ON THE DEPRIVATION-SENSITIVE MEASUREMENT OF POVERTY

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SUMMARY

Measuring the overall degree of poverty in a society, any poverty index is desired to depend on the feeling of relative deprivation of the poor. Investigating this problem, present paper deals with the sensitivity of the overall poverty measurement to the change in the overall degree of relative deprivation felt by the poor. According to the approach applied, a decrease in the overall degree of relative deprivation is considered ceteris paribus as a poverty measurement reducing factor no matter what additional change occurred in the income configuration of the poor. The paper discusses a poverty measure which explicitly involves the value of an overall deprivation index of the poor and hence is deprivation sensitive in the sense described above.

KEYWORDS: Poverty measurement; Relative deprivation; Transfer sensitivity.

In order to measure the poverty in a society of n persons with $Y_i \geq 0$ ($i=1,2\ldots,n$) incomes, we first of all need to identify who the poor are. In this identifying process the population is split into two groups by fixing an appropriate poverty line z, which is common and given for all individuals. People with incomes not higher than (or strictly below) this income threshold constitute π, the q-member set of 'the poor'. Once this subset of the society has been distinguished, a comprehensive, brief P poverty index is needed to aggregate the information about the poverty gaps of the poor.[2] This overall poverty index should reflect the relative number of the poor (q,n), the distance of the poor from the poverty line (δ_π) and the degree of dispersion among the poor (σ_π) while its value is expected (but not necessarily) to fall into the [0,1] interval with $P=1$ when everyone in the society has zero income and $P=0$ when no poor are in the society at all: $0 \leq P = f(q,n,\delta_\pi,\sigma_\pi) \leq 1$.[3] It was *Amartya Sen* (1976) who in his pioneering work, argued for taking into account the feeling of relative deprivation as the σ_π component of poverty. In addition, he introduced some basic axioms (reasonable requirements) to be satisfied by any poverty index. One of these axioms is the minimal regressive transfer axiom which

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[2] The poverty gap is the shortfall of an individual from the poverty line.
[3] The 'π' subscript indicates that the measure concerned is evaluated for the subgroup of the poor.

states that the poverty index should increase due to the transfer when a poor person gives a positive amount of his (her) income to a 'richer' poor, who, however, remains poor despite the transfer. Without doubt such a transfer raises the degree of inequality, but not necessarily that of relative deprivation, which is also a straightforward aspect of the income dispersion. Consequently, when an overall relative deprivation measure is involved in the poverty index, its reduction due to a regressive transfer may occasionally, *ceteris paribus,* reduce the degree of poverty. Nevertheless, despite this reducing effect, the level of the overall poverty index does not necessarily decrease. This is the basic problem to be discussed in this paper. Thus, the paper is structured as follows. Section 1 summarizes the basic principles of measuring poverty. In Section 2, the deprivation impact of the regressive transfer is investigated based on some *Paul* type relative deprivation measure including a newly defined deprivation index as well. Based on these deprivation indices, Section 3 introduces a new poverty index, which inherits the properties of the deprivation indices applied.

1. Poverty index constructions

Let us consider a population of n persons with their $\mathbf{Y}=(Y_1 \leq ... \leq Y_i \leq ... \leq Y_j \leq ... \leq Y_n)$ ordered discrete income distribution ($Y_1 \geq 0$) and the corresponding $P(\mathbf{Y},z)$ poverty index the value of which indicates the overall degree of poverty associated with the z poverty line. The following definitions are of our interest in relation with the income distribution.

– *Regressive transfer*. $\mathbf{Y}^t$ is obtained from $\mathbf{Y}$ by a single regressive transfer if this transfer reduces the i person's income by a Δ positive amount and simultaneously gives this income to a richer (at least not poorer) person so that $Y^t_i = Y_i - \Delta$ and $Y^t_j = Y_j + \Delta$ while all other incomes remain unchanged.

– *Weak definition of the poor*. Any person with income less than the poverty line is considered poor.

– *Strong definition of the poor*. Any person with income not higher than the poverty line is considered poor.

– *Truncated income distribution*. The $\mathbf{Y}_\pi$ distribution is truncated by the poverty line if the nonpoor incomes are omitted from the income distribution.

– *Censored income distribution*. The $\mathbf{Y}^c$ distribution is censored if the incomes above the poverty line are replaced by the level of the poverty line itself (*Hamada* et al., 1978).

Concerning the properties of poverty measures, a basic framework of eight 'core' axioms has been distinguished by *Zheng* (1997).[4]

1. Focus axiom: the poverty measure is required to be independent of the income distribution of the nonpoor.

2. Symmetry axiom: this axiom says that the poverty measure is invariant to any permutation of the income recipients.

[4] These axioms are 'core' axioms in the sense that 'they are independent and jointly they can formulate other reasonable axioms' such as weak (strong) monotonicity, nonpoverty growth, monotone sensitivity, progressive transfer, normalization, decomposability axioms, etc. For further details see *Sen* (1976), *Takayama* (1979), *Thon* (1979), *Blackorby* and *Donaldson* (1980), *Kakwani* (1980a,b), *Clark* et al. (1981), *Kundu* and *Smith* (1983), *Foster* et al. (1984), *Hagenaars* (1987), etc.

3. Replication invariance axiom: $P(\mathbf{Y},z)=P(\mathbf{Y}',z)$ whenever $\mathbf{Y}'=(\mathbf{Y},\mathbf{Y},...,\mathbf{Y})$ is obtained by some replications of $\mathbf{Y}$.

4. Continuity axiom: the poverty measure is a continuous function of Y for any given z.

5. Increasing poverty line axiom: $P(\mathbf{Y},z)<P(\mathbf{Y},z')$ whenever $z<z'$.

6. Regressive transfer axiom: $P(\mathbf{Y},z)<P(\mathbf{Y}',z)$ whenever $\mathbf{Y}'$ is obtained from $\mathbf{Y}$ by a regressive transfer with at least the donor being poor.

7. Weak transfer sensitivity axiom: $P(\mathbf{Y}',z)>P(\mathbf{Y}'',z)$ whenever $\mathbf{Y}'$ and $\mathbf{Y}''$ are obtained from $\mathbf{Y}$ by transferring a $\Delta>0$ income from poor person i to j and from poor person k to l respectively with $Y_j\text{-}Y_i=Y_l\text{-}Y_k>\Delta,\ Y_k>Y_i$ with no one crossing the poverty line after the transfers.

8. Subgroup consistency axioms: considering a grouped population the poverty index, ceteris paribus, must decrease by the decrease in the poverty level of a subgroup.

From the deprivation point of view, the so-called minimal regressive transfer axiom is the focus of our attention in the following approach.[5]

Minimal regressive transfer axiom: the poverty index must increase whenever, with other given things, a poor person gives a positive amount of his (her) income to a 'richer' poor, who 'however' remains poor despite this transfer.

A poverty index which is sensitive to the relative number of the poor and simultaneously insensitive to the incomes above the poverty line can be constructed applying either the so-called truncated or the censored income distribution. In the case of the truncated distribution P must be an explicit function of q and n, while using the censored income distribution P implicitly possesses this insensitivity property.

The most common measure of poverty is the $H=q/n$ '*head-count ratio*' which is the relative number of the poor proportional to the total population. Another fundamental poverty measure is the '*income-gap ratio*' I which is the percentage shortfall of the average income of a poor from the poverty line. Its value indicates the δ_π distance of the poor from the poverty line: $I=1-\sum^{q}_{i=1} r_i/q$ where $r_i=Y_i/z$ is the *relative income* of the poor person i, proportional to the poverty line. In addition, when $\sigma_\pi=0$, i.e. all the poor have the same income level, the $H{\cdot}I$ product of these two factors – termed '*normalized poverty value*' – is an appropriate measure of poverty.

Clearly, both H, I and $H{\cdot}I$ are completely insensitive to any change in the income configuration when the average income of the poor remains unchanged. Nevertheless, creating an I_σ distribution-sensitive version of the income-gap ratio, it yields a distribution-sensitive $H{\cdot}I_\sigma$ *poverty value.*[6] This way we get one of the basic definitions of the poverty level.[7]

[5] Any poverty index, which satisfies the minimal transfer axiom, is termed *distribution-sensitive* poverty measure in the literature.

[6] The subscript σ indicates distribution-sensitive measure.

[7] Other definitions of P applied by the literature are as follows: (*i*) Poverty is the normalized weighted sum of some function of the individual $g_i=z\text{-}Y_i$ poverty gaps (for all $i\in\pi$) with the $P=H{\cdot}I$ normalization requirement when there is no dispersion among the poor at all. (*ii*) Poverty is the weighted average of the 'head count ratio' and the 'normalized poverty value' with weights E_π and (1- E_π) respectively where $0 \leq E_\pi \leq 1$ is the degree of inequality of the incomes of the poor. (*iii*) Poverty is the inequality index of the censored income distribution. (*iiii*) Poverty is the distribution-sensitive income (welfare) -*gap ratio* of the censored income distribution $P=I_\sigma(\mathbf{Y}^c)$. For the most important poverty indices proposed by the literature so far see e.g. *Foster* (1984) and *Zheng* (1997).

At this stage our purpose below is to characterize the parameter σ_π by measuring the feeling of relative deprivation among the poor in relation to other poor persons, based on some appropriate individual deprivation function.[8]

Deprivation function: Individual i feels $d_{i<j}= d_{ij}>0$ deprivation in relation to any j person with income $Y_j> Y_i$ and $d_{i\geq j}=d_{ij}=0$ deprivation otherwise. Any j person with $d_{ij}>0$ deprivation is considered as a reference person of i and they constitute the reference group of i. The overall measure D of relative deprivation is some function of the individual $d(Y_i)$ deprivation functions: $D=f\{d(Y_i)\}$.

Paul (1991) argued that an aggregate index of relative deprivation had to be based on such an individual deprivation function which is sensitive to income transfers among those who are richer than him and satisfies the following desirable axioms.

– *Deprivation axiom 1*: the incomes of all others remaining the same, the deprivation of person i declines with the increase in his own income, i.e., $\partial D(Y_i)/\partial Y_i < 0$.

– *Deprivation axiom 2*: an increase in the income of person j causes an increase in the relative deprivation of person i, i.e., $\partial D(Y_i)/\partial Y_j > 0$.

– *Deprivation axiom 3*: the deprivation of person i increases less than proportionately with the increase in the income of person j, i.e., $\partial^2 D(Y_i)/\partial Y_j^2 < 0$.

– *Deprivation axiom 4*: if Y_i, Y_j, Y_k, Y_l and Y_m are the incomes of persons i, j, k, l and m, such that $Y_i < Y_j < Y_k < Y_l < Y_m$, then a transfer of income, say $\Delta>0$ from person m to person l will cause less deprivation to person i than the transfer of Δ from person k to j, i.e., $\partial^3 D(Y_i)/\partial Y_j^3 > 0$.

– *Deprivation axiom 5*: the deprivation of person i decreases less than proportionately with the increase in its own income. In other words, marginal deprivation of person i increases with the increase in its own income, i.e., $\partial^2 D(Y_i)/\partial Y_i^2 > 0$.

– *Deprivation axiom 6*: the higher the income of person i is, the lower the increase in the marginal deprivation is, i.e., $\partial^3 D(Y_i)/ \partial Y_i^3 < 0$.

2. Measuring the relative deprivation of the poor

The question arising at this stage is how a regressive transfer influences the D overall degree of relative deprivation. Let us divide the population into two subgroups: on the one hand we have the set of people unaffected by the transfer, on the other hand we have a two-member group of the donor and the receiver.

It is obvious that among those with unaffected incomes, the degree of relative deprivation remains unchanged, while between the donor and the receiver it increases. However, the overall impact of the regressive transfer is ambiguous, because some of the remaining individual deprivations decrease while others increase simultaneously. While deprivations felt in relation to the donor and those felt by the receiver decrease, deprivations felt by the donor and those felt in relation to the receiver increase. Besides, when

[8] In accordance with Runciman's criteria (*Runciman*, 1966), a person is relatively deprived of *X*, when: '(*i*) he does not have *X*, (*ii*) he sees some other person or persons, which may include himself at some previous or expected time, as having *X*, (*iii*) he wants *X*, (*iiii*) he sees it as feasible that he should have *X*.' The relativity of the concept is introduced by (*ii*) and (*iiii*), and the feeling of deprivation is defined by (*i*) and (*iii*). Runciman's criteria suggest that people compare themselves with some reference group within the society rather than with the whole society. Those people to whom person i compares himself constitute the reference group i.

the income rank of the donor or the receiver changes, the reference group of the donor will broaden and the reference group of the receiver will narrow. Altogether, as a joint result of these factors, the overall degree of relative deprivation can either increase or decrease.

Now with the reference group of a poor person defined, several methods can be applied for measuring the *overall degree* of relative deprivation.

Firstly, let us define the deprivation function felt by person i with respect to person j as

$$d_{i<j} = (Y_j / Y_i)^{1/\beta} - 1$$

and the relative deprivation of person i as

$$D(Y_i) = (1/q) \sum_j d_{i<j}$$

where $\beta>0$ is the deprivation aversion parameter.[9] Then, the Paul-index of the relative deprivation, which satisfies all the deprivation axioms listed previously, is as follows[10]

$$D_{(\beta)} = (1/q) \sum^q_{i=1} D(Y_i).$$

As β increases, the degree of the relative deprivation of the society decreases.

While characterizing the relative deprivation of the poor, it is a serious disadvantage of index $D_{(\beta)}$ that it is not defined for zero incomes, although this is a realistic situation among the poor. Furthermore there is no upper limit to express an extreme degree of being deprived, but $D_{(\beta)}=0$ when all incomes of the poor are equal.

Considering the case of a regressive transfer – as a consequence – the Paul-index always indicates an increase of the overall degree of relative deprivation and hence $D_{(\beta)}$ satisfies the *Dalton-Pique* principle of transfer. This is because the rising effect felt in relation to the receiver of the transfer dominates the reducing factor felt in relation to the donor, and the rising effect felt by the donor dominates the reducing factor felt by the receiver.

On the other hand – as it has been investigated in the literature – a relative deprivation index does not necessarily increases as a result of the regressive transfer. So it is, from this point of view that we will discuss further on a relative deprivation index which is inversely related to the Paul's function and allows the deprivation rising factor to dominate the reducing factor and hence sometimes indicates a decrease rather than an increase in the overall degree of relative deprivation.

For this reason let us consider alternatively the

$$d_{i<j} = (1 - Y_i/Y_j)^{1/\beta}$$

deprivation function ($\beta>0$) which is defined for zero Y_i incomes as well. Using this function, the relative deprivation of person i is

$$Q(Y_i) = (1/q) \sum_j d_{i<j}$$

[9] Recall that for $d_{i<j}$, $Y_i < Y_j$.

[10] We do not use the *Chakravarty-Chakraborty* (1984) general relative deprivation index here, because it does not satisfy the deprivation axioms 3–6.

and the overall measure is

$$Q_{(\beta)}= [\ (1/q)\ \Sigma^{q}_{i=1}\ Q(Y_i)\ ]^{\beta}.$$

Obviously, $0\leq Q_{(\beta)}\leq(q\text{-}1)/q$ with $Q_{(\beta)}$=0 when all the poor have equal incomes and $Q_{(\beta)}=(q\text{-}1)/q$ when there is a perfect inequality among the poor. Index $Q_{(\beta)}$ can also be interpreted as the average proportion of the individual incomes which is not shared by the deprived poor.

Index $Q_{(\beta)}$ satisfies the deprivation axioms 1-2 for β>0, axiom 3 for $\beta>(0<c_1<1)$, axiom 4 for $\beta>(0<c_2<1)$, axiom 5 for $0<\beta<1$ and axiom 6 for $0<\beta<0.5$ and $\beta>1$. As β approaches infinity, $Q_{(\beta)}$ becomes zero.

From the point of view of the regressive transfer the following properties of $Q_{(\beta)}$ can be summarized.

– $Q_{(\beta)}$ always increases when the donor is the poorest and the receiver is the richest among the poor because there is no reducing effect in this case at all.

– A reduction in someone's deprivation felt in relation to the donor always dominates his (her) increment felt in relation to the receiver.

– Assuming β=1 unit deprivation aversion, the fall and rise in the deprivation of the receiver and the donor felt respectively in relation to a common reference person equalize one another. Hence, in this case, the change of $Q_{(\beta)}$ will be a decrease when the decrease of deprivation felt in relation to the donor dominates the joint effect of the remaining increasing factors, namely the deprivation felt by the donor in relation to nonrichers than the receiver, and felt by nonrichers than the receiver.

– Assuming β>1 deprivation aversion, the reducing factor felt by the receiver exceeds the rising factor felt by the donor in relation to the reference persons of the receiver and the reduction in someone's deprivation felt in relation to the donor becomes more dominant to his/her increment in relation to the receiver.

– Assuming $0<\beta<1$ deprivation aversion, the reducing factor felt by the receiver is dominated by the rising factor felt by the donor in relation to the reference persons of the receiver. Meanwhile, the reduction in someone's deprivation felt in relation to the donor becomes less dominant to his (her) increment in relation to the receiver.

3. Poverty indices based on Paul-type deprivation measures

At the outset let us consider the $r_1 \leq r_2 \leq \ldots \leq r_q$ truncated distribution of the relative incomes and define the[11]

$$r_{(\beta)} = [\ (1/N)\cdot \Sigma_{j=1,\ldots,q}\ (q+1\text{-}j)(1/r_j)^{1/\beta}\ ]^{|\beta|}$$

weighted average deprivation of these relative incomes felt in relation to the *unit poverty line*, where $N=q(q+1)/2$ means the sum of the (q+1-j) weights and $\beta\neq 0$.[12] This index represents the overall degree of being deprived among the poor, where all the reference persons have an income level corresponding to the poverty line. Clearly $1/r_{(1)}$ is the

[11] As earlier defined, $r_i=Y_i/z$.

[12] Obviously, this is a slightly modified version of the Paul's deprivation index.

weighted harmonic mean and $r_{(-1)}$ is the weighted arithmetic mean of the relative incomes. In other words, $1/r_{(1)}$ is a deprivation preserving representative (average) relative income, which preserves the $r_{(1)}$ degree of the relative deprivation felt by the average income level in relation to the poverty line.

Furthermore, let us consider the

$$1 - Q_{|\beta|}$$

complement of index Q, termed '*relative satisfaction*'.[13] Apparently $1–Q_{(1)}$ represents the proportional amount of income of the richer poor owned by the deprived persons in an average sense. Based on this relative satisfaction we specify the following $H{\cdot}I_\sigma$ type index which depends on the overall degree of the relative deprivation felt among the poor:

$$P_{(\beta)} = H{\cdot}I_{(\beta)} = H \cdot [\ 1 - (1/r_{(\beta)})^{\beta/|\beta|}\ (1- Q_{|\beta|})\ ]$$

where $\beta \neq 0$.

Recalling the interpretation of $1–Q_{(1)}$ and $1/r_{(1)}$, the meaning of the $(1–Q_{(1)})/r_{(1)}$ quantity is the proportional satisfaction of the 'representative deprived poor person' who is deprived of the deprivation-preserving relative income level. So, $I_{(1)}$ represents a *deprivation gap-ratio* in relation to the unit poverty line.

Unfortunately $P_{(\beta>0)}$ is not defined for zero incomes. However, this problem can be eliminated by choosing $\beta<0$ values for which $r_{(\beta<0)}$ is the $1/\beta$-order moment of the relative incomes and is defined for zero incomes as well.

Obviously, $0 \leq P_{(\beta<0)} \leq 1$ and $0 \leq P_{(\beta>0)} < 1$ with $P_{(\beta<0)}=1$ when each member of the society has a zero income and $P_{(\beta<0)}=P_{(\beta>0)}=0$ when there are no poor in the society at all. In addition, ceteris paribus, the higher the weighted (parametric) average of the relative incomes is, the lower the degree of poverty is, and the higher the overall relative deprivation among the poor is, the higher the level of poverty is.

Since $1/r_{(\beta>0)}$ and $r_{(\beta<-0.5)}$ always decrease as a result of a regressive transfer, this decrement – depending on the value of β - can dominate a simultaneous decrement of Q. So choosing an appropriate value for β (putting more weight on the lower tail of the income distribution) an increment of $P_{(\beta)}$ is expected in the case of a minimal regressive transfer.

Apparently index $P_{(\beta)}$ satisfies the focus, symmetry, increasing poverty line and transfer sensitivity axioms, but it is not continuous at the poverty line level and it is not replication invariant.[14] Finally, its deprivation-sensitivity (similarly to the problem of the regressive transfer) may conflict with its subgroup consistency.

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[13] This terminology has been introduced by *Yitzhaky* (1979).

[14] Although Q is replication invariant, this is not valid for r.

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