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## **Impacts of Policies on Poverty. Basic Poverty Measures**

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# Impacts of Policies on Poverty

## Basic Poverty Measures

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## 1 SUMMARY

This module describes two of the most commonly used poverty measures in applied policy works, i.e., the headcount ratio (HR) and the poverty gap (PG) ratio. These are basic poverty indicators used to investigate impacts of public policies on poverty. After providing a conceptual background to HR and PG, this module describes step-by-step procedures and provides numerical examples to calculate these measures. In addition, advantages and shortcomings of these measures are discussed, and their explanatory power is investigated.

## 2 INTRODUCTION

### Objectives

Poverty measurement is essential to implement effective policies to fight poverty and to evaluate the poverty impacts of other policies. The aim of this module is to illustrate two simple approaches to poverty measurement. In particular, this module deals with how to build the **headcount ratio** and the **poverty gap ratio**.

### Target audience

This module targets current or future policy analysts who want to assess and/or monitor the impact of policies on poverty. In addition, academics, officers in ministries and other professionals can make use of this material for their work. Furthermore, students interested in poverty issues may find this material relevant for their studies.

### Required background

The trainer should verify that the audience is familiar with the concept of income distribution and with the concept of poverty, especially with the poverty line definition. Basic knowledge of mathematics and statistics is required.

A complete set links of other related EASYPol modules are included at the end of this module. However, readers will also find links to related material throughout the text where relevant<sup>1</sup>.

## 3 CONCEPTUAL BACKGROUND

Poverty measurement requires that relevant characteristics of poor people be aggregated in a given way. In poverty analysis this problem is known as the «**aggregation**

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<sup>1</sup> EASYPol hyperlinks are shown in blue, as follows:

- a) training paths are shown in **underlined bold font**;
- b) other EASYPol modules or complementary EASYPol materials are in ***bold underlined italics***;
- c) links to the glossary are in **bold**; and
- d) external links are in *italics*.

**problem**», i.e. how to pass from the identification of poverty to the measurement of poverty<sup>2</sup>.

Measuring poverty goes back a long way in history. Consequently, we have many available poverty indices. One of the main issues in poverty analysis, therefore, is which of the poverty indices do we choose? The best way of selecting a poverty index is to investigate whether it satisfies some of the desirable properties. For example, should a poverty index increase if poverty increases? Should a poverty index be sensible to the number of poor people or rather to the level of their incomes with respect to the poverty line? <sup>3</sup>

In poverty measurement there is a basic distinction between **ad hoc measures** and **axiomatic measures**. The first set of measures, widely used until the axiomatic approach was developed by Sen, 1976, lacks a theoretical derivation. Whereas, the second set of measures is explicitly based on a set of desirable properties that a poverty index should respect (**axioms**). In addition, a third set of measures, which derived directly from the stochastic dominance literature, is based on the **dominance** of either Lorenz Curves or Generalized Lorenz Curves<sup>4</sup>.

The availability of so many indices has made poverty measurement a field that has generally been fraught with disagreement and difficulties. This is the reason why «*the*» measure of poverty does not exist. Rather, there are many possible ways of measuring poverty.

We will now look at the simplest **ad hoc** poverty measures. Two widely used poverty indexes belonging to this category are:

- The head-count ratio (HC);
- The poverty gap (PG).

### 3.1 The head-count ratio (HC)

The headcount ratio (*HC*) is the simplest way of measuring poverty. It gives the percentage of population which is not above the poverty line. It can be formally defined as follows:

$$[1] \quad HC = \frac{P}{N}$$

<sup>2</sup> On the identification of poverty see the EASYPol Modules 005 and 006 respectively: [Impacts of Policies on Poverty: Absolute Poverty Lines](#), [Impacts of Policies on Poverty: Relative Poverty Lines](#). On the conceptual difference between identification and aggregation, see Sen, 1997, Chapter A.6.

<sup>3</sup> This discussion is addressed in the EASYPol Module 008: [Impacts of Policies on Poverty: Axioms for Poverty Measurement](#).

<sup>4</sup> See the EASYPol Module 010: [Impacts of Policies on Poverty: Generalised Poverty Gap Measures](#).

where  $P$  is the number of poor people (those below a poverty line  $z$ ) and  $n$  is total population<sup>5</sup>.

It is worth noting that  $HC$  is directly related to the Cumulative Distribution Function (CDF)  $F(y)$ . The latter, by definition, gives the percentage of population below a given income level. At income level  $z$ , the corresponding value of the CDF illustrates the percentage of the poor population, i.e.  $HC = F(z)$ .

There are uncountable examples of the use of the headcount ratio in empirical works. Almost any applied policy work on poverty uses this very simple poverty measurement. Just to quote some examples, Deaton, 1997, reports headcount ratio for Côte d'Ivoire in the period 1985-1988, showing that poverty hit 30 per cent of the population in 1985 and about 46 per cent in 1988. The author also reports analogous figures for South Africa in 1993, showing that Blacks were more in poverty than Whites (about 32 per cent and almost zero per cent, respectively).

### 3.2 The Poverty Gap (PG)

For any individual, the poverty gap may be defined as the distance between the poverty line  $z$  and his/her own income  $y$ . Aggregating individual poverty gaps for all poor individuals, gives the aggregate poverty gap:

$$[2] \quad PG = \sum_{i=1}^P (z - y_i)$$

where  $P$  is the number of poor individuals (and not the size of total population!). A refined version of the poverty gap normalises expression [2] over the maximum amount of money that would be needed to wipe out poverty. This last amount is given by the product between the number of poor individuals  $P$  and the poverty line  $z$ .

The intuition is simple. As  $z$  represents the minimum individual income for which an individual is not considered poor, the product of this income with the number of poor individuals  $P$  gives the amount of money that is necessary to eradicate poverty.

According to this definition, we have a normalised version of the poverty gap:

$$[3] \quad PG = \sum_{i=1}^P \left( \frac{z - y_i}{Pz} \right)$$

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<sup>5</sup> An alternative analytical expression is  $HC = \frac{\sum_{i=1}^N 1(y_i \leq z)}{N}$ , where the "1" indicator at the numerator is a function assuming value 1 if the  $i^{\text{th}}$  individual has income  $y$  below the poverty line  $z$ , and assuming value 0 otherwise. As above,  $N$  is the size of total population (and not the total number of poor individuals!).

In turn, expression [3] may be restated in another way. As  $P$  and  $z$  are constants under the summation sign, we can rewrite:

$$[4] \quad PG = \sum_{i=1}^P \left( \frac{z - y_i}{Pz} \right) = \frac{Pz}{Pz} - \frac{Y_p}{Pz} = 1 - \frac{\bar{y}_p}{z}$$

where  $Y_p$  is the total income of poor individuals, while  $\bar{y}_p$  is the mean income of the poor. Expression [4] may be defined as «the percentage of average income of the poor that falls short of the poverty line».

The same observation made for the headcount ratio holds for the poverty gap. Headcount ratio and poverty gap are indeed almost universally reported as the two basic poverty measurements, for both temporal and cross-sectional analysis and in both developed and less developed countries. This is the case, for example, for the Jamaica Food Stamp Programme<sup>6</sup>, for the poverty analysis on the Russian Federation<sup>7</sup> and for the poverty analysis of Papua New Guinea<sup>8</sup>. A poverty gap of 0.142 in 1988 recorded in Côte d'Ivoire means that the average income of the poor is about 86 per cent of the poverty line ( $1 - 0.142 = 0.858$ ). The poverty gap in South Africa among Blacks in 1993 is 0.106, which means that the average income of the poor is about 89 per cent of the poverty line ( $1 - 0.106 = 0.894$ )<sup>9</sup>.

## 4 A STEP-BY-STEP PROCEDURE TO BUILD HC AND PG

### 4.1 A step-by-step procedure to calculate HC

Given the restricted number of parameters needed to define  $HC$ , the step-by-step procedure is also very simple. Figure 1 illustrates the case.

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<sup>6</sup> Ezemenari and Subbarao, 1998.

<sup>7</sup> Ferrer-i-Carbonell and Van Praag, 2000.

<sup>8</sup> Gibson, 1998.

<sup>9</sup> Deaton, 1997, reports poverty gap measures for both Côte d'Ivoire and South-Africa.



**Figure 1 - A step-by-step procedure to calculate HC**

STEP	Operational content
1	If not already sorted, sort the income distribution by income level
2	Define the poverty line
3	Identify poor as those individuals with incomes below the poverty line
4	Count the poor and calculate their percentage on total population

**Step 1** is required in order to work with individuals ordered in an ascending level of income. Income distributions should always be sorted before proceeding to define poverty measurements.

**Step 2** is specific to poverty measurement. In what follows, we assume that the poverty line has already been defined according to either absolute or relative methods<sup>10</sup>.

**Step 3** requires that we focus on individuals with incomes below the poverty line.

**Step 4**, instead, requires that we count the poor and divide their number by the total population. This is the **headcount ratio**.

#### 4.2 A step-by-step procedure to calculate PG

Figure 2 illustrates the steps needed to calculate the poverty gap. **Step 1** and **Step 2** are the same as in the case of *HC*. According to expression [4], and given the definition of the poverty line, the only parameter that has to be calculated is the mean income of poor individuals (**Step 3**). By taking 1 minus the ratio of mean income of poor people to the poverty line gives *PG* (**Step 4**).

<sup>10</sup> See EASYPol Modules 005 and 006 respectively: [Impacts of Policies on Poverty: Absolute Poverty Lines](#) and [Impacts of Policies on Poverty: Relative Poverty Lines](#).

**Figure 2 - A step-by-step procedure to calculate PG**

STEP	Operational content
1	If not already sorted, sort the income distribution by income level
2	Define the poverty line
3	Calculate mean income of poor individuals
4	Calculate the poverty gap as one minus the ratio of mean income of the poor to the poverty line

## 5 A NUMERICAL EXAMPLE OF HOW TO CALCULATE HC AND PG

Despite, or because of, their wide uses in empirical work, the way in which these two indexes are built is not usually spelled out. In what follows, therefore, the focus will not be on a real example but on the way to build these indexes starting from a simplified income distribution.

### 5.1 An example of how to calculate *HC*

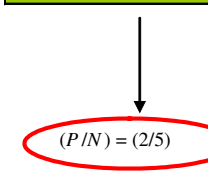
**Step 1** – Table 1, below, first illustrates how to calculate *HC* from a simulated income distribution. Let us start with an income distribution with five individuals, having a total income equal to 50 currency units and mean income equal to 10 currency units. Sorting the income distribution is the basic task of this step.

**Step 2** – Let us also assume that the poverty line is set to **8** currency units (in this case equal to 80 per cent of mean income in a relativist view).

**Step 3** – It is easily seen that poor individuals are two, i.e., those having income below the poverty line.

**Step 4** – As the poor individuals are two, *HC* can now be calculated by the ratio of the number of poor people to total population. In the example, this gives a headcount ratio equal to 0.4, i.e., **40 per cent** of the population

**Table 1 - The headcount ratio**

STEP 1		STEP 2	STEP 3		STEP 4
Sort the income distribution		Define the poverty line (\$)	Assign value 1 to each individual with income below the poverty line and count the total number of poor		Take the ratio of the total number of poor in Step 3 to total population
Individual	A - A typical income distribution	Poverty line 8	Individual	1 if poor	HC 0.40
1	3		1	1	 $(P/N) = (2/5)$
2	6		2	1	
3	9		3	0	
4	12		4	0	
5	20		5	0	
Total income	50		Total number of poor	2	
Mean income	10				

## 5.2 An example of how to calculate PG

Table 2, below, gives an example of how to calculate the poverty gap, starting from the same initial income distribution as in Table 1.

**Step 1** – Let us start again with an income distribution with five individuals, having total income equal to 50 currency units and mean income equal to 10 currency units. Sorting the income distribution is the basic task of this step.

**Step 2** – Let us also assume that the poverty line is again set to 8 currency units (in this case equal to 80 per cent of mean income in a relativist view).

**Step 3** – This step requires that we calculate the average income of poor individuals. Therefore, incomes of poor individuals must be added and the resulting number divided by the number of poor individuals (two persons in the income distribution).

**Step 4** – We are now ready to apply expression [4], giving a *PG* equal to 0.438. This means that, in aggregate, the required income to eradicate poverty is 43.8 per cent of the poverty line times the number of poor individuals. In Table 2, indeed, the required income to lift the first individual above the poverty line is 5 currency units (8-3). For the second, the required income is 2 (8-6). The sum of these gaps gives 7, which is the product of  $[(0.438 \times 8) \times 2]$  – the poverty gap times the poverty line times the number of poor individuals. Alternatively, *PG* means that the average income of the poor is only 56.2 per cent of the poverty line ( $1 - 0.438$ ).

**Table 2 - An example of how to calculate PG**

STEP 1		STEP 2	STEP 3		STEP 4
Order the income distribution		Define the poverty line (\$)	Calculate mean income of poor people (those below the poverty line)		Calculate the poverty gap
Individual	A - A typical income distribution	Poverty line 8	Individual	Income of poor individuals	PG 0.438
1	3		1	3	
2	6		2	6	
3	9		Mean income of the poor	4.5	
4	12				
5	20				
Total income	50				
Mean income	10				

## 6 ON THE PROPERTIES OF HC AND PG

### 6.1 The main properties of HC

It is worth discussing some properties of both *HC* and *PG*. This discussion will prove useful also in the case of the analysis of other poverty measures. It also introduces the issue of axioms in poverty measurement, i.e. to the set of desirable properties that a poverty measure should have. Simplicity of these measures, as we will show, has some costs in terms of their sensitivity to the change in the income distribution.

The headcount ratio *HC* has the following properties:

- ***HC* has zero as lower limit.** It happens when all individuals have an income just above the poverty line. In this case, the number of poor is zero and its ratio to total population is also zero.
- ***HC* has 1 as upper limit.** If everybody is poor, the number of poor people is equal to total population.
- ***HC* is scale invariant.** If all incomes and the poverty line are scaled by the same proportional factor  $\alpha$ , *HC* would stay invariant.
- ***HC* is translation invariant.** If all incomes and the poverty line are increased (decreased) by the same absolute amount of money, *HC* would remain the same. The reason is that *HC* is independent of the *level* of incomes, as it is only sensitive to the *number* of poor.
- *HC* does not obey the principle of transfers, i.e., it does not vary when the same total income is redistributed among individuals, if nobody crosses the poverty line. In this latter case, the number of poor people would remain the same and *HC* also gives the same number. This shortcoming may lead *HC* to behave in a perverse way. If, for example, an extremely poor person gives enough of his/her income to a relatively lesser poor person to lift him/her out of the poverty line (a regressive transfer), the *HC* ratio will record less poverty because there will be one less person below the

poverty line, even though the extreme poor person is now even poorer. Similarly,  $HC$  does not increase if a poor individual gives part of his/her income to a rich individual (who is already above the poverty line).

Table 3, below, illustrates, with some examples, the behaviour of  $HC$  under alternative hypotheses. Starting from the initial income distribution, it is worth comparing the behaviour of  $HC$  with two alternative income distributions: i) the first, income distribution **B**, is where all poor individuals have zero income; ii) the second, income distribution **C**, is where all poor individuals have an income equal to the poverty line. In income distribution **A**, the number of people with an income below the poverty line is 2. Therefore,  $HC$  is given by the ratio  $2/5$ , which gives 0.4. This means that 40 per cent of the population is poor. When the incomes of all poor individuals are replaced by zero incomes (income distribution **B**), the headcount ratio does not change. As in **A**, there are again two people with incomes below the poverty line.  $HC$  is therefore 0.4 also in this case. An analogous line of reasoning can be used for income distribution **C**. Even though all poor individuals have incomes that are equal to the poverty line, there are again two people who are not above the poverty line. Poverty, as measured by  $HC$ , is again 0.4 (columns C and D). This suggests that  $HC$  is not sensitive to the **depth** of poverty. If different distributions give rise to the same **number** of poor,  $HC$  will show the same value, regardless of the position of individuals with respect to the poverty line.

Table 3 also shows that  $HC$  is both scale and translation invariant (columns E and F). If **original incomes and the poverty line** are increased by 20 per cent, the value of  $HC$  would stay the same. The same happens when both **original incomes and the poverty line** are increased by the same absolute amount of money (say, 2 currency units). Indeed, columns E and F give the same number for  $HC$ , i.e. 0.4.

Columns G and H, instead, show that *HC* obeys the principle of transfers only when people involved in redistribution cross the poverty line. In the first case (column G), the richest individual gives one unit of income to the poorest individual. But the latter individual still stays below the poverty line. The *HC* is therefore equal to 0.4. Whereas, in column H redistributing 3 currency units from the richest individual to a poor individual who is lifted out of poverty halves the headcount ratio (from 0.4 to 0.2), as only one person is now in poverty (20 per cent of the total population).

### Table 3 - The behaviour of HC

Individual	A- The initial income distribution	B - All poor individuals have zero income	C - All poor individuals have incomes equal to the poverty line
A	B	C	D
1	3	0	8
2	6	0	8
3	9	9	9
4	12	12	12
5	20	20	20
Poverty line	8	8	8
Mean income	10	8	11

Original income distribution with all incomes <u>and the poverty line</u> increased by 20%	Original income distribution with all incomes <b>and the poverty line</b> increased by \$ 2	Original income distribution with a redistribution of \$1 from the richest to the poorest, nobody crosses the poverty line	Original income distribution with a redistribution of \$3, the receiver crosses the poverty line
E	F	G	H
4	5	4	3
7	8	6	9
11	11	9	9
14	14	12	12
24	22	19	17
10	10	8	8
12	12	10	10

HC	0.40	0.40	0.40
	0.40	0.40	0.20

	Denotes the individuals involved by the income transfer
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Denotes the individuals involved by the income transfer

## 6.2 The main properties of PG

Poverty gap  $PG$  has similar properties:

- **$PG$  has zero as lower limit.** When all incomes of poor individuals are equal to the poverty line, mean income of the poor and the poverty line itself are equal. The calculated  $PG$  is therefore zero.
- **$PG$  has 1 as the upper limit.** When all incomes of poor individuals are equal to zero, mean income among the poor is also zero. The calculated  $PG$  is therefore 1.
- **$PG$  is scale invariant.** If all incomes and the poverty line are scaled by the same proportional factor  $\alpha$ ,  $PG$  would remain the same, as mean income and the poverty line would either increase or decrease by the same percentage.
- **$PG$  is not translation invariant.** If all incomes and the poverty line are increased (decreased) by the same amount of money,  $PG$  would decrease (increase). Note the difference with  $HC$ .
- **$PG$  satisfies the principle of transfers only in particular cases.** If transfers occur among poor people, mean income of the poor would not change, and  $PG$  would remain the same.  $PG$  may also behave in a perverse way, after a progressive transfer, if a poor individual having an income greater than the average income of the poor is lifted out of poverty. In this case, after the poor individual has been lifted out of poverty, the average income of the poor would decrease. This latter effect would increase the poverty gap, even though there are less poor people in poverty. Therefore, depending on the position of the poor individual with respect to mean income of the poor, when he/she is lifted out of poverty the  $PG$  measure may either increase or decrease, surely an undesirable feature for a poverty index.

Table 4, below, illustrates the properties of the  $PG$  index.

**Table 4 - The behaviour of PG**

Individual	A- The initial income distribution	B - All poor individuals have zero income	C - All poor individuals have incomes equal to the poverty line	Original income distribution with all incomes and the poverty line increased by 20 per cent	Original income distribution with all incomes and the poverty line increased by \$2	Original income distribution with a redistribution of \$1 from the richest to the poorest, nobody crosses the poverty line	Original income distribution with a redistribution of \$3, the receiver crosses the poverty line
A	B	C	D	E	F	G	H
1	3	0	8	3.6	5	4	3
2	6	0	8	7.2	8	6	9
3	9	9	9	10.8	11	9	9
4	12	12	12	14.4	14	12	12
5	20	20	20	24.0	22	19	17
Poverty line	8	8	8	10	10	8	8
Mean income	10.0	8.2	11.4	12.0	12.0	10.0	10.0
Mean income of the poor	4.5	0.0	8.0	5.4	6.5	5.0	3.0
PG				0.438	1.000	0.000	

0.438				0.350	0.375	0.625	
				6			
				5			
Denotes the individuals involved by the income transfer							

Income distributions **B** and **C** illustrates the upper and lower limit of  $PG$  (columns C and D), ranging from 0 and 1. Column E illustrates that  $PG$  is scale invariant, as increasing all incomes and the poverty line by 20 per cent does not change the measured

*PG*. Whereas, column F reveals that *PG* is sensitive to absolute translations of the income distributions. By increasing all incomes and the poverty line by 2 currency units, the measured *PG* is reduced, in the example, to 0.35, as the average income of poor individuals is now higher than in the previous case. In column G, we can see that a **progressive transfer** of 1 currency unit reduces the poverty gap (note the difference with *HC*). At the same time, it is worth noting the undesirable property of this index, illustrated in column H. After a progressive transfer where the poor individual has been lifted out of poverty, the calculated *PG* increases from 0.438 to 0.625! This is so because the receiver of the transfer has an initial income of 6 which is above the mean income of the poor (4.5). The opposite would be true if the receiver had an income above the initial mean income of poor individuals. Indeed, the fact that the poverty gap is 0.625 in column H and 0.375 in column G does not mean that eradicating poverty, in **aggregate terms**, is easier in the case of column G. If we take the aggregate figure (*PG* x poverty line x number of people in poverty) this gives 6 currency units in column G (0.375 x 8 x 2) and 5 currency units in column H (0.625 x 8 x 1).

## 7 A SYNTHESIS

It is worth summarising the main features of *HC* and *PG* in table 5.

**Table 5 - The main characteristics of *HC* and *PG***

	LOWER LIMIT	UPPER LIMIT	SCALE INVARIANCE	TRANSLATION INVARIANCE	PRINCIPLE OF TRANSFERS	APPEAL
<b>HC</b>	0	1	YES	YES	NO -The principle is satisfied only in special cases	Low
<b>PG</b>	0	1	YES	NO	NO -The principle is satisfied only in special cases	Low

A convenient feature is that both range from 0 and 1, i.e. they are bounded from below and from above with straight forward extreme values. Both are also scale invariant, and this may be a convenient feature, as the poverty index does not change with equi-proportional increases of all incomes. Only *HC* is translation invariant, however, and it depends on the fact that the focus of *HC* is on the number of poor people and not on their income levels. *PG* is indeed not translation invariant. A very undesirable feature of both indexes, which suggests that we look for other possibilities, is that neither of them obey the principle of transfers. This shortcoming more than compensates some other convenient features, hence the reason why our judgement on their appeal for poverty measurement is «Low». Notwithstanding this severe shortcoming, both indexes are widely used in empirical applications. Yet, we must be aware of their strong limitations.

## 8 READERS' NOTES

### 8.1 Time requirements

The delivery of this module to an audience already familiar with the definition of poverty both in absolute and relative terms may take about three hours.

### 8.2 Frequently asked questions

- ✓ **Is the headcount ratio the simplest way to measure poverty?** The answer is yes, as the headcount ratio only needs to define a poverty line and to count the poor as a proportion of total population. Even though widely used, this measure has serious shortcomings, as it is not very sensitive to changes of the income distribution involving poor individuals.
- ✓ **How do we remedy the insufficiency of the headcount ratio?** In order to give a more appropriate picture of poverty, poverty measures based on the distance between individual incomes and the poverty line should be used. This is the case of the poverty gap.
- ✓ **Why are the headcount ratio and the poverty gap so widely used in applied works?** They are easy to calculate and convey an immediate political message: poor are too many; the distance of the poor from the poverty line is too big. More complicated poverty measures, even though more precise, may be undermined by the difficulty in their interpretation, especially for policy-makers. Nevertheless, we must be aware of the limitations of both *HC* and *PG*.

### 8.3 EASYPol links

Complementary EASYPol modules are listed here below.

The following modules serve as background material to better understand the content of the present module

- EASYPol Module 004: [Impacts of Policies on Poverty: The Definition of Poverty](#)
- EASYPol Module 005: [Impacts of Policies on Poverty: Absolute Poverty Lines](#)
- EASYPol Module 006: [Impacts of Policies on Poverty: Relative Poverty Lines](#)

Furthermore, the modules here below contain more advanced materials on poverty measurement:

- EASYPol Module 008: [Impacts of Policies on Poverty: Axioms for Poverty Measurement](#)
- EASYPol Module 009: [Impacts of Policies on Poverty: Distributional Poverty Gap Measures](#)
- EASYPol Module 010: [Impacts of Policies on Poverty: Generalised Poverty Gap Measures](#)



## 9 REFERENCES AND FURTHER READINGS

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