ ), Improved Poverty Gap Index ( $P_1^*$ ) And Improved Square Poverty Gap Index ( $P_2^*$ ).**

**Table 6: Estimates of Improved Head Count Index ( $P_0^*$ ), Improved Poverty Gap Index ( $P_1^*$ ) and Improved Squared Poverty Gap ( $P_2^*$ ) for Relative (Mean Per capita Exp) and Hybrid Poverty Lines ( $Z_H$ ) for the whole Country.**

Z (Code)	B	Z Value	$P_0^*$	$P_1^*$	$P_2^*$
Zr <sub>1</sub>	-	110,984.90	0.1931	0.0936	0.0535.6
	0.1	36,427.56	0.0165	0.0020	0.0018
	0.2	116,401.00	0.2054	0.1021	0.0593
	0.3	371,949.20	0.4398	0.3334	0.2621
	0.4	1,188,531.00	0.4974	0.4526	0.4141
	0.5	3,797,842.00	0.4998	0.4854	0.4716
	0.6	12,135,653.00	0.5000	0.4954	0.4909
	0.7	38,778,396.00	0.5000	0.4986	0.4971
	0.8	24,000,000.00	0.5000	0.4996	0.4991
	0.9	396,000,000.00	0.5000	0.4999	0.4997

Table 6 shows the relative and hybrid poverty lines for the Improved poverty indices for the whole country. For  $Z_{r1} = \text{₦}110,984.90$ ;  $P_0^*$ ,  $P_1^*$  and  $P_2^*$  where obtained as 0.1931, 0.0936 and 0.0536 respectively (traditional estimate when  $\beta = 0$ ). For  $Z_H = \text{₦}36,427.56$  ( $\beta = 0.1$ ) the indices where obtain as 0.0165, 0.0020 and 0.0018. From the table,  $P_0^*$  increased as  $\beta$  increased and converged at  $\beta = 0.6$  with the value 0.5000.  $P_1^*$  and  $P_2^*$  also increased as  $\beta$  increased.

**Table 7: Estimates of Improved Head Count Index ( $P_0^*$ ), Improved Poverty Gap Index ( $P_1^*$ ) and Improved Squared Poverty Gap ( $P_2^*$ ) for Relative (2/3 Mean Per capita Exp) and Hybrid Poverty Lines ( $Z_H$ ) for the whole Country**

Z (Code)	$\beta$	Z Value	$P_0^*$	$P_1^*$	$P_2^*$
$Z_{r2}$	-	73,989.93	0.1036	0.0408	0.0201
	0.1	34,980.09	0.0144	0.0038	0.0015
	0.2	1,073,34.30	0.4959	0.4469	0.4054
	0.3	329,348.90	0.4238	0.3120	0.2396
	0.4	1,010,587.00	0.4950	0.4433	0.3999
	0.5	3,100,924.00	0.4995	0.4820	0.4655
	0.6	9,514,9 91.00	0.4999	0.4822	0.4656
	0.7	29,196,156.00	0.5000	0.4981	0.4962
	0.8	89,586,577.00	0.5000	0.4994	0.4988
	0.9	275,000,000.00	0.5000	0.4998	0.4996

Table 7 shows the relative and hybrid poverty lines for the Improved poverty indices for the whole country.  $Z_{r2} = ₦73,989.93$ ;  $P_0^*$ ,  $P_1^*$  and  $P_2^*$  where obtained at 0.1036, 0.0408 and 0.0201 respectively (traditional estimate when  $\beta = 0$ ). For  $Z_H = ₦34, 98.09$  ( $\beta = 0.1$ ) the indices where obtain as 0.0144, 0.0038 and 0.0015. From the table,  $P_0^*$  increased as  $\beta$  increased and converge d at  $\beta = 0.7$  with the value 0.5000.  $P_1^*$  and  $P_2^*$  also increased as  $\beta$  increased

**Table 8: Estimates of Improved Head Count Index ( $P_0^*$ ), Improved Poverty Gap Index ( $P_1^*$ ) and Improved Squared Poverty Gap ( $P_2^*$ ) for Relative (Median Per capita Exp) and Hybrid Poverty Lines ( $Z_H$ ) for the whole Country.**

Z (Code)	B	Z Value	$P_0^*$	$P_1^*$	$P_2^*$
Zr3	-	85,906.95	0.3837	0.0573	0.0299
	0.1	35,506.39	0.0154	0.0041	0.0016
	0.2	110,58.40	0.1925	0.0931	0.0513
	0.3	344,439.50	0.4301	0.3200	0.2479
	0.4	1,072,793.00	0.4959	0.4469	0.4053
	0.5	3,341,327.00	0.4998	0.4834	0.4679
	0.6	10,406,910.00	0.5000	0.4947	0.4894
	0.7	32,413,405.00	0.5000	0.4983	0.4966
	0.8	101,000,000.00	0.5000	0.4995	0.4989
	0.9	314,000,000.00	0.5000	0.4998	0.4997

Table 8 shows the relative and hybrid poverty lines for the Improved poverty indices for the whole country. For  $Z_{r3} = \text{₦}85,906.39$  ;  $P_0^*$ ,  $P_1^*$  and  $P_2^*$  where obtained at 0.3837, 0.0573 and 0.0299 respectively (traditional estimate when  $\beta = 0$ ). For  $Z_H = \text{₦}35,506.39$  ( $\beta = 0.1$ ) the indices where obtain as 0.0154, 0.0041 and 0.0016. From the table,  $P_0^*$  increased as  $\beta$  increased and converged at  $\beta = 0.6$  with the value 0.5000.  $P_1^*$  and  $P_2^*$  also increased as  $\beta$  increased

**Table 9: Estimates of Improved Head Count Index ( $P_0^*$ ), Improved Poverty Gap Index ( $P_1^*$ ) and Improved Squared Poverty Gap ( $P_2^*$ ) for Relative (2/3 Median Per capita Exp) and Hybrid Poverty Lines ( $Z_H$ ) for the whole Country**

Z (Code)	$\beta$	Z Value	$(P_0^*)$	$(P_1^*)$	$(P_2^*)$
Zr4	-	57,271.30	0.0616	0.0207	0.0093
	0.1	34,095.52	0.0135	0.0035	0.0014
	0.2	101,974.50	0.1739	0.0807	0.0447
	0.3	304,989.96	0.4116	0.2969	0.2245
	0.4	912,177.76	0.4934	0.4406	0.3938
	0.5	2,728,182.00	0.4996	0.4796	0.4609
	0.6	8,159,565.70	0.5000	0.4932	0.4866
	0.7	24,403,986.00	0.5000	0.4977	0.4955
	0.8	72,988,507.00	0.5000	0.4992	0.4985
	0.9	218,297211.00	0.5000	0.4998	0.4995

Table 9 shows the relative and hybrid poverty lines for the Improved poverty indices for the whole country. For  $Z_{r4} = \text{₦}57,271.30$  ;  $P_0^*$ ,  $P_1^*$  and  $P_2^*$  where obtained at 0.0616, 0.0207 and 0.0093 respectively (traditional estimate when ( $\beta=0$ )).For  $Z_H = \text{₦}34,095.52$  ( $\beta =0.1$ ) the indices where obtain as 0.0135, 0.0035 and 0.0014. From the table,  $P_0^*$  increase as  $\beta$  increase and converge at  $\beta = 0.6$  with the value 0.5000.  $P_1^*$  and  $P_2^*$  also increased as  $\beta$  increased

Close observation of the values of the estimates considering the hybrid poverty lines reveals that there was a consistence increase in their values from  $\beta = 0.1$  to  $\beta = 0.5$  and little or no change in the values from  $\beta = 0.6$  to  $\beta = 0.9$ . These results Madden (2000) who obtained same result for  $\beta = 0.5$  and  $\beta = 0.7$  in his analysis using House Budget Survey.

From the foregoing, the below poverty lines with their corresponding values of  $\beta$  and Improved poverty indices( $P_0^*$ ,  $P_1^*$  and  $P_2^*$ ) are selected as the poverty lines and Improved Generalised Foster-Greer-Thorbecke (IGFGT) estimates for the analyses.

For Nigeria as a whole, the selected elasticity ( $\beta$ ) value was 0.6 for the mean per capita expenditure poverty line value of  $\text{₦}12,135,653.00$ .This gave rise to Improved estimates of 0.5000, 0.4954 and 0.4909 respectively for Improved head count index, Improved poverty gap and Improved Square poverty gap indices. With the same elasticity value 0.6 at different poverty lines the following are observed;

The estimates of the Improved head count, Improved poverty gap and Improved square poverty gap indices were 0.4999, 0.4822 and 0.4656 for  $\frac{2}{3}$  Mean per capita expenditure poverty line of  $\text{₦}9,514,991.00$  ; 0.4999, 0.4947 and 0.4966 for Median per capita expenditure poverty line of  $\text{₦}10,406,910.00$  and

0.5000, 0.4932, and 0.4866 for  $\frac{2}{3}$  Median per capita expenditure poverty line of ₦3,159,565.70 respectively.

The use of the hybrid poverty line vis-à-vis the appropriate choice of  $\beta$  indicates that more of the households are experiencing starvation. The poverty situation of an individual/household already experiencing starvation could be said to be deep and severe at the same time. This position is supported by minimal variations in the values of  $P_0^*$ ,  $P_1^*$  and  $P_2^*$  respectively.

The hybrid approach could therefore be recommended for intervention purposes (policy formulation and poverty eradication programmes). The implication of this is germane to the appropriate determination of those who are truly poor. The estimation of 50% of the population being starved is corroborated by Kazeem (2018) who opined that “The 86.9 million Nigerians now living in extreme poverty represent nearly 50% of it’s estimated 180 million population”. World Bank (2018) also reported that “almost half the population of Nigeria is living below the international Poverty line (\$2 per day)”.

## CONCLUSION

Three Poverty Levels were used in this research namely, the Starving, Extremely poor and Moderately poor poverty lines as against the two conventional poverty levels (Core poor and Moderately poor) that has been in use. The number of the households in these new levels were also estimated using the household expenditure.

Hybrid Poverty line was adopted instead of the traditional relative or absolute Poverty line which is often arbitrary and highly sensitive to extreme observations. Also, the existing Foster-Greer-Thorbecke (FGT) poverty index is limited by its exclusion of variations among the poor. Hence, this study developed an Improved Generalised Foster-Greer-Thorbecke (IGFGT) poverty index incorporating the new poverty levels and the use of hybrid poverty lines thereby allowing the inclusion of variations among the poor and addressing the problems of arbitrariness and sensitivity to extreme observations.

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