

Integrating fuzzy approach to measuring food poverty at sub-national level in Italy: an analysis using the household budget survey

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Abstract. Despite increasing efforts to tackle poverty and hunger, relevant disparities persist among households, thus requiring innovative approaches to address the multitude dimensions of food poverty. Given the complexity in defining the phenomenon of food poverty, the fuzzy approach applied to an expenditure-related metric allows for capturing valuable insights into the food poverty situation in Italy which cannot be properly described by the classical binary set theory. Indeed, by considering the equivalized household food expenditure at household level obtained from the 2021 Household Budget Survey data, this paper proposes for the first time the use of fuzzy set approach to measure food poverty at regional level. Although preliminary findings are interesting, we are exploring two further developments. The first is to test for statistical differences among Italian region while the second is to adjust poverty thresholds for price level differences.

Keywords: food poverty, fuzzy approach, household budget survey

1 Introduction and aim of the paper

Food poverty, characterized by inadequate access to sufficient, safe, and nutritious food for a healthy lifestyle, remains a pressing global concern, affecting an estimated 2.3 billion people worldwide as of 2020 [1]. The Covid-19 pandemic, economic downturns and the ongoing Russia-Ukraine war have worsened the global food security crisis leading to a rapid escalation in food prices. Persistent challenges in developed countries include economic inequality and the presence of food deserts, exacerbated by factors like food and energy price increases recorded in recent years. In developed countries, food poverty has gained prominence, with assessments shifting from economic indicators to more comprehensive approaches. Therefore, addressing economic disparities is crucial in reducing food insecurity and improving the economic and physical access to food in developed countries. Indeed, food consumption plays a pivotal role in well-being and socio-economic development, as it is closely related to prevailing poverty and inequality.

Across EU Member States, food and non-alcoholic beverages constitute a significant portion of household expenditure, especially for lower-income households which allocate over 30% of their budget to food, thus highlighting the higher economic vulnerability of these households. According to the 2022 ISTAT report on poverty, in Italy approximately 11,1% of the population lives in relative poverty, with higher incidence among households living in southern regions. Therefore, a detailed study focusing on food poverty challenges faced by Italian households is crucial.

Our study emphasizes the importance of investigating food poverty among Italian households at regional level by proposing the use of the fuzzy approach as a novel methodology for analyzing food poverty in Italy. We go beyond the conventional study based simply on the poor/non-poor dichotomy defined in relation to the chosen poverty line(s). The state of deprivation is thus seen in the form of ‘fuzzy sets’ [6] to which all members of the population belong but to varying degrees. Given the continuum of membership function, it is possible to define the extent of which an element belongs to the set, that is, the grade of membership.

The analysis at regional level allows us to capture sub-national disparities giving us a disaggregate picture of food poverty situation in Italy that might also help policy makers to implement more effective policies in a comparative perspective.

By using the Italian Household Budget Survey (HBS) microdata released by ISTAT, we follow the analytical approach developed by [2] to measure economic food poverty by considering the distribution of the equivalized household food expenditure. Similarly to the concept of the At-Risk-of-Poverty used to measure relative poverty in the European Union [4], we computed the At Risk-of-Food-Poverty (ARoFP) rate, which is based on relative specific food poverty line established at national level.

2 Method and data

The HBS offers insights on the household consumption expenditure behaviors, and it is used to produce official statistics of poverty in Italy. In this analysis we use the equivalized food expenditure, using the Carbonaro equivalence scale, to account for different household sizes. In a fuzzy approach to poverty measurement, let y_i denotes the equivalent food expenditure for household i and let $\mu(y_i)$ denotes the fuzzy membership function for that household. We specified the following form [2]:

$$\begin{aligned} \mu(y_i) &= (1 - F_Y(y_i))^{\alpha-1} (1 - L_Y(y_i)) = \\ &= \left(\frac{\sum_j w_j |y_j > y_i|}{\sum_j w_j |y_j > y_1|} \right)^{\alpha-1} \left(\frac{\sum_j w_j y_j |y_j > y_i|}{\sum_j w_j y_j |y_j > y_1|} \right). \end{aligned} \quad (SEQ "equation" \setminus n \setminus$$

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where F_Y is the empirical cumulative distribution function of y , L_Y is the Lorenz curve, and w_j is the sampling weight of unit i . We chose this formula as it is expressed in terms of the empirical cumulative density of the poverty equivalised food expenditure and the Lorenz curve. In fact, other fuzzy approaches use mathematical

formulations that do not depend on statistical or economic functions [2]. Moreover, the parameter $\alpha \geq 2$ controls the steepness of the function and can be set iteratively so that the average of μ equals an official measure of deprivation like the Head Count Ratio or another measure.

In this case, we calculated the parameter so that the expected value of the function equals the AROFP. This measure is defined as [4]:

$$AROF P = \frac{\sum_i w_i I(\hat{y}_i < \hat{\tau})}{\sum_i w_i} \quad (2)$$

where $\hat{\tau}$ is the food poverty threshold and it is calculated as the 60% of the median of the equivalized food expenditure. Instead of studying the whole membership function, we focused on the analysis of the average of the function at different sub-domains (i.e. geographical domains, sub-populations) by estimating a weighted average of the membership values of the households in each sub-domain.

3 Results and conclusions

In this section we report the fuzzy estimates for households living in food poverty conditions in the 20 Italian regions. From the results reported in Table 1 it is possible to note that Puglia and Sardegna are the most deprived regions, while Valle d'Aosta, Pie-monte and Friuli-Venezia Giulia are the regions showing the smallest values of the estimates. Overall, we have provided accurate estimates [4] as the coefficient of variations are frequently below the 10%. However, even for regions whose estimate is above 10%, this does not exceed the 16%, as recommended in [5]. It is worth noting that even if our results tend to confirm findings in [3], at least two further developments need to be considered. The first is to test for statistical differences among Italian regions. The second is to consider the diversity in purchasing power among Italian region in calculating the poverty thresholds using the spatial price indexes published by ISTAT to assure that the poverty line(s) represent approximately the same standard of living across the different areas.

Table 1. Estimated fuzzy measures of food deprivation and their sampling errors.

Region	Estimate	Std. Dev.	Coefficient of variation (%)
Abruzzo	0.26	0.03	11.37
Basilicata	0.20	0.03	14.27
Calabria	0.23	0.03	11.08
Campania	0.22	0.02	7.41
Emilia-Romagna	0.20	0.02	7.60
Friuli-Venezia Giulia	0.18	0.03	16.05
Lazio	0.21	0.01	6.32
Liguria	0.22	0.03	12.26
Lombardia	0.21	0.01	5.52
Marche	0.19	0.02	10.99
Molise	0.28	0.03	11.72
Piemonte	0.19	0.02	8.67
Puglia	0.31	0.02	6.86
Sardegna	0.32	0.03	10.57

Region	Estimate	Std. Dev.	Coefficient of variation (%)
Sicilia	0.19	0.01	7.93
Toscana	0.21	0.02	7.09
Trentino-Alto Adige	0.22	0.02	9.45
Umbria	0.20	0.02	12.29
Valle d'Aosta	0.18	0.03	16.15
Veneto	0.21	0.02	8.15

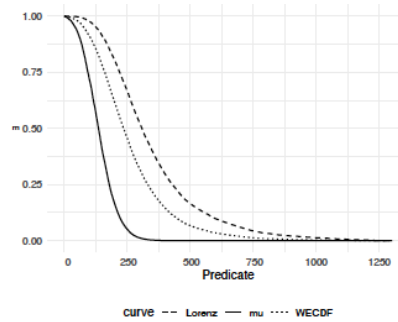


Fig. 1. Estimated membership function.

References

1. FAO. 2021. The State of Food Security and Nutrition in the World 2021: Transforming Food Systems for Food Security, Improved Nutrition and Affordable Healthy Diets for All. Vol. 2021. Food & Agriculture Org.
2. Betti, Gianni, and Achille Lemmi. Poverty and Social Exclusion: New Methods of Analysis. Routledge (2013).
3. Laureti, T., Benedetti, I. Measuring and communicating uncertainty of poverty indicators at regional level. Publications Office of the European Union. (2020)
4. Marchetti, S., Secondi, L. The economic perspective of food poverty and (in) security: An analytical approach to measuring and estimation in Italy. Social indicators research, 162(3), 995-1020 (2022).
5. Statistics-Canada. 2005 survey of financial security - public use microdata file, user guide. published by authority of the minister responsible for statistics Canada. Statistics of Canada, (2007)
6. Zadeh, L.A. "Fuzzy sets" Information and Control, 8, pp. 338-353 (1965)