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## Absolute poverty measurement with minimum food needs: A new inverse method for advanced economies

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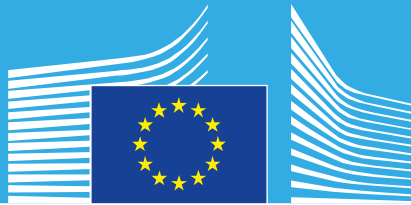
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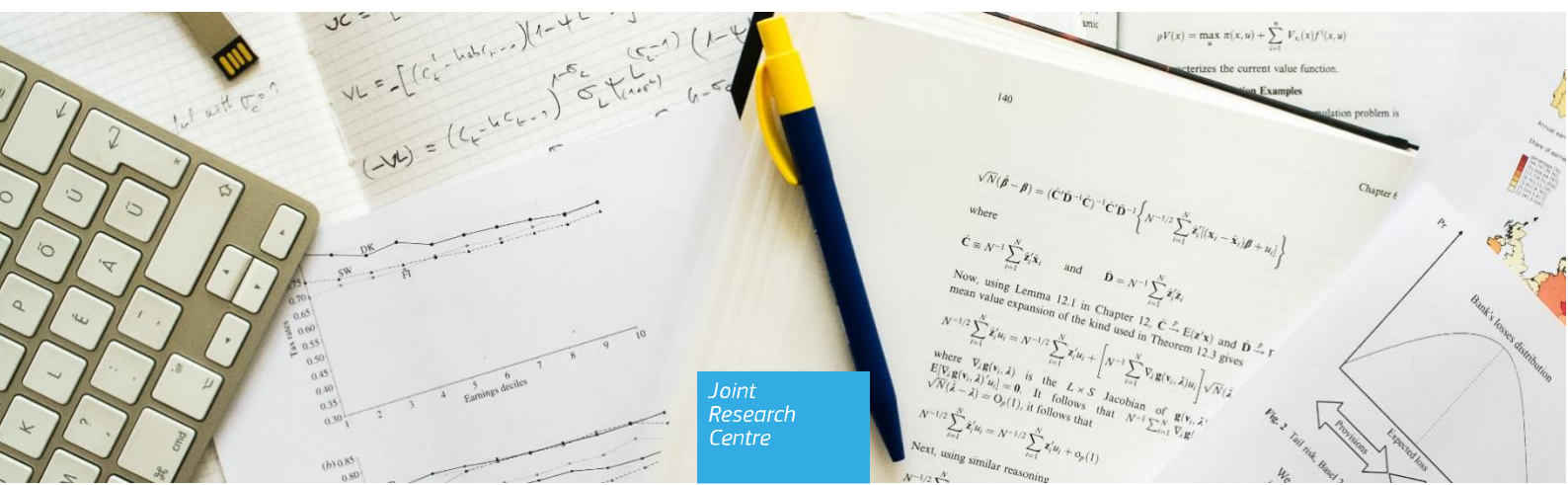
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# JRC TECHNICAL REPORT

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# Absolute poverty measurement with minimum food needs: A new inverse method for advanced economies

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Joint Research Centre, European Commission

9th February 2022

## Abstract

This paper explores the feasibility of calculating absolute poverty lines on the basis of minimum food expenditures in developed countries. It makes three important contributions. First, it demonstrates that standard statistical methods used in the developing world deliver either inadequate poverty estimates in rich countries characterised by a relatively low food expenditure share. Second, it proposes a new simulation-based method that focuses on the non-food Engel curve and uses available food reference budgets not as inputs but as targeted reference points for the calculations. Finally, an empirical application of the new method using household budget survey data from Italy shows that resulting poverty estimates are in line with the official figures of the Italian Statistical Office in terms of both the poverty rate and the poverty profiles. The proposed method is therefore well suited to produce robust and consistent absolute poverty measures in a large number of developed countries.

**JEL Classification:** C10, C63, D12, E20, G50, I32

**Keywords:** absolute poverty measurement, household expenditures, statistical modeling

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# 1 Introduction and motivation

Absolute poverty lines are often calculated on the basis of predetermined food reference budgets. This is made possible by a relatively clear-cut definition of individuals' nutritional needs and reference diets, the widespread availability of food prices, and observed regularities in household consumption. It is theoretically possible to determine households' minimum non-food expenditures in the same bottom-up way, but considerable practical difficulties abound: basic non-food needs are typically rather diverse and lack a clear anchor that would allow for a straightforward representation, while non-food prices are often more variable and less accessible than food prices. This is even more so in developed countries with pluralistic societies, heterogeneous preferences and large inequalities in living conditions.

Therefore, most existing approaches to absolute poverty measurement involve the use of statistical techniques and household budget survey data to calculate the overall poverty line on the basis of food budget inputs. The main questions concern how to account for households' non-food spending and what part of their observed expenditures should be considered for inclusion in the poverty line. In most applications, the practical issue boils down to selecting the relevant population segment whose typical or average observed non-food expenditure could be reasonably considered as representing minimum non-food needs. In the relevant literature, two approaches have gained widespread currency. The so-called "traditional" method takes an agnostic view of what constitutes necessity and focuses on households whose observed food expenditure corresponds to their respective food reference budget (Bidani et al., 2001). The alternative "austere" method proposed by Ravallion and Bidani (1994) gained recognition by offering an appealing necessity test of displacement effects, and focuses on the non-food spending of those households whose total expenditure equal their food reference budget. The underlying argument is that if a household that can barely afford to purchase the minimum food basket chooses to divert some of its resources to non-food spending, this latter clearly needs to be essential and can justifiably be included in the poverty line.

Since food-based absolute poverty measurement has predominantly been the province of developing countries characterised by relatively low non-food expenditure shares, the practical relevance of this methodological choice is rather limited. This is not the case in the context of advanced economies where households' non-food expenditure share often reaches as high as 80 percent. Under such circumstances, the "austere" and "traditional" methods tend to identify very different reference households and lead to vastly divergent poverty estimates. Given the renewed interest in absolute poverty measurement in high-income countries of the EU and the OECD in recent years, it is of high academic and policy interest to assess the conceptual validity and methodological implications of using standard measurement techniques outside of the developing world.

This paper deliberates on these issues and makes three distinct contributions. First, it demonstrates that the two standard methods currently in use are not applicable in the context of developed countries where households' food expenditure share is low. In particular, I show how the "traditional" method delivers unrealistically high poverty estimates due to its inability to differentiate between necessary and non-necessary non-food expenditures, and why the "austere" method becomes overly constrained and yields improbably low poverty estimates when applied in rich-country settings. Second, the paper proposes a new simulation-based inverse method for robust and accurate poverty measurement in developed countries. The proposed method closely follows the mechanics of the Ravallion-Bidani approach, but exploits the symmetry of the underlying demand system and focuses on the dominant non-food Engel curve instead. Specifically, I use the available food reference budgets not as inputs but as targeted reference points during the calculations, and apply a simulation-based estimation procedure that identifies the optimal level of minimum non-food needs based on the observed distance between actual and predicted food budgets.

The paper's third contribution is an empirical application of the proposed method using household budget survey data from Italy, the only EU country engaged in official measurement of abso-

lute poverty. The kind cooperation and support received from the National Institute of Statistics (ISTAT) allowed me to use the official Italian food reference budgets and reference poverty lines for the calculations. The new poverty estimates based on the proposed method are in line with the official ISTAT figures, both as far as the overall level and the relative concentration of poverty across different population segments are concerned. The empirical analysis also demonstrates the inadequacy of the standard "austere" and "traditional" methods used in developing countries. The resulting inverse poverty estimates are naturally sensitive to the food budget inputs but are robust to various measurement choices of both generic (i.e. the regression specification) and specific type (i.e. the presumed structure of unobserved minimum non-food needs).

These results can pave the way for a systematic application of the inverse method for consistent poverty measurement in a large number of developed countries. Improved measurement would be essential for raising awareness, motivating action, designing policy, and monitoring progress for poverty reduction and eradication. The proposed inverse method could be flexibly applied for a wide range of absolute measurement strategies, could deliver complementary poverty estimates to existing indicators, and provide an effective and cross-country comparable benchmark for meeting sustainable development goals. One prominent ongoing application concerns the European Commission's pilot project aimed at measuring and monitoring absolute poverty in the EU (Menyhert et al., 2021).

The remainder of the paper is structured as follows. Section 2 presents the existing statistical methods of food-based absolute poverty measurement, and demonstrates their main limitations and flaws in the context of developed countries characterised by relatively low food expenditures. Section 3 introduces and reviews in detail the proposed new inverse method that enables accurate and robust measurement of absolute poverty in rich countries where households' expenditures are dominated by non-food spending. Section 4 applies the proposed method using official absolute poverty estimates and household budget survey data from Italy, and demonstrates the feasibility and robustness of the method. Section 5 concludes and draws the main policy implications.

## 2 Existing practices in absolute poverty measurement

Poverty may be measured from an absolute or relative standpoint. While relative poverty concerns horizontal inequalities, absolute poverty refers to some time-consistent standard that represents individuals' and households' basic minimum needs (Ravallion, 2015). Absolute poverty measures therefore have particular policy relevance in that they can provide a sound basis for monitoring purposes and effective social policy interventions. For these reasons, cost of living estimates and absolute poverty lines are widely available in developing and developed countries alike (Foster 1998; Gordon and Townsend, 2000; Glennerster, 2002; Scruggs and Allan, 2006; Atkinson, 2019). The detailed modelling of individuals' and households' basic food needs tend to constitute a central element of most approaches, and minimum expenditure thresholds for non-food needs (e.g. housing, transportation) are often defined in relation to the food reference budgets, as pioneered by the United States and followed by other countries (Orshansky, 1969; Havasi, 2015). Despite these similarities, the scope, methodology and application of these minimum thresholds differ so much that no cross-country comparable absolute poverty measurement has proved possible so far.

International comparability is better among developing countries where simpler and more homogeneous methods dominate. Low- and medium-income countries (LMICs) are often characterised by inferior non-food needs and lack of reliable survey data, which renders more in-depth and granular poverty measurement impractical or unfeasible. For this reason, the use of nutrition-based food budgets and simple statistical mapping techniques based on household budget survey microdata has become the standard workhorse in the developing world. The convergence of methods is actively promoted by the World Bank that has long been offering expert training, financial support and a methodological blueprint to local policy-makers engaged in absolute poverty measurement (World Bank, 2007, 2019). Academic researchers have employed similar strategies to estimate poverty in many developing countries such as Indonesia, Uganda or Ethiopia (Ravallion

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and Bidani, 1994; Dercon and Pramila, 1998; Appleton, 2001).

In these measurement frameworks, food reference budgets are typically constructed on nutritional grounds and target the same pre-determined standard of living across all individual and household types. At the conceptual level, the main challenge lies in ensuring that the appropriate non-food threshold derived from observed household expenditures also corresponds to the same standards. Given the large heterogeneity in households' basic needs and financial position, and the lack of established normative criteria to assess the necessity of different components of non-food spending, this is no easy task. In most applications, the practical question boils down to selecting a reference set of households whose observed non-food expenditures may reasonably be considered as appropriate non-food poverty lines for all.

Two different approaches have gained widespread currency (Bidani et al., 2001). The so-called "traditional" method focuses on those households whose food expenditure is equal to their food reference budgets, and considers their typical non-food expenditure as the relevant non-food poverty threshold. This approach takes an agnostic view of what constitutes basic non-food needs and only assumes positive demand elasticities for, and limited trade-offs between, food and non-food consumption. Specifically, if a household can barely afford to satisfy its basic food needs, it is presumed to be also at risk of failing to meet its minimum non-food needs. However, since non-food needs are less satiable and often subordinate to food needs in practice, the resulting traditional poverty lines are best considered as generous upper bound estimates of minimum living costs.

The second, "austere" method by Ravallion and Bidani (1994) gained popularity by proposing an appealing test for assessing the necessity of non-food spending. Specifically, these authors argue that only those non-food expenditures should be included in the poverty line that demonstrably displace basic food spending. While some displacement likely occurs over a wide range of consumption levels, it clearly takes place among households whose total expenditure equals their food reference budget. For them, every unit of non-food spending immediately reduces basic food spending, and can therefore be considered just as essential as those. Ravallion and Bidani (1994) thus claim that the non-food poverty line should correspond to the typical level of non-food spending among such households.<sup>1</sup> Given the strictness of the underlying necessity test, the "austere" poverty lines likely represent lower bound estimates of households' minimum expenditures.

It is worth noting that the austere and traditional methods deliver very similar poverty estimates in developing countries where food expenditures dominate household spending. As long as households' non-food spending is relatively low, both methods identify comparable reference households and the practitioner's choice between them may come down to political or methodological preferences. Specifically, the austere method may be discounted on account of its inconsistency with rational choice theory given the different utility levels the resulting food and non-food poverty thresholds represent (Kakwani, 2010).<sup>2</sup> The traditional method, on the other hand, can be rebuked for its unconditional accounting of households' non-food expenditures despite available evidence that a non-negligible share of these hardly qualify as essential.<sup>3</sup> While further genuine methodological concerns may be raised with respect to either method (e.g. sensitivity to differences in preferences and relative prices), the biggest practical concern for most applications is the availab-

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<sup>1</sup>Note that, by accepting that the designated minimum non-food budget applies to all households, Ravallion and Bidani (1994) implicitly also assume positive income elasticities and limited tradability between food and non-food spending.

<sup>2</sup>In particular, Kakwani (2010) argues that the food budget component of the austere poverty line is associated with a higher income and utility level than the corresponding non-food component. Endowed with a total budget around the austere poverty line, rational households would trade-off some of their food budget to non-food spending under most reasonable preference orderings. While this seems true, it is not obvious why this would be inherently problematic for the purposes of poverty measurement.

<sup>3</sup>Analysis of the World Bank's Global Consumption Database shows that, in a typical developing country, around 17% of households' non-food spending is devoted to uses other than housing, transportation, communication, health and personal care. The relevant share is only marginally lower in poorer populations segments belonging to the bottom half of the global income distribution.

ility (or lack thereof) of good-quality household budget survey data (Ravallion, 1998).

## 2.1 Limitations in the context of rich countries

In recent years, the interest in absolute poverty measurement has been on the rise around the world, raising the question of whether and how standard statistical methods are applicable in developed countries (Atkinson, 2019). In contrast to LMICs, advanced economies are characterised by relatively low food expenditures and extensive non-food needs. According to Eurostat data, households in EU and OECD countries typically devote less than 20% of their total spending on food and non-alcoholic beverages.<sup>4</sup> The relative importance of food-related spending has also been on the decline in the developing world, and recent data from the World Bank’s Global Consumption Database show that households’ average food expenditure share is less than 50% in the majority of sampled countries, in many cases even among the relatively poor (see Figure B1 in the Appendix for details).

In theory, standard methods should function reasonably well even in rich countries with relatively low food expenditures, for several reasons. First, they do not posit a hierarchy of basic needs or depend on the primacy of food expenditures: with monotonically increasing food and non-food Engel curves, standard methods remain operational regardless of the expenditure distribution or the choice of food (or even non-food) anchors. Second, while relatively low food budgets may compromise the precision of non-food mapping, cross-country analysis of EU-HBS data shows that within-country variation in households’ food/non-food expenditure ratio decreases markedly with income. In other words, as the projection base (i.e. the food reference budget) shrinks in relative terms, the projection accuracy (i.e. the predicted non-food expenditure share) improves, without a clear net effect on the statistical quality of resulting poverty estimates. Third, regular and comparable household budget survey data are widely available in advanced economies.

At the practical level of measurement, however, the food expenditure share turns out to play a pivotal role in delivering accurate and valid poverty estimates. This is because the ratio of the food and non-food components in the standard poverty lines is a deterministic function of reference households’ observed food expenditure share  $s^F$ . The traditional method consistently replicates the relevant expenditure ratio, but the food budget share of the austere poverty line follows a non-linear transformation and equals  $1/(2 - s^F)$ .<sup>5</sup> Given the different functional forms, the alignment between the two mappings depends crucially on the observed food expenditure share. Figure 1 shows that the wedge in the food/non-food budget ratio between the austere and traditional methods grows exponentially as the food expenditure share decreases. While both methods deliver very similar results in developing countries with dominant food expenditures, the food budget share of the poverty line can diverge markedly in advanced economies with relatively low food expenditure share. In particular, Figure 1 reveals that, given its focus on displaced food consumption, the austere method always delivers poverty lines where the food component dominates.

Moreover, beside the aforementioned divergence that forces practitioners to take sides, none of the standard methods are likely to deliver realistic poverty estimates in rich countries. For one, as the food expenditure share decreases, the austere method is expected to understate the minimum cost of living to an ever larger degree due to its increasing inability to account for the majority of typical non-food spending. Similarly, the traditional method increasingly overestimates the minimum living costs as an ever larger share of households’ non-food expenditures do not represent truly basic needs in advanced economies. In sum, existing methods tend to produce unrealistically low or improbably high poverty lines that provide little indication of true level of minimum expenditures associated with a given targeted living standard in rich countries.<sup>6</sup>

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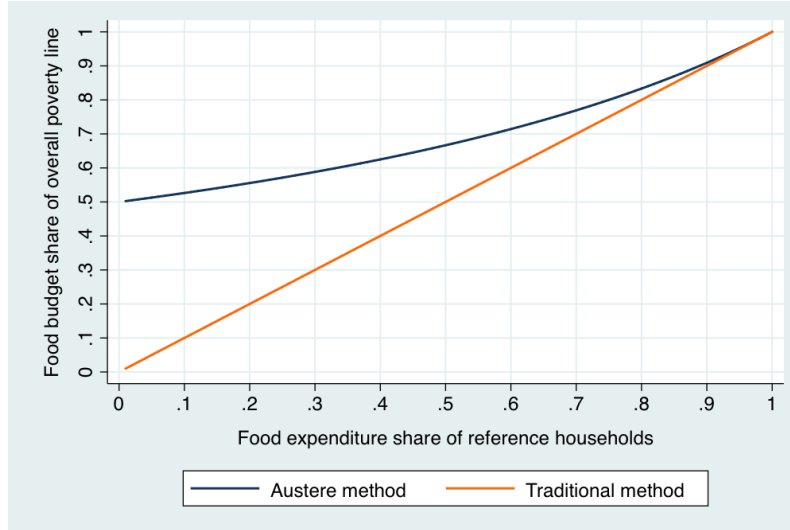
<sup>4</sup>For detailed official statistics, see the series 'nama\_10\_co3\_p3' of the Eurostat database at <https://ec.europa.eu/eurostat/data/database> or the national accounts statistics of the OECD at [https://stats.oecd.org/Index.aspx?DataSetCode=SNA\\_TABLE5#](https://stats.oecd.org/Index.aspx?DataSetCode=SNA_TABLE5#).

<sup>5</sup>See detailed exposition in Section 3.

<sup>6</sup>On top of these methodological problems, there are also practical issues standing in the way of the straightforward application of standard methods in advanced economies. The austere poverty line, in particular, can suffer from lack of identification as the number of reference households whose total expenditure



Figure 1: The relationship between expenditure and budget patterns for standard methods



Source: Own calculations based on the mechanics of the austere and traditional measurement methods.

### 3 A new inverse method for developed countries

In this section, I propose a new inverse method that delivers reasonable estimates of absolute poverty in developed countries with inferior food expenditures. The proposed measurement strategy builds directly on the austere method but uses food reference budgets not as inputs but rather as targeted reference points to the estimation procedure. This is made possible by the symmetry of the underlying demand system, which allows me to focus on the non-food Engel curve and use simulation-based methods to find the optimal level of hypothetical non-food inputs – the one for which implied and actual food reference budgets coincide. This way, it becomes possible to apply the necessity test logic of the austere method, while eliminating the constraints it imposes on the potential size of the non-food budget. For a better understanding of the proposed method, let us first review the austere methodology in detail.

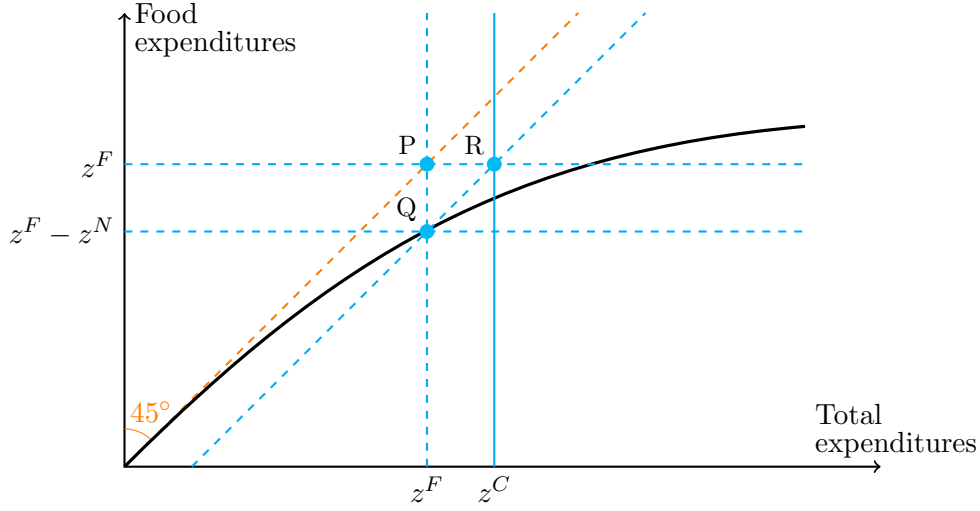
#### 3.1 The austere method by Ravallion and Bidani (1994)

The austere method of Ravallion and Bidani (1994) is based on the empirical regularity, called Engel’s law, that household expenditure on food is an increasing concave function of total expenditures. The illustration in Figure 2 shows a theoretical Engel curve for food, and highlights in particular how an ever increasing part of households’ expenditures are diverted towards non-food spending. The functional relationship itself reveals nothing about households’ supposed minimum needs in general, except that low-income households prioritise food needs over non-food ones. The main insight of Ravallion and Bidani (1994) is that, for a particular set of households, observed expenditure patterns do indeed illuminate the potential sphere of basic non-food needs. Specifically, for households whose total spending equals their food reference budget  $z^F$ , all non-food expenditure  $\overline{PQ}$  displaces essential food spending, and must therefore respond to equally vital needs. Given the normality of non-food demand,  $\overline{PQ}$  can be regarded as a reasonable estimate of minimum non-food needs  $z^N$  for all households. The sum of  $z^F$  and  $z^N$  then produces the combined or overall poverty line  $z^C$ , with a straightforward graphical representation along the horizontal axis. Figure 2 also demonstrates that the implied non-food budget is always inferior to the input food budget ( $z^N < z^F$ ), no matter how flat or bent the food Engel curve is.

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equals their food budget is likely to be very low. In the Italian HBS, for example, less than 1% of sampled households report total expenditures around or below the food poverty line, which raises strong doubts about the statistical robustness and empirical validity of the resulting poverty estimates.

Figure 2: The Ravallion and Bidani (1994) method of setting poverty lines



The estimation procedure focuses on the food demand equation derived from the AIDS (“Almost Ideal Demand System”) framework developed by Deaton and Muellbauer (1980). The AIDS model approximates the consumption demand of representative utility-maximizing households through relative budget shares driven by relative prices and real income. The model has many appealing features for the estimation of log-linear Engel curves (e.g. subsistence-level utility, PIGLOG preferences, symmetry of the Slutsky matrix) that Ravallion and Bidani (1994) exploit in the rudimentary context of only two composite goods. See Appendix A for technical details and step-by-step derivations.

Specifically, Ravallion and Bidani (1994) use the following log-linearised demand specification:

$$s_h^F = \alpha^F + \beta^F \log(y_h/c_h^0) + \gamma^{FF} \log p_h^F + \gamma^{FN} \log p_h^N + \mu_h \quad (1)$$

where  $s_h^F$  denotes the food expenditure share of household  $h$ , the log of real household income is expressed as nominal expenditures  $y_h$  adjusted for the cost of subsistence-level utility  $c_h^0$ , while  $p_h^F$  and  $p_h^N$  are the unit price of the food and non-food goods, respectively. Setting the food reference basket as the numeraire ( $p_h^F = z_h^F$ ), expressing the cost of subsistence-level utility through prices, and taking advantage of the parameter restrictions on demand elasticities ( $-\gamma_{FF} = \gamma_{FN}$ ) allow Ravallion and Bidani (1994) to re-write Equation in terms of relative prices ( $p_h^N/z_h^F$ ).

Eventually, these authors estimate the following reduced-form specification with standard budget survey microdata:

$$s_h^F = \alpha^F + \beta^F \log(y_h/z_h^F) + \sum_{r=1}^R \phi_r D_r + \pi^T \mathbf{x}_h + \epsilon_h^F \quad (2)$$

where dummy variables  $D_r$  account for differences in relative prices across geographical areas and the control vector  $\mathbf{x}_h$  captures potential variations in minimum needs across households with different characteristics.<sup>7</sup> The parameter  $\beta^F$  absorbs the variable effect of income on the food expenditure share, while the intercept  $\alpha^F$  directly identifies the average food expenditure share among reference households where  $y_h = z_h^F$ . For each household type, the minimum non-food

<sup>7</sup>In effect, Ravallion and Bidani (1994) uses a quadratic specification with an additional squared logarithmic term for added flexibility to capture the curvature of the food Engel curve along the income distribution.

budget is calculated as one minus the predicted (conditional) food expenditure share  $\hat{s}_h^F$ , with the overall poverty line given by

$$z_h^C = z_h^F + z_h^N = z_h^F + z_h^F(1 - \hat{s}_h^F) = z_h^F(2 - \hat{s}_h^F) \quad \text{where} \quad \hat{s}_h^F = \hat{\alpha}^F + \sum_{r=1}^R \hat{\phi}_r D_r + \hat{\pi}^\top \mathbf{x}_h \quad (3)$$

### 3.2 The proposed inverse method

The proposed measurement strategy for advanced economies builds directly on the technical apparatus of the austere method, but takes an inverted perspective. In particular, it focuses on the non-food demand equation in order to circumvent the main limitation of the original method – that of producing non-food poverty thresholds inferior to the food reference budgets. By modeling the dominant non-food expenditures directly, and using food reference budgets as targeted reference points rather than inputs, it becomes possible to retain the necessity element of the austere method without unduly constraining the resulting poverty lines.

To present the method in more detail, I propose to focus on the reduced-form specification of the non-food demand equation:

$$s_h^N = \alpha^N + \beta^N \log(y_h/z_h^N) + \sum_{r=1}^R \phi_r D_r + \pi^\top \mathbf{x}_h + \epsilon_h^N \quad (4)$$

where superscripted variables and parameters are exact non-food counterparts to the relevant food-specific terms in Equation (2). The current specification follows directly from the symmetry of the AIDS model and the zero-utility cost function, provided that the minimum non-food bundle is chosen as the numeraire.<sup>8</sup> Equations (2) and (4) are therefore direct counterparts and can be used in the exact same way to derive minimum thresholds for the opposite expenditure type. Specifically, Equation (4) is set to produce overall poverty lines with food/non-food budget ratios that are in line with households' observed expenditure shares in advanced economies.

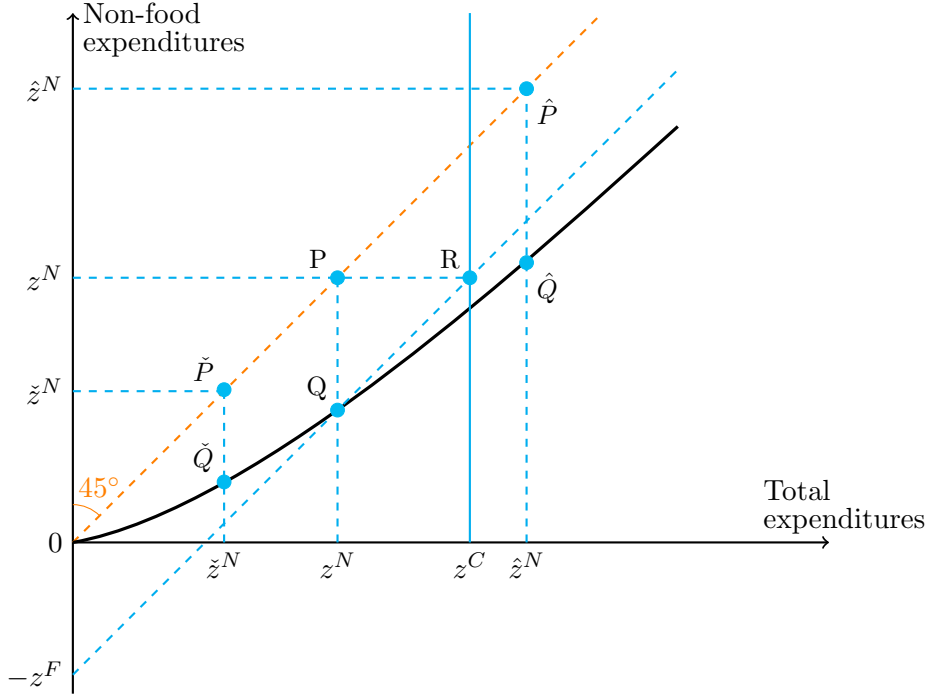
There is one major problem, though: households' minimum non-food budget  $z_h^N$  is unobserved, and Equation (4) cannot be directly estimated. Note, however, that the austere method establishes a functional relationship between the input and output reference budgets and the observed expenditure shares, which means that mapping from either expenditure type to the other is conceptually one and the same exercise. This makes it possible to use available food budgets not only as inputs to the calculations, but also as reference points against which the performance of different hypothetical non-food inputs can be evaluated. Specifically, the best estimate of minimum non-food needs is the one that predicts food poverty thresholds as similar to the actual food reference budgets at hand as possible. At the core of the inverse method is a simulation-based algorithm to identify non-food budgets of this kind.

The mechanics of the method are illustrated in Figure 3 below. The setting is very similar to the one presented in Figure 2, except that the vertical axis now represents households' non-food expenditures through a convex Engel curve.<sup>9</sup> The fundamental difference consist in the absence of a clear-cut reference point (i.e. the observed non-food reference budget) that would immediately designate the appropriate total expenditure level to consider. However, since the food reference budget  $z^F$  is observed, one can draw an additional 45-degree line (i.e. the dashed blue diagonal on the graph) representing all potential expenditure allocations with a comparable level of food spending. The task is then simply to find the intersection of this shifted diagonal and the Engel curve, and choose the corresponding total expenditure level as the non-food reference budget. On the graph,  $z^N$  is the only non-food input that delivers minimum food needs  $\overline{PQ}$  corresponding to

<sup>8</sup>See Appendix A for technical details and formal derivations.

<sup>9</sup>The convex non-food Engel curve is a direct counterpart to the concave food Engel curve in Figure 2. Note that its slope remains constantly below the 45-degree line in accordance with normality requirements for both food and non-food goods.

Figure 3: The proposed inverse method of setting the poverty line



the available food reference budget  $z^F$ . Any expenditure level to the right of this point (such as  $\hat{z}^N$ ) implies too large food thresholds, while any point to the left (such as  $\tilde{z}^N$ ) implies too small ones. Once the optimal non-food reference budget is found, the combined poverty line  $z^C$  is calculated in exactly the same way as in the original case.

The technical implementation of the inverse method involves the use of simulation-based optimisation methods. In order to find the minimum non-food needs and overall absolute poverty line for any given household type, the following steps are foreseen:

1. Define a range of expenditure amounts that covers all potential levels of households' minimum non-food needs.
2. Define an appropriate metric that captures the distance between households' implied food threshold and their available food reference budget.
3. Estimate Equation (4) iteratively using each possible realisation of the non-food reference budget as input, and calculate the appropriate distance metric.
4. Choose the expenditure level with the smallest distance between implied and actual food budgets as the relevant minimum non-food budget.
5. Calculate the overall poverty line as the sum of the available food reference budget and the resulting optimal non-food budget.

It is worth taking a deeper look at the actual outcome of this procedure and assessing it in the context of the prevailing methods. Specifically, it can be shown that the proposed inverse method produces overall poverty lines that amount to  $z^F (1 + 1/s^F)$ , as opposed to the thresholds  $z^F (2 - s^F)$  and  $z^F (1/s^F)$  delivered by the austere and traditional methods, respectively.<sup>10</sup> This implies that the structure of the inverse poverty lines is very similar to the one produced by the

<sup>10</sup>In an analogous fashion to the austere method, the inverse poverty lines are calculated as  $z^N (2 - s^N)$ .

traditional method, and that its level may be the highest of all. Indeed, if food expenditure shares were the same across all households, the inverse poverty line would be consistently higher than even the traditional poverty line - by exactly the amount of the food reference budget.

In practice, however, the food expenditure share is far from being equal across households. In Italy, for example, the estimated (average) food expenditure share is .35 among the low-income households identified by the austere method, .14 among the marginal households identified by the traditional method, and .21 among the reference households identified by the proposed inverse method. These lead to typical scaling coefficients of 1.65 (austere method), 5.76 (inverse method) and 7.14 (traditional method), and show how the proposed method leads to an intermediate estimate between the two pre-existing methods. By focusing on households whose actual food consumption is lower than their respective food reference budgets, the proposed inverse method therefore retains the main features of the austere method in that it delivers a stringent absolute poverty lines that overrepresents the dominant (food or non-food) component of household expenditures. The relative position of the inverse threshold between the austere and traditional poverty lines depends both on the mean food expenditure share in the population, and the steepness and curvature of the corresponding food Engel curve.<sup>11</sup>

### 3.3 Related measurement issues

While the proposed inverse method is straightforward to implement, there are some related methodological issues. These concern the imposed horizontal structure of minimum non-food needs across different household types, the design and dimensionality of the search algorithm, and the calculation of the overall poverty line once the optimal level of non-food budget has been identified. I briefly review these in turn.

Regarding the structure of minimum non-food needs, note first that the original method by Ravallion and Bidani (1994) is indifferent to how the food reference budgets are specified. Their structure across individual and household types is irrelevant as long as the covariates in the regression equation ensure that separate conditional predictions are derived for each household type and food budget input (see Equation (2) for more details). For the implementation of the proposed inverse method, however, one needs to have an a priori idea of how minimum non-food needs vary across different household types. Since minimum non-food needs are unobserved, very different hypothetical structures are possible: theoretical alternatives range from a fixed common definition for all households to a joint (non-separable) differentiation of minimum needs along several socio-demographic dimensions (e.g. household size and composition, homeownership status, region of residence). Importantly, the set of feasible optimisation procedures hinges directly on the presumed horizontal structure of households' minimum non-food needs: due to the simultaneous estimation of poverty lines for all household types, the dimensionality of the search algorithm needs to reflect and correspond to the differentiation modes foreseen.

A useful practical solution is to rely on pre-existing equivalence scales. These are widely used statistical tools to account for variations in minimum needs across different household types.<sup>12</sup>

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In optimum, the implied food component corresponds to the predetermined food reference budget, so  $z^N (1 - s^N) = z^F$ . Using this relationship, and exploiting that  $s^F \equiv 1 - s^N$ , produces the equality in question.

<sup>11</sup>A lower average food expenditure share  $s^F$ , ceteris paribus, moves the inverse poverty threshold closer to the traditional one in relative terms. A steeper and/or more concave Engel curve tends to have the opposite effect, but the exact functional parameters may bring about convoluted changes. See Figure 3 for a visual analysis.

<sup>12</sup>Equivalence scales are based on either subjective or objective considerations. In principle, they can incorporate a wide range of factors, but most standard equivalence scales account only for differences in household size and composition: the OECD modified scale, in particular, assigns the respective weights of 50% and 30% for each additional adult and child in the household, relative to the unit weight of the household head. Despite being widely used for their simplicity in social policy research, equivalence scales has received relatively little scholarly attention as far as their empirical validity or methodological

The most common variants, such as the OECD modified equivalence scale, determine households' minimum needs based on the number and age of their members. In the current context, their particular advantage lies in reducing the complexity of the search problem to a single dimension: it becomes sufficient to focus on the non-food budget of a single (equivalised) adult only, which then automatically determines the appropriate minimum thresholds for all household types as a function of the respective equivalence weights. The empirical application in Section 4 shows that, provided that one uses a sufficiently flexible regression specification with a rich control structure, the particular choice for the structure of minimum non-food needs matters surprisingly little for the resulting poverty outcomes.

The second, closely related issue concerns the search problem and the sampling algorithm used for the optimisation procedure. As long as households' minimum non-food needs are postulated in a uni-dimensional way (i.e. through equivalence scales or by applying a fixed common threshold), the simplest iterative non-random sampling algorithms are sufficient.<sup>13</sup> With low-dimensional search domains, standard random sampling algorithms (such as Monte Carlo methods, rejection sampling, repeated systematic sampling) can become necessary (Carsey and Harden, 2013). If, for some reason, households' minimum non-food needs were to be differentiated along several different margins simultaneously, more advanced sampling approaches (such as Bayesian MCMC methods) may be required to deal with the multi-dimensionality of the search domain (Gammerman and Lopes, 2006). However, such options are unlikely to be of much practical relevance, as it is hard to imagine a scenario where a practitioner has very strong priors about the structure of non-food minimum needs, yet would estimate their level in direct relation to food reference budgets.

The third and final measurement concern is related to the calculation of the overall poverty line once the optimal level of non-food budget has been identified. Given the simultaneous estimation of large number of different conditional means (i.e. food expenditure shares associated with each household type), most sampled household will likely see a wedge between their observed and predicted food reference budgets under even the best performing scenario (i.e. optimal level of non-food budgets). The question arises how to proceed with the calculation of the overall poverty lines in the face of this situation. Three potential solutions appear reasonable: use 1) the actual food budgets with the non-adjusted (optimal) non-food budgets, 2) use the actual food budgets with appropriately re-scaled (optimal) non-food budgets that equalise the actual and predicted food budgets for all households, or 3) the predicted food reference budgets with the non-adjusted (optimal) non-food budgets.<sup>14</sup> Among these, the second options seems the most appropriate, as it valorises actual food budgets (rather than predicted ones), and considers estimated food expenditure shares as the central parameters of modelling (rather than the absolute budget values). For this reason, I present empirical estimates based on this approach in the following chapter, and only discuss the sensitivity of these results to the alternative approaches just considered. One may already note at this point that, in most practical applications with similarly structured food and non-food needs, the resulting overall poverty lines are close to identical with all three approaches. In fact, it is best to consider the distance between the different sets of poverty lines as a diagnostic tool for the validity of the regression specification in a given empirical context.

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shortcomings (e.g. insensitivity to price and preference differentials) are concerned. For more details, see De Ree et al. (2013).

<sup>13</sup>In practical terms, this means looping through a reasonable range of potential non-food budgets, evaluating the distance metric associated with each realisation, and selecting the best performing case.

<sup>14</sup>To illustrate these three options, let us imagine a hypothetical household whose actual and predicted monthly food budgets are 300 and 320 euro, respectively, and whose implied optimal non-food budget amounts to 1000 euro per month. In this case, the monthly overall poverty lines would amount to 1300 [300+1000] euro with the first approach, 1237.5 [300 + 1000/(320/300)] euro with the second approach, and 1320 [320 + 1000] euro with the third approach.

## 4 An empirical application with Italian budget survey data

This section contains an application of the inverse method using Italian data. The main objective of the analysis is to assess the method’s empirical performance against established alternatives and official estimates, and ascertain its robustness to different modelling assumptions.

### 4.1 ISTAT methodology and data

The empirical exercise focuses on Italy, the only EU country where the National Statistical Institute (ISTAT) carries out regular official measurement of absolute poverty since 2005. The ISTAT methodology is documented in detail by Grassi and Panuzzi (2009) and accessible in English through Grassi et al. (2010) and Cutillo et al. (2020). It differentiates between three expenditure categories (i.e. food, housing, residual) to determine customised minimum income thresholds for a wide range of sampled households. The respective budgets are derived using a variety of different methods (e.g. regression analysis, reference budget techniques) and sources (e.g. official regulations, expert inputs), and account for differences in socio-economic status, homeownership and residency across households.

The ISTAT food budgets, in particular, are calculated on an individual basis for 60 different combinations across 2 genders, 10 age categories and 3 regions. The respective monthly budget amounts vary between 90 and 190 euros per month, and are superior for men and residents of Northern Italy due to higher nutritional needs and prices, respectively. The corresponding age profiles are relatively flat across all but the youngest (0-6) and oldest (75+) categories, as presented in Figure B3 of the Appendix. Household-level budgets are constructed on the basis of equalised gender-neutral budgets across 6 age clusters, by means of simple additive aggregation of household members’ respective amounts in each region.<sup>15</sup> Economies of scales are considered *ex post* through a negative exponential scaling factor that adjusts households’ combined budgets in proportion to the number of household members. The proportionate reductions in question are below what most commonly used equivalence scales imply.<sup>16</sup>

The microdata for the ISTAT calculations come from the ‘Indagine sulle spese delle famiglie’, a national survey of household expenditures and finances used for official poverty calculations in Italy. The dataset contains detailed information on the consumption patterns and income situation of approximately 15.000 Italian households. The augmented data files and methodological guidance kindly provided to us by ISTAT colleagues allow for a precise reconstruction of the official methodology. Importantly, this involves the calculation of the ISTAT welfare aggregate to capture households’ relevant consumption expenditures against which their minimum needs can be compared.<sup>17</sup>

For the empirical analysis, I am using data from the 2015 wave. This reveals that, on average, Italian households spend 19.3% of their total expenditures on food, to the tune of 444 euros per month.<sup>18</sup> The typical level of food spending is considerably higher than the monthly food reference

<sup>15</sup>To create gender-neutral budgets, ISTAT takes the population-weighted mean of the respective men and women budgets by age category in any given region. The corresponding reference budgets for the eventual 6 age groups (0-3, 4-10, 11-17, 18-59, 60-74, 75+) are then obtained by taking the population-weighted mean across the relevant clustered categories.

<sup>16</sup>The relevant scaling coefficients are estimated from observed expenditure patterns across non-financially constrained households of different size. Due to the scaling adjustments, the combined reference budgets of a 3-person and 6-person household, for example, are only 76.9% and 65.3% of their respective original budgets as obtained by simple aggregation.

<sup>17</sup>The ISTAT welfare aggregate is calculated, for each household, as total expenditures net of (1) extraordinary spending on property maintenance, and (2) regular spending on insurance, annuities and loan repayments, but inclusive of (3) imputed rent for homeowners calculated on the basis of going market rate. In some cases, tenants’ actual expenditures on housing rent are also adjusted to provide conformity with prevailing market rents (Grassi and Panuzzi, 2009)

<sup>18</sup>The relevant empirical Engel curves for food expenditures are presented in Figure B2 of the Appendix.

budgets calculated by ISTAT (271 euros on average), but 25% of households still fall short of meeting their minimum food needs. A larger gap separates households' average non-food spending and their non-food reference budgets (2062 vs. 729 euros per month), implying a rather low non-food poverty rate of 5.3%. This discrepancy between the food and non-food poverty rate reflects the comparatively high weight (25% on average) the food component carries in the Italian poverty line.

This also suggests that the ISTAT methodology represents a less than perfect reference point for methodological comparisons in the current context. This is because, due to different budget allocations in the resulting poverty lines, the inverse method will always yield higher poverty lines and rates than the corresponding official figures when applied with the same food budget inputs.<sup>19</sup> For this reason, the main objective of the empirical analysis is to assess if the inverse method is capable of replicating the official figures in any way, and whether the resulting horizontal poverty profiles are comparable.

## 4.2 Main poverty estimates

This section presents the main poverty estimates associated with the inverse method, and compares them with three alternatives: the "austere" and "traditional" poverty estimates as well as the official ISTAT indicators. All three statistical methods feature the same quadratic regression specification with an identical control structure, use the same ISTAT welfare indicator and food reference budgets, and are based on the entire data sample.<sup>20</sup> For the inverse method, I assumed that the structure of minimum non-food needs is in line with the modified OECD equivalence scale, which allowed me to concentrate on the equivalised individual-level non-food budget individual during the optimisation procedure and employ the simplest uni-dimensional search algorithm. To better understand the behaviour of the statistical methods, I explore three different aggregation methods for constructing food reference budgets at the household level: beyond the re-scaled additive approach of ISTAT, two less generous approaches based on working-age individual budgets and standard equivalence scales (i.e. the modified OECD scale and the square root scale) are also considered.

Table 1 presents the mean poverty line, the average poverty gap and the headcount poverty rate for all estimation method and food budget combinations. Three main conclusions emerge. First, the resulting estimates corroborate that standard methods yield unrealistically low or improbably high poverty estimates in rich countries such as Italy: the "austere" and "traditional" poverty rates are consistently below 1% or above 20%, regardless of the generosity of the food budgets inputs. Beside these numerical anomalies, the inadequacy of the standard methods is also evident by the rigidity of the corresponding poverty lines: while the food budget inputs and associated food poverty rates change substantially across the different aggregation techniques, the variation in the resulting austere and traditional (overall) poverty lines remains rather insignificant.<sup>21</sup> Second, the inverse method delivers reasonable poverty rates sufficiently close to the official Italian estimate of 6.1%: depending on the way household-level food budgets are calculated, the resulting poverty rates range between 5.3% and 14.9%. As expected, the replication of the official methodology is not perfect, since the difference in budget allocations does not allow for matching both the ISTAT poverty rate or the ISTAT food budgets simultaneously. The third conclusion is that the sensitivity of the inverse poverty lines is driven entirely by differences in households' presumed minimum food expenditures. Estimation uncertainty plays a negligible role: the distance functions based on root mean square error (RMSE) differences between actual and predicted food reference budgets

<sup>19</sup>Note the discussion in the previous sections how, in the presence of dominant non-food expenditures, the budget components in the inverse poverty lines relate to the food and non-food expenditure shares.

<sup>20</sup>The control variables on the right hand side include separate dummies for type and region of residence, household size, as well as household members' age-gender profiles. The traditional method was implemented using the same specification as the inverse method, with adjusted logarithmic terms that feature food (rather than total) expenditures in their argument. Alternative parametric and non-parametric specifications deliver qualitatively similar results.

<sup>21</sup>The average food budget inputs range from 2719 euros (equivalised budgets with square root scale) to 3250 euros (re-scaled additive budgets), and imply food poverty rates between 18.6% and 25.0%.



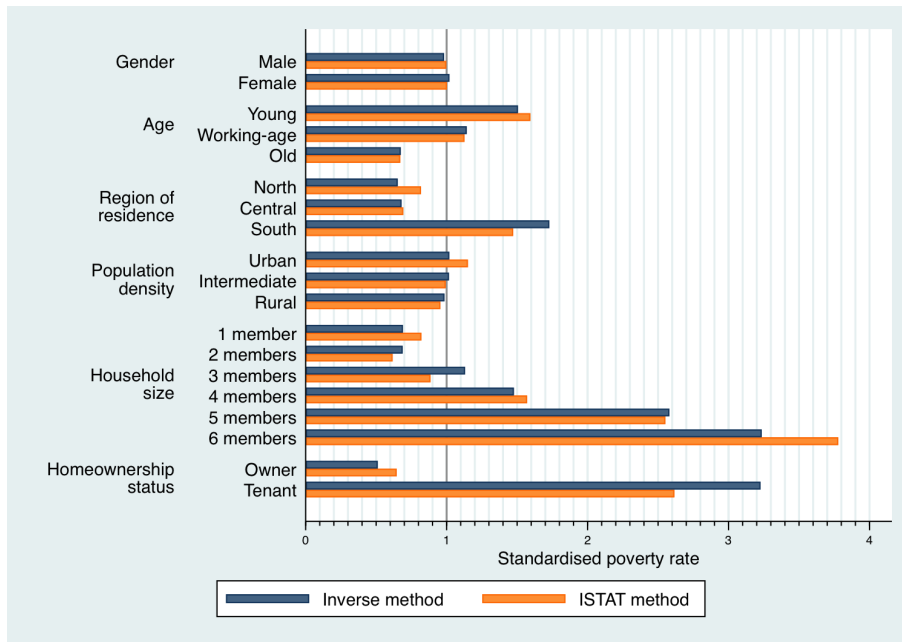
Table 1: Main poverty estimates for Italy associated with different estimation methods

		Poverty line	Poverty gap	Poverty rate
Austere method	Equiv. food budget (SQRT scale)	4185	779	.0012
	Equiv. food budget (MOECD scale)	4562	1088	.0014
	Re-scaled additive food budget	5138	1419	.0022
Inverse method	Equiv. food budget (SQRT scale)	12585	3246	.0530
	Equiv. food budget (MOECD scale)	14578	3948	.0858
	Re-scaled additive food budget	17954	5423	.1485
Traditional method	Equiv. food budget (SQRT scale)	21794	5650	.2164
	Equiv. food budget (MOECD scale)	22496	5927	.2321
	Re-scaled additive food budget	23593	6572	.2548
Official ISTAT methodology		12299	2826	.0610

*Notes:* All figures represent weighted averages obtained on the full 2015 data sample. The poverty gap denotes the average shortfall in expenditures among households below the poverty line. The presented poverty lines and poverty gaps represent annual euro values. The equivalised food budgets at the household-level were calculated based on the square root (SQRT) scale and the modified OECD (MOECD) scale, respectively. The official ISTAT figures are based on more generous re-scaled additive aggregation method.

indicate a clear and unique optimum, the confidence intervals for the food share predictions are minimal, and the statistical alignment between the actual and predicted food budget values is very close in equilibrium (see Figures B4, B5 and B6 in the Appendix for more details).

Figure 4: Poverty profiles associated with the proposed method



*Notes:* The presented poverty profile is based on the reference specification using MOECD equivalised food budgets and non-food minimum needs structure. Standardised poverty rates denote the group-specific poverty rate divided by the national average. The age and gender categories are calculated at the individual level, while the remaining categories represent household-level aggregates.

In addition to the headcount ratio, another crucial measurement aspect concerns the relative incidence of poverty across different population segments. Sound modelling needs to ensure that the resulting poverty lines represent the same standard of living for all households, even in the presence of cross-sectional variation in preferences and relative prices (Ravallion and Bidani, 1994). Due to its more refined and granular approach, the ISTAT methodology is better suited to account for such

Table 2: Robustness of results to differences in the structure of non-food needs

		Mean poverty line	Mean poverty gap	Poverty rate
Reference specification		14578	3948	.0858
Equivalence scales	No equivalence scale	16819	4147	.1490
	Square root scale	14931	3727	.0939
	Traditional OECD scale	14034	4330	.0770
Geographical differentiation	Region based	15083	4349	.0820
	Population density based	14555	3977	.0858
	Region & population density based	14930	4357	.0809
HH-based differentiation	Reference person based	14713	3432	.1005
	Household size based	14868	3816	.0971
	Household composition based	15135	4035	.1022

*Notes:* All figures represent weighted averages obtained on the full 2015 data sample. The poverty gap denotes the average shortfall in expenditures among households below the poverty line. The presented poverty lines and poverty gaps represent annual euro values. The equivalised food budgets at the household-level were calculated using the modified OECD scale.

horizontal differences, and thus represents a good reference point for assessing the performance of the inverse method. The relevant poverty profiles are presented in Figure 4 and show the uneven concentration of poverty in various segments of the Italian population. Specifically, they reveal that selected groups - such as children, tenants, large households or southern Italians - experience an incidence of poverty that can be several times higher than the national average. Figure 4 also shows that the poverty profile associated with the proposed inverse method is closely aligned with the one based on official ISTAT figures, and correctly identifies both the extent and direction of within-country imbalances. This is another advantage of the proposed method over existing approaches that either greatly overstate ("austere" method) or severely understate ("traditional" method) the extent of horizontal differences in group-specific poverty rates (see Figure B7 in the Appendix for details).

### 4.3 Robustness and sensitivity of poverty measures

In the previous section, I demonstrated that the proposed inverse method is sufficiently flexible, offers reasonable and statistically accurate measurement, and correctly identifies horizontal differences in the poverty profiles. While the resulting poverty outcomes are certainly sensitive to the food budget inputs, this is a natural feature of all statistical approaches discussed in the paper.<sup>22</sup> It remains to show, however, that the proposed method is also robust to changes in the measurement and estimation strategies. This is far from evident as seemingly innocuous technical choices of measurement can drastically alter the resulting poverty outcomes (Buhmann et al., 1988; Atkinson et al., 1995; De Vos and Zaidi, 1997).

The main robustness issue concerns the presumed structure of minimum non-food needs across households. Since these latter are unobservable, different assumptions may be imposed that can potentially influence the level and topology of the resulting poverty lines. The three main factors at play are the extent of non-food scale economies households should be allowed to realise, the potential variation of regional prices that may alter minimum non-food needs along geographical lines, and the potential heterogeneity of minimum needs across different household types. Table 2 presents poverty estimates derived on the basis of different hypothetical non-food structures that vary along the aforementioned dimensions. The reference specification, presented also in Table 1, uses a common equivalised non-food budget based on the modified OECD scale for all sampled

<sup>22</sup>It is worth noting that the stability of the "austere" and "traditional" poverty rates presented in Table 1 is not an inherent feature of these methods, but the result of employing them in a rich country environment characterised by low observed food expenditure share. When applied in developing countries with inverted expenditure patterns, they display a similar degree of sensitivity by construction.

households in the search algorithm.<sup>23</sup> The upper panel shows that alternative equivalence scales have a rather limited (i.e. less than one percentage point) effect on the resulting poverty rates, except for the extreme case of using the same fixed non-food minimum budget for all sampled households. The middle panel shows that using geographically differentiated non-food thresholds matters even less and produces close to identical poverty rates as the reference specification. Differentiating non-food minimum needs by household characteristics (rather than through equivalence scales) is equally inconsequential: the relevant poverty lines and rates in the bottom panel are 1-2 percentage points higher than in the reference specification, which suggesting that standard equivalence scales may disregard some of the cross-sectional variation in households' minimum needs. Overall, however, these analyses suggest that, as long as minimum non-food needs are reasonably structured and not unduly constrained, the resulting poverty estimates are robust to the particular modelling choices. The main reason for this is that households' minimum needs are captured through their observed expenditure patterns, and a sufficiently rich control structure on the right hand side of the regression equation can absorb these differences in a sufficiently granular and flexible way.

The second robustness aspect concerns the regression specification itself, and the sensitivity of poverty estimates to different functional forms and control settings in particular. Changes to these latter may influence what share of variation in households' observed food expenditure shares is accounted for, which can substantially alter the predicted scaling factors used to map from food to overall poverty lines. Table 3 shows the resulting poverty indicators associated with different specifications, and indicate that the role of geographic and demographic control variables is rather limited in shaping measurement outcomes. Mean poverty lines and rates are very close to one another, especially for richer specifications that simultaneously capture differences in expenditure patterns along income, geography and demographics. While the overall stability of these estimates may be a unique feature of the Italian data, the richer specifications are expected to deliver robust estimates in a variety of empirical settings.<sup>24</sup>

Table 3: Robustness of the proposed method to the regression specification

	Mean poverty line	Mean poverty gap	Poverty rate
Reference specification w. full controls	14578	3948	.0858
Linear logarithmic term structure w. full controls	15437	4331	.0995
Regional clusters only w. full household controls	14562	3961	.0852
Density clusters only w. full household controls	14275	3825	.0810
No reference person controls	14578	3948	.0858
No household composition controls	14689	3995	.0876
No household controls at all	14912	4052	.0921
No controls at all	14594	3945	.0863

*Notes:* All figures represent weighted averages obtained on the full 2015 data sample. The poverty gap denotes the average shortfall in expenditures among households below the poverty line. The presented poverty lines and poverty gaps represent annual euro values. The household-level food budgets and the structure of non-food basic needs were calculated using the modified OECD scale.

There are other generic aspects of measurement that may matter for the sensitivity of poverty outcomes (e.g. definition of the welfare indicator, sampling method for household survey) but these are not strictly related to the proposed methodology presented in this paper. The analysis in the current shows that, within the confines of standard measurement, the inverse method delivers consistent and robust poverty estimates, especially if based on a rich regression specification that accounts for differences in expenditure patterns across households.

<sup>23</sup>Note that they are eventually re-scaled for the calculation of the overall poverty lines. See Section 3.3 for discussion.

<sup>24</sup>Note that the stability of estimates presented in Table 3 also hold for the poverty estimates based on the austere and traditional methods.

## 5 Conclusion and policy implications

In this paper, I explored the feasibility of calculating absolute poverty lines on the basis of minimum food expenditures in developed countries. To do this, I first demonstrated that the standard statistical methods used in the developing world deliver either unrealistically low or improbably high poverty rates as a result of households' low food expenditure shares. As a remedy, I proposed a new simulation-based inverse method that exploits the symmetry of the underlying demand system and focuses on non-food Engel curve. This requires that available food reference budgets are used not as inputs but as targeted reference points when calculating the appropriate scaling coefficients to map from food to overall poverty lines. A straightforward empirical application of the new method on Italian data shows that the method delivers poverty estimates in line with the official figures by the Italian Statistical Office (ISTAT) as far as both the level and relative concentration of poverty are concerned. The resulting poverty estimates are naturally sensitive to the specification of the food reference budget inputs, but conditional on these the method delivers robust and accurate measurement under a variety of different empirical settings.

These results can pave the way for a systematic application of the inverse method for consistent poverty measurement in a large number of developed countries. As [Atkinson \(2019\)](#) argues convincingly, better measurement of poverty is essential for raising awareness, motivating action, designing good policy, and gauging progress for poverty reduction and eradication. This crucially requires integrating international organisations' measurement frameworks with countries' own national analyses. The proposed inverse method can be flexibly applied for both simpler measurement strategies based on direct food/non-food mapping (as typical of developing countries) and more granular approaches that differentiate between different non-food categories (such as minimum cost of living estimates in advanced economies). Furthermore, given its limited resource requirements, the proposed methodology can deliver comparable absolute poverty estimates for a large number of advanced economies simultaneously. One prominent ongoing application concerns the European Commission's pilot project aimed at the development of EU-wide absolute poverty indicators ([Menyhert et al., 2021](#)) where the proposed methodology was used to produce consistent absolute poverty estimates for 26 EU countries for the first time.

The application of the method requires basic food reference budgets and standard household budget survey data readily available in most countries ([United Nations, 2005](#)). While these are typically available at the national level and suffer from lack of harmonisation, considerable attention and effort have been devoted in recent years to ensuring international comparability across these sources. Academic contributions include the proposal by [Allen \(2017\)](#) for a blueprint to generate needs-based food reference budgets in a universal but customised manner, while recent European Commission funded policy projects delivered more refined cross-country comparable food reference budgets for all EU countries ([Goedemé et al., 2015](#)). In these countries, age- and gender-specific common dietary reference values and harmonised item-level price statistics are also available for more consistent measurement ([European Food Safety Authority, 2017](#))<sup>25</sup>. The harmonisation of HBS surveys also leaves a lot to be desired, but clear and continued progress over the years has ensured the comparability of consumption expenditures, sampling methods and household classifications ([Hoffmeyer-Zlotnik and Warner, 2013](#)). In the European Union, Eurostat has long been working with member NSOs to improve comparability of national HBS statistics, and a new common legal framework for social statistics collection will further increase the quality of future data waves ([Eurostat, 2020](#)). With the proposed statistical methods and convergent data collection protocols, it will become feasible to deliver truly refined and cross-country comparable absolute poverty measures for most advanced economies.

Such new poverty estimates could help contextualise and complement existing measures of poverty and social exclusion. In developed countries, in particular, they may fill the gap left by existing indicators (such as non-monetary measures of material deprivation or "at-risk-of-poverty"

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<sup>25</sup>More details on Eurostat's detailed consumer prices are available at [https://ec.europa.eu/eurostat/cache/metadata/en/prc\\_dap\\_esms.htm](https://ec.europa.eu/eurostat/cache/metadata/en/prc_dap_esms.htm)

type relative thresholds) and provide customised needs-based measurement of poverty both in the cross-section and over time (Eurostat, 2019). At the international level, new absolute poverty estimates would have the potential to contribute to the refinement of the World Bank's International Poverty Line (IPL) or the deliver alternative measurement tools to monitor progress in poverty eradication and the substantive realisation of the Sustainable Development Goals (United Nations, 2018). In advanced economies of the EU and OECD where the relevant strategic poverty targets are typically based on relative, inequality-driven measures of poverty (Darvas, 2019), the proposed poverty estimates could be used to present appropriate, fixed and actionable targets for effective policy-making.

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## Appendix A - Technical annex on the AIDS demand equation

The theoretical basis for the empirical strategy employed by [Ravallion and Bidani \(1994\)](#) is the now canonical Almost Ideal Demand System (AIDS) developed by [Deaton and Muellbauer \(1980\)](#). This section provides a brief technical presentation of the frameworks' most relevant features and properties, and shows how it is applied in practice in the context of absolute poverty measurement is.

The AIDS demand functions of representative utility-maximizing household  $h$ , are centred on the respective budget shares and take the following form for any consumption good  $i$ :

$$s_{ih} = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log (y_h/x_h P) \quad (\text{A1})$$

where the relevant expenditure share  $s_{ih}$  is a function of individual prices  $p_j$ , household income  $y_h$  and household characteristics  $x_h$ . The price index  $P$  is defined by

$$\log P = \alpha_0 + \sum_k \alpha_k \log p_k + \frac{1}{2} \sum_j \sum_k \gamma_{kj} \log p_k \log p_j \quad (\text{A2})$$

For a closed system ( $\sum_{i=1}^n \alpha_i = 1$ ) where demand is homogeneous of degree zero in prices ( $\sum_i \gamma_{ij} = 0$ ,  $\sum_j \gamma_{ij} = 0$ ) and cross-elasticities are symmetric ( $\gamma_{ij} = \gamma_{ji}$ ), the AIDS budget shares are deterministic functions of relative prices and real household income.

Importantly, [Deaton and Muellbauer \(1980\)](#) define consumer preferences so that aggregate behaviour mimics the rational choice of a single representative consumer and corresponding budget shares are of "price-independent generalized linear-in-logs" (*PIGLOG*) form. This allows for representing consumers' cost function represents as a weighted average of subsistence-level utility floor ( $u = 0$ ) and satiation-level utility ceiling ( $u = 1$ ). In particular, the price index  $P$  is set to correspond to the cost of the zero (i.e. subsistencelevel) utility  $c^0$ :

$$c^0(u, \mathbf{p}) = c^0(\mathbf{p}) = P \quad (\text{A3})$$

[Ravallion and Bidani \(1994\)](#) take advantage of this latter property when applying the AIDS framework for the purposes of poverty measurement in the simplified context of only two goods - composite bundles of food ( $F$ ) and non-food ( $N$ ) items. Their proposed demand specification is as follows:

$$s_h^F = \alpha^F + \beta^F \log (y_h/c_h^0) + \gamma^{FF} \log z_h^F + \gamma^{FN} \log p_h^N + \mu_h \quad (\text{A4})$$

where  $s_h^F$  is the food expenditure share of household  $h$ ,  $z_h^F$  is the unit price of the food bundle and  $p_h^N$  is the unit price of the non-food bundle. Note that while the non-food bundle is left unspecified, the numeraire food bundle is defined as to represent minimum food needs, with  $p_h^F$  corresponding to the relevant food reference budget  $z_h^F$ .

Using Equations [\(A1\)](#), [\(A2\)](#) and [\(A3\)](#), the cost of zero utility for household  $h$  is given by

$$\begin{aligned} \log c_h^0 &= \alpha_0 + \alpha^F \log z_h^F + \alpha^N \log p_h^N + \\ &+ \frac{1}{2} \left[ \gamma^{FF} (\log z_h^F)^2 + 2\gamma^{FN} \log z_h^F \log p_h^N + \gamma^{NN} (\log p_h^N)^2 \right] + \pi^\top \mathbf{x}_h \end{aligned} \quad (\text{A5})$$

where the multiplicative household scalars  $x_h$  of Equation [\(A1\)](#) are now featured as a vector exogenous variables. The parameter restrictions imply that  $\gamma^{FN} = \gamma^{NF} = -\gamma^{FF} = -\gamma^{NN}$ , which allows [Ravallion and Bidani \(1994\)](#) to re-write the equation in terms of real (i.e. food budget adjusted) household income and the relative food/non-food price ratio  $k_h$ :

$$s_h^F = \alpha^F + \beta^F \log (y_h/z_h^F) + \delta_h^F \log k_h + \pi^\top \mathbf{x}_h + \mu_h \quad (\text{A6})$$



where  $\log k_h \equiv \log(p_h^N/z_h^F)$  and  $\delta_h^F = \gamma^{FF} - \beta^F (1 - \alpha^F + \gamma^{FF} k_h/2)$ .<sup>26</sup> With no information on non-food prices, Ravallion and Bidani (1994) propose the following reduced-form specification for estimation:

$$s_h^F = \alpha^F + \beta^F \log(y_h/z_h^F) + \sum_{r=1}^R \phi_r D_r + \pi^\top \mathbf{x}_h + \epsilon_h \quad (\text{A7})$$

where systematic geographical differences in the price ratio are accounted for by a set of dummy variables  $D_r$ . Regrettably, Ravallion and Bidani (1994) do not discuss the associated measurement issues (i.e. the structural relationship between model parameters) and proceed with simple OLS estimation of Equation (A7) to obtain the required scaling factors.

Due to the unrealistically low scaling factors one obtains with the Ravallion-Bidani method if households' food expenditure share is low, this specification is hardly applicable for poverty measurement in rich countries. However, given the symmetry of the AIDS demand system and the zero utility cost function in particular, one can readily focus on the non-food demand equation instead. Mechanically inverting Equation (A6) yields the following demand equation:

$$s_h^N = \alpha^N + \beta^N \log(y_h/p_h^N) + \delta_h^N \log l_h + \pi^\top \mathbf{x}_h + \mu_h \quad (\text{A8})$$

where variable and parameters with the  $N$  superscript are exact counterparts to the respective food-specific terms, and  $\log l_h \equiv \log(p_h^F/p_h^N)$ . Setting households' minimum non-food needs as the numeraire non-food bundle implies that  $p_h^N = z_h^N$ . The resulting regression specification then becomes directly comparable to Equation (A7), and can be used for poverty measurement in a similar manner:

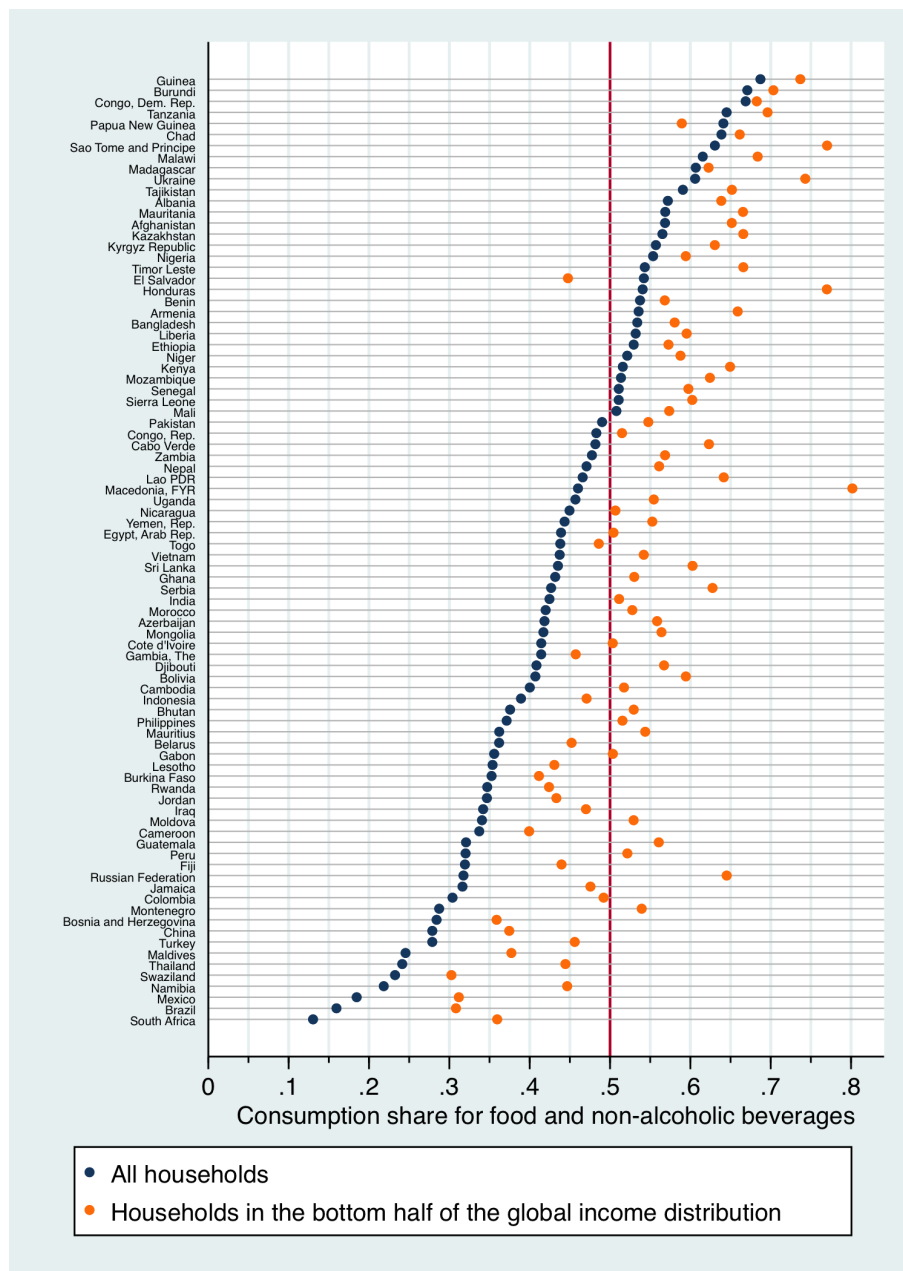
$$s_h^N = \alpha^N + \beta^N \log(y_h/z_h^N) + \sum_{r=1}^R \phi_r D_r + \pi \mathbf{x}_h^\top + \epsilon_h \quad (\text{A9})$$

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<sup>26</sup>Note that this is a rather cumbersome specification as  $\delta_h^F$  is a combination of model variables and parameters, and is dependent on price ratio  $k_h$  itself. The version featured in Ravallion and Bidani (1994) also ignores the term with the household characteristics on the right hand side.

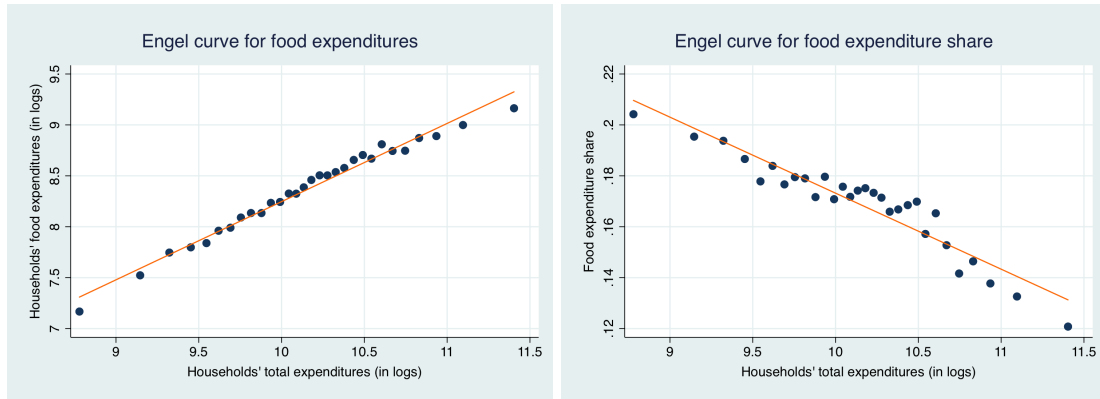
## Appendix B - Charts and tables

Figure B1: Households' food consumption share in developing countries



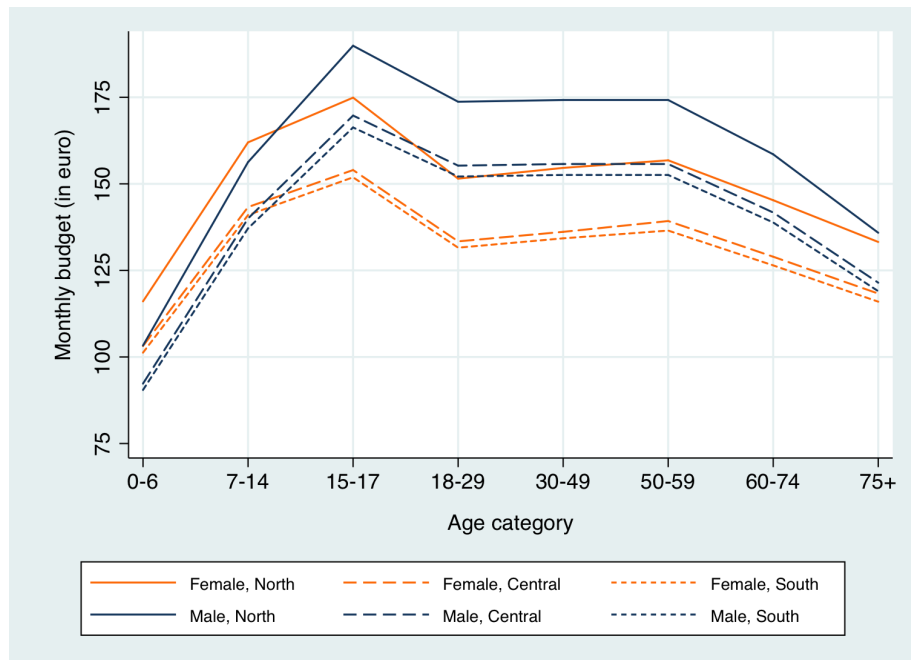
Notes: Data come from the World Bank's Global Consumption Database and concern all 86 non-European sampled countries. The presented figures refer to 2010.

Figure B2: Empirical Engel curves for food expenditures in Italy



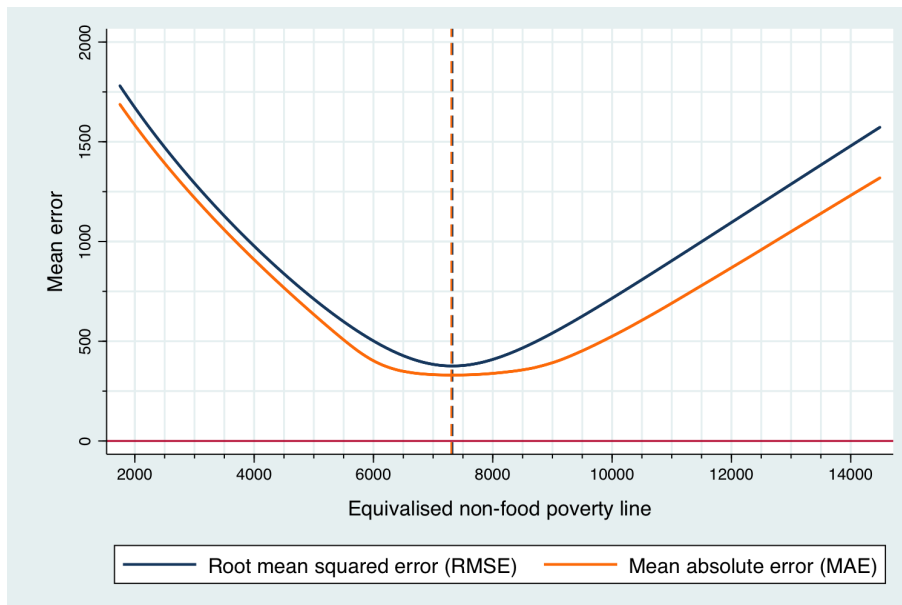
Source: Own calculations based on the 2015 wave of Italian HBS microdata.

Figure B3: Age profiles of ISTAT food reference budgets (2015)



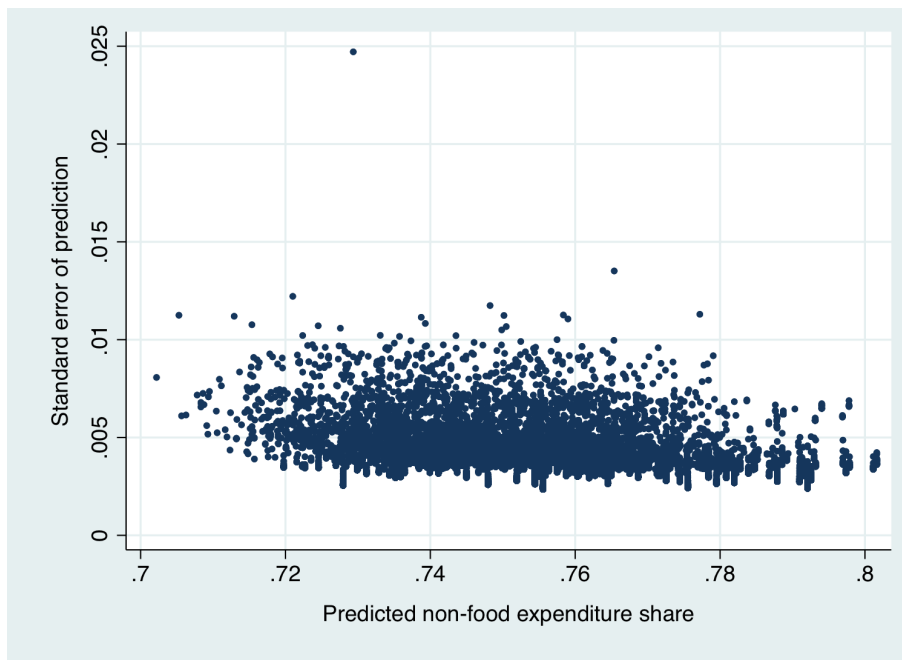
Source: ISTAT.

Figure B4: Distance function associated with different equivalised non-food expenditure



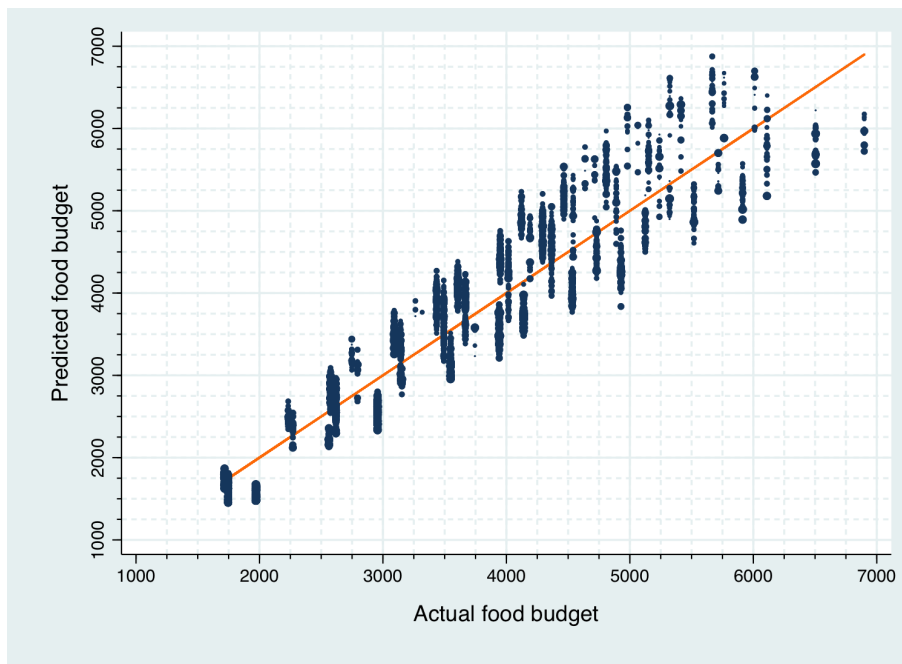
*Notes:* The presented distance functions are associated with the inverse method implemented on the basis of equivalised food budgets using the modified OECD scale. The structure of non-food minimum needs across households is assumed to follow the same equivalisation patterns. The vertical lines denote the optimal value for the equivalised (individual-level) non-food budgets by distance metric (7320 for RMSE-based distance and 7310 for MAE-based distance), where the respective distance functions reach their minimum.

Figure B5: Standard error of prediction



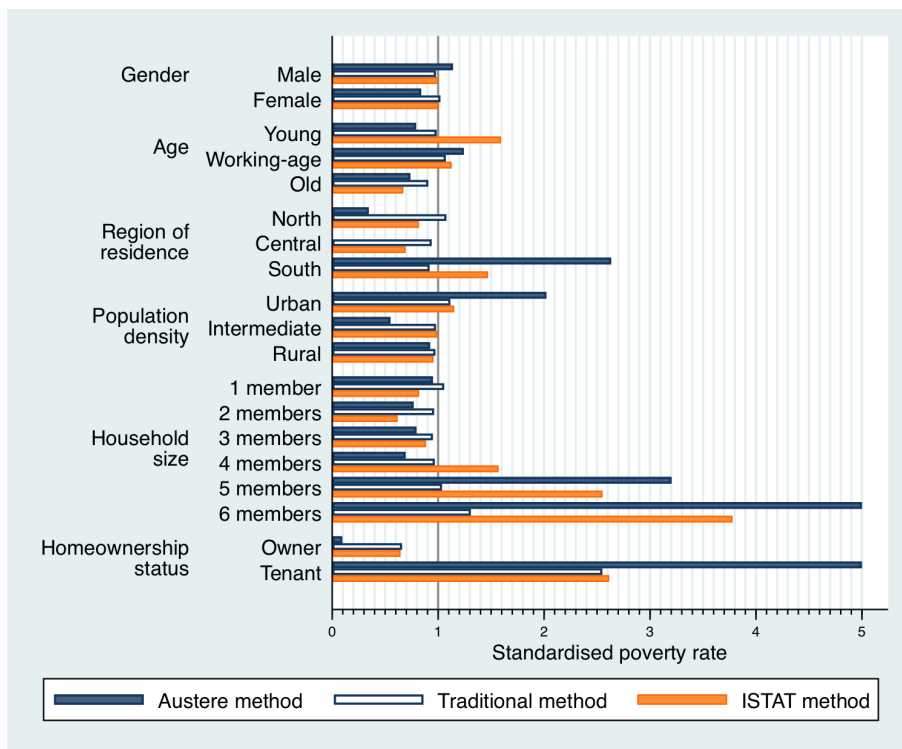
*Notes:* The presented data come from the inverse method implemented on the basis of equivalised food budgets using the modified OECD scale. The structure of non-food minimum needs across households is assumed to follow the same equivalisation patterns. The predicted expenditure shares and standard errors refer to conditional predictions for the reference households whose total expenditure equals their respective food budgets.

Figure B6: Comparison of actual and predicted food reference budgets



Notes: The presented data come from the inverse method implemented on the basis of equivalised food budgets using the modified OECD scale. The structure of non-food minimum needs across households is assumed to follow the same equivalisation patterns. The predicted food budgets are associated with the optimum level of the (equivalised) non-food budgets. The statistical correlation between the two variables is 0.941.

Figure B7: Poverty profiles associated with standard measurement methods



Notes: The presented poverty profiles are based on the reference specification based on equivalised food budgets using the modified OECD scale. Standardised poverty rates denote the group-specific poverty rate divided by the national average. The age and gender categories are calculated at the individual level, while the remaining categories represent household-level aggregates. Normalised poverty rates are censored at 5 for presentational purposes.

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