On the estimation of the food poverty line

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Abstract

The paper compares two alternative methods of estimating the food poverty line, the "food basket method" (FB) and the "minimum cost method" (MC), and it shows that under plausible restrictions on households' preferences and consumption behavior the FB method tends to overestimate the food poverty line with respect to the MC method. The overestimation is also transmitted to the poverty line to an extent that depends on the food expenditure share, the elasticity of the non-food expenditure share with respect to food expenditure and the elasticity of total expenditure with respect to food expenditure.

1 Introduction

In the cost of basic needs approach to poverty analysis [8], the poverty line, i.e. the threshold value for household expenditure that identifies the poverty status, can be conveniently expressed as the sum of two components: the food component, called food poverty line, and a second component that identifies non-food basic needs. This second component is usually estimated starting from the food component and by taking into account the consumption behavior of poor households [6], [8]. The estimation of the food poverty line therefore has a direct and an indirect impact on poverty estimates.

A first method to estimate the food poverty line relies on the identification of a basic need food bundle representative of the consumption pattern of poor households. The market value of this bundle provides the estimate of the food poverty line. We refers to this first method as the "food basket method" (FB). The FB method is quite popular among practitioners[1] and the reason is that the representative basic need bundle identifies, by construction, the same standard of living for all households. This means that the property of "consistency" is always satisfied. Another advantage is the transparency with respect to the composition

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[1] See for instance the systematic studies on poverty based on the Living Standard Measurement Surveys in developing countries carried out by the World Bank

of the food basket underlying the food poverty line. An alternative approach, that we call the "minimun cost method" (MC), is based on the estimate of the average cost of one calorie incurred by poor households, without specifying the food bundle actually consumed by those households. The advantage of the MC method is that it takes into account for the "specificity" of the consumption patterns of the households, for instance in response to different market conditions in different areas. The drawback is that the MC method is less transparent and, to the extent that it does not specify a unique basic need bundle, it entails the risk of violating the consistency property [3].

This paper shows that, for given a reference group of poor households with homogeneous preferences and under economically meaningful and plausible restrictions, the FB method implies an overestimation of the food poverty line with respect to the MC method[2]. Intuitively, the upward bias of the FB method depends on the fact that it does not take into account for the substitution effects among food consumption goods due to relative prices dispersion. However, it is possible to prove that this bias persists even in the absence of significant substitution effects. The FB and the MC methods are in fact two different ways of calculating the average cost of one calorie underlying the food poverty line. The FB method is based on a "plutocratic mean" of the cost of one calorie, with weights that are proportional the relative per capita caloric consumption of the households. The MC methods relies on a "democratic mean" in which every household receives the same weight [4],[1]. If the cost of one calorie is positively correlated to relative per capita caloric consumption, then the FB method overestimates the food poverty line with respect to the MC method, even in the absence of price dispersion or in the absence os substitution effects due to price dispersion. Moreover, if the elasticity of the non food component of the poverty line with respect to the food poverty line is positive, the overestimation of the food poverty line also affects the total poverty line and, as a consequence, all the possible poverty measures.

The rest of the paper is organized as follows. Section 2 describes analytically the FB and the MC methods. Section 3 compares the two methods. Section 4 analyzes the impact of the overestimation of the food poverty line on the total poverty line. Conclusions follow.

2 Estimation methods of the food poverty line

According to the cost of basic needs approach, the food poverty line is given by the minimum cost needed to achieve an exogenously given minimum energy requirement (ER). This energy requirement is measured in term of per capita and per diem caloric consumption and

[2]The assumption of homogeneous preferences is crucial here; in a standard microeconomic framework with regular preferences, a fixed consumption bundle cannot be the solution of a cost minimization problem for all the possible price vectors. In this sense, the results obtained in this paper are in line with those illustrated in [2].

it is determined on a normative basis[3]. The main issue is therefore that of estimating the cost function of a subset of poor households given the specific market conditions faced by the households and the minimum standard of living identified by ER. Such a cost can be calculated by estimating the market value of a food bundle, representative of the consumption pattern of the poor households and such that it provides ER (method FB), or alternatively by directly estimating the average minimum price of one calorie paid by the poor households and multiplying that price for the amount ER (method MC). The next two subsection describe analytically these two alternative estimation strategies.

2.1 The food basket method

Let us denote with $\mathbb{H}$ the reference group of households considered for the estimation of the food poverty line. The households belonging to $\mathbb{H}$ are indexed by $h = 1, 2, ..., H$. The set $\mathbb{H}$ is usually identified looking at a specific real expenditure or income percentile that, on the basis of a priori information, is supposed to be placed around the poverty line or, in any case, that identifies a subset of households representative of the consumption behavior of poor households. We also assume that these households have homogeneous preferences; this extreme assumption rule out any aggregation problem or composition effect due to agents' heterogeneity. Let us define the food basket including n food consumption goods consumed by household h as:

$$\mathbf{q}^h = \left(q_1^h, q_2^h, \ldots, q_n^h\right)$$

The average basket consumed by the households belonging to the reference group $\mathbb{H}$ is:

$$E_{\mathbb{H}}\left[\mathbf{q}^h\right] = \left(E_{\mathbb{H}}\left[q_1^h\right], E_{\mathbb{H}}\left[q_2^h\right], \ldots, E_{\mathbb{H}}\left[q_n^h\right]\right)$$

where $E_{\mathbb{H}}$ denotes the average over all the households belonging to $\mathbb{H}$. Let k_i, $i = 1, 2, ..., n$ be the coefficients that convert quantities into calories. The calorie content of $\mathbf{q}^h$ is given by:

$$\sum_{i=1}^{n} k_i E_{\mathbb{H}}\left[q_i^h\right] = EI$$

Let $\lambda = ER/EI$ be the minimum energy requirement relative to the average energy intake of the poor households, and $E_{\mathbb{H}}[p_i]$ be the average price of commodity i paid by the same households. Hence, according to the FB method, the food poverty line is:

$$FPL_{(FB)} = \lambda \sum_{i=1}^{n} E_{\mathbb{H}}[p_i]\, E_{\mathbb{H}}\left[q_i^h\right] \tag{1}$$

[3]We will abstract here from the quality and the composition of the calories consumed by the household, i.e. from the micro-nutrient contained in a given food bundle.

In other words, the food poverty line is given by the average market value of a representative bundle $E_{\mathbb{H}}\left[\mathbf{q}^h\right]$ rescaled through λ in such a way that it provides exactly the calorie amount ER.

2.2 The minimum cost method

An alternative estimation strategy for the food poverty line is to calculate the average cost of one calorie over all the households belonging to the reference group $\mathbb{H}$. If the behavior of these households is consistent with the standard microeconomic consumption model, such an average cost can be interpreted as a minimum cost. The minimum cost to obtain ER on the market can be thus derived by multiplying the unitary average cost by the amount ER. Let us define the average cost of one calorie for the household h as follows:

$$c^h = \frac{\sum_{i=1}^{n} p_i^h q_i^h}{\sum_{i=1}^{n} k_i q_i^h} = \frac{\sum_{i=1}^{n} p_i^h q_i^h}{Kcal_h}$$

where $Kcal_h$ is the calorie intake of household h. The average minimum cost of one calorie will be given by:

$$E_{\mathbb{H}}\left[c^h\right] = E_{\mathbb{H}}\left[\frac{\sum_{i=1}^{n} p_i^h q_i^h}{Kcal_h}\right]$$

Hence, the food poverty line based on the MC estimation method is:

$$FPL_{(MC)} = E_{\mathbb{H}}\left[\frac{\sum_{i=1}^{n} p_i^h q_i^h}{Kcal_h}\right] \cdot ER \tag{2}$$

It should be noted that the MC method is based directly on the food expenditure of the poor households belonging to $\mathbb{H}$ and therefore does not make explicit a representative consumption basket[4]. From this point of view, the MC method incorporates all the substitution effects due to relative price variability within the reference group $\mathbb{H}$.

3 Comparing the food basket and the minimum cost methods

This section compares the two estimation methods illustrated above to find out if there are specific and economically meaningful condition such that the FB method tends to overestimate the food poverty line with respect to the MC method, or vice versa.

[4]It should also be observed that the MC method does not require the estimation of the average market prices of food items

First of all, note that the equation (2) can be rewritten as follows:

$$FPL_{(MC)} = E_{\mathbb{H}}\left[\sum_{i=1}^{n} p_i^h q_i^h \cdot \frac{ER}{Kcal_h}\right] = E_H\left[\sum_{i=1}^{n} p_i^h q_i^h \cdot \lambda_h\right]$$

where $1/\lambda_h$ denotes the caloric intake of household h relative to the minimum energy requirement ER, which means that the food poverty line underlying the MC method can be also formulated as a weighted average food expenditure with weights that depend on the household's relative caloric intake. Suppose now that λ_h is stochastically independent from food expenditure[5]. Hence:

$$FPL_{(MC)} = E_{\mathbb{H}}\left[\lambda_h\right] \cdot E_{\mathbb{H}}\left[\sum_{i=1}^{n} p_i^h q_i^h\right] = E_{\mathbb{H}}\left[\lambda_h\right] \cdot \left[\sum_{i=1}^{n} E_{\mathbb{H}}\left[p_i\right] E_{\mathbb{H}}\left[q_i^h\right] + \sum_{i=1}^{n} cov_{\mathbb{H}}\left(p_i^h q_i^h\right)\right]$$

remembering equation (1) we can write:

$$FPL_{(FB)} - FPL_{(MC)} = \left(\sum_{i=1}^{n} E_{\mathbb{H}}\left[p_i\right] E_{\mathbb{H}}\left[q_i^h\right]\right)\left(\lambda - E_{\mathbb{H}}\left[\lambda_h\right]\right) - E_{\mathbb{H}}\left[\lambda_h\right] \cdot \sum_{i=1}^{n} cov_{\mathbb{H}}\left(p_i^h q_i^h\right) \quad (3)$$

Suppose now that $E_{\mathbb{H}}\left[\lambda_h\right] = \lambda$. This implies that the first right-hand term of equation (3) goes to zero and $FPL_{(FB)} - FPL_{(MC)} > 0 \iff \sum cov_{\mathbb{H}}\left(p_i^h q_i^h\right) < 0$. But the latter condition is equivalent to assuming "gross substitutability" between food consumption goods, a restriction certainly satisfied under the assumptions of regular preferences. As already mentioned, the MC method takes into account for the substitution effects, whereas the FB method neglects such effects. It is therefore not surprising that by assuming regularity of the demand functions, the FB method tends to overestimate the minimum cost necessary to satisfy a given caloric requirement.

The problem, however, is that condition $E_H\left[\lambda_h\right] = \lambda$ is not generically satisfied. Remember that $H\left[x\right] = 1/E\left[1/x\right]$, where $H\left[x\right]$ is the harmonic mean of x. Accordingly, $E_H\left[\lambda_h\right] = ER/H_H\left[Kcal_h\right]$, from which, by Cauchy's inequality, we get $E_H\left[\lambda_h\right] \geq \lambda$. Hence, the first right-hand term of equation (3) is not necessarily equal to zero and is possibly negative. Because of that, the sign of $FPL_{(FB)} - FPL_{(MC)}$ is ambiguous even if the consumption goods are gross substitutes. Add to this that also the hypothesis of stochastic independence between λ_h and food expenditure can be violated and therefore equation (3) does not represent an exact decomposition of $FPL_{(FB)} - FPL_{(MC)}$. However, we can identify further economically meaningful restrictions that allow us to remove such an ambiguity. Maintaining the assumption of gross substitutability, it is possible to write:

[5]This assumption is clearly implausible, and indeed it is more likely that the two variables are positively correlated. But in our context this hypothesis is analytically useful to isolate the role played by the substitution effects

$$FPL_{(FB)} = \frac{\sum_{i=1}^{n} E_{\mathbb{H}}[p_i] E\left[q_i^h\right]}{E_{\mathbb{H}}[Kcal_h]} ER > \frac{H \cdot E_{\mathbb{H}}\left[\sum_{i=1}^{n} p_i^h q_i^h\right]}{H \cdot E_{\mathbb{H}}[Kcal_h]} ER = (*)$$

where H is the number of households belonging to the reference group $\mathbb{H}$. It should be noted now that:

$$(*) = \frac{\sum_{h=1}^{H}\sum_{i=1}^{n} p_i^h q_i^h}{Kcal_h} \cdot \frac{Kcal_h \cdot ER}{H \cdot E_{\mathbb{H}}[Kcal_h]} = ER \cdot \sum_{h=1}^{H} c^h \left(\frac{Kcal_h}{\sum_{h=1}^{H} Kcal_h}\right)$$

where c^h is the cost of one calorie for household h. In other words $FPL_{(FB)}/ER$, i.e. the average cost of one calorie implicitly adopted in the FB method, is always larger than the the average of one calorie calculated by using weights proportional to relative calorie intake of the households belonging to the reference group $\mathbb{H}$.
Analogously we can rewrite equation (2) as follows:

$$FPL_{(MC)} = \frac{ER}{H} \frac{\sum_{h=1}^{H}\sum_{i=1}^{n} p_i^h q_i^h}{Kcal_h} = ER \cdot \sum_{h=1}^{H} c^h \left(\frac{1}{H}\right)$$

In other words $FPL_{(MC)}/ER$ is equal to the average of one calorie calculated by using equiproportional weights. Recalling the terminology introduced by [4] e [1], the MC estimates the minimum cost of one calorie as a "democratic mean" of the households' costs, while the FB method always exceed the estimates obtained as a "plutocratic mean", where the household's weights are not based on relative expenditure but on relative calorie intake. If the average cost of one calorie and per capita relative calorie intake of the households are positively correlated, it is possible to conclude that:

$$FPL_{(FB)} > (*) > FPL_{(MC)} \tag{4}$$

The question is then how plausible is the hypothesis of positive correlation that guarantees the validity of inequality (4). In this regard, it should be noted that if real per capita income or consumption are positively correlated with calorie per capita intake and with the quality of calories consumed by the households, the positive correlation between the average cost of one calorie and relative calorie intake seems entirely plausible. It should also be noted that, given the assumption of gross substitutability and the fact that $FPL_{(FB)} > (*)$, such a correlation is a sufficient but non a necessary condition for the validity of inequality (4). It becomes a necessary condition only in the absence of gross substitutability. In that case one would have $\sum_{i=1}^{n} cov_{\mathbb{H}}\left(p_i^h q_i^h\right) = 0$, from which $FPL_{(FB)} = (*)$, and therefore (4) would be satisfied if and only if $(*) > FPL_{(MC)}$. We conclude that the FB method overestimates the food poverty line even if the substitution effects between food consumption goods are negligible, i.e. if the specificity of the household consumption pattern has little relevance, as long as there is a positive correlation between the average cost of one calorie and the relative per capita calorie intake of the poor households.

4 The impact on the upward bias on the poverty line

The cost of basic needs approach defines the poverty line as the sum of the food poverty line and the non-food expenditure component. The non-food component, in the most popular empirical formulation of the method, can be estimated on the basis of the average non-food consumption of those households whose food consumption is around the food poverty line[6]:

$$TPL = FPL + E\left[x_{nf}^h \middle| x_f^h \simeq FPL\right] \tag{5}$$

where x_{nf}^h and x_f^h denote non-food and food expenditure of household h respectively. Let w_{nf}^h be the non-food budget share of household h and let x^h be the total expenditure of the same household. Hence

$$x_{nf}^h = w_{nf}^h \cdot x^h = w_{nf}^h \left(x_{nf}^h + x_f^h\right)$$

After some algebra we obtain:

$$\frac{dx_{nf}^h}{dFPL} = \frac{w_{nf}^h}{w_f^h} \cdot \left(\eta_{w_{nf}/x_f} + \eta_{x/x_f}\right)$$

where η_{w_{nf}/x_f} is the elasticity of non food expenditure wrt food expenditure and η_{x/x_f} is the elasticity of total expenditure wrt food expenditure. Substituting in equation (3) and by applying the Leibenitz rule we get:

$$\frac{dTPL}{dFPL} = 1 + \frac{dE\left[x_{nf}^h \middle| x_f^h \simeq FPL\right]}{dFPL} = 1 + E\left[\frac{w_{nf}^h}{w_f^h} \cdot \left(\eta_{w_{nf}/x_f} + \eta_{x/x_f}\right)\right]$$

Using equation (5), we can approximate the elasticity of the poverty line wrt the food poverty line as follows:

$$\eta_{TPL/FPL} \cong \frac{FPL}{TPL} + \frac{TPL - FPL}{TPL} \cdot \eta \tag{6}$$

where $\eta = \eta_{w_{nf}/x_f} + \eta_{x/x_f}$. If the elasticities of the share of non-food expenditure and total expenditure wrt to food expenditure are positive, the marginal impact of changes in the food

[6]According to the terminology introduced by Martin Ravallion [5][6], such a criterion identifies the "upper bound poverty line".

Table 1: The impact of the upward bias of the FPL over the PL

	$\eta = 1.2$	$\eta = 1.5$	$\eta = 2$
$\Delta = 2.5\%$	1.95 (2.8%)	1.96 (3.2%)	1.97 (3.9%)
$\Delta = 5.0\%$	2.01 (5.6%)	2.02 (6.4%)	2.05 (7.8%)
$\Delta = 10\%$	2.11 (11, 1%)	2.14 (12.8%)	2.19 (15.5%)

poverty line on the poverty line will be positive and greater than 1. We also observe that if the Engel law holds true, $\eta_{x/x_f} > 1$ and $\eta_{w_{nf}/x_f} > 0$. It follows that values of η, and therefore of $\eta_{TPL/FPL}$, greater than 1 are entirely plausible. In order to get an idea of the possible impact of the overestimation of the food poverty line induced by the FB method compared to the AC method, we refer to the so called international poverty line constructed for global poverty comparisons, and in particular to the 1.90 USD PPP adjusted poverty line. We assume that we can disaggregate the international line into the food component and the non-food component based on the consumption pattern of poor households. For example, if the food expenditure share of poor households w_f is 0.45, the food poverty line underlying the international line would be $0.45 \cdot 1.90 = 0.8$. We assume that the international line has been calculated using the MC method. We further assume that the elasticity $\eta_{TPL/FPL}$ is constant and that the food expenditure share of poor households is$w_f = 0.45$. Table 1 shows the effects of a percentage overestimation Δ of the food poverty line induced by applying method FB instead of method MC, by alternative values of the elasticity η. The numbers in the round brackets indicates the percentage change with respect to the official 1.90 USD PPP adjusted poverty line. Those numbers coincides with the values of the elasticities $\eta_{TPL/FPL}$ in equation (6). The numbers out of the brackets measures the absolute change in the poverty line.

As can be seen, for sufficiently high, but not implausible values of the percentage overestimation Δ and for plausible values of the food expenditure share and of the elasticity η, the international poverty line increases significantly from its initial value of USD 1.90 to values exceeding the value of 2.15 USD, which correspond to the new international poverty line recently updated by the World Bank on the basis of the 2017 PPPs. The final impact on poverty estimates will, of course, depend on the elasticity of poverty measures with respect to the poverty line.

5 Conclusion

Two alternative methods of estimating the food poverty line are analytically compared: the "food basket method" (FB) and the "minimum cost method" (MC). The FB method while having the merit of making the composition of the subsistence food basket explicit, neglects potential substitution effects between goods. In contrast, the MC takes such effects into account. It has been shown that under the assumption of homogeneous preferences and gross substitutability and/or positive correlation between relative per capita calorie intake and the average cost of one calorie, the FB method tends to overestimate the food poverty line. The impact of this overestimation is also transmitted to the total poverty line to an extent that depends on the food expenditure share, the elasticity of the non-food expenditure share with respect to food expenditure and the elasticity of total expenditure with respect to food expenditure.

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