IES 2022 Innovation & Society 5.0: Statistical and Economic Methodologies for Quality Assessment

BOOK OF SHORT PAPERS

Editors: Rosaria Lombardo, Ida Camminatiello and Violetta Simonacci

Book of Short papers
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Preface

This Book of Short Papers includes all peer-reviewed long-abstracts submitted to the IES2022 conference, titled "Innovation & Society 5.0: Statistical and Economic Methodologies for Quality Assessment", held at the University of Campania "L. Vanvitelli" on January 27-28, 2022. IES2022 is the 10th meeting of the biennial international conference proposed by the permanent group Statistics for the Evaluation and Quality in Services (SVQS) of the Italian Statistical Society (SIS). The SVQS group, born in 2004, focuses on national research programs and applied research activities, on statistical methods and methodologies for the evaluation of the quality of services in public and private fields. For further information, please visit https://www.svqs.it/. IES2022 has been sponsored by the Italian Statistical Society (SIS), the European Network for Business and Industrial Statistics (ENBIS), and the International Association for Statistical Computing (IASC). In addition, also the two SIS groups Statistics and Data Science (SDS) and Enhancement of Public Statistics (VSP) actively supported the conference. IES2022 aims at stimulating a scientific debate on the challenges of Society 5.0 with respect to quality assessment. The conference provides an important moment of reflection for the development of new ideas and methodologies by promoting the rethinking of the open issues in service evaluation within the new paradigm of an interconnected cyber-social system. Service quality assessment represents the starting point for the development of effective policies for private and public institutions, which is crucial for the development of society. Big data, heterogeneous multi-layered structure and designs, cutting-edge analytical tools, and advanced data harvesting techniques have become fundamental for research; nonetheless, they require a continuous effort in terms of proper treatment, interpretation, and supervision to ensure the centrality of human and social problems. In this perspective, IES 2022 main goals are:

- to promote and coordinate the statistical and economic methodologies for the evaluation of a human-centered society emphasizing how statistical thinking, design, and analysis may be of use to a Society 5.0;
- to foster advanced methodological research supporting the assessment of the quality of social services;

- to be a platform where the experts of Statistics, Data Mining, Data Science, Machine Learning, and related disciplines meet for analyzing Big Data.

The high turn-out of the conference, with a total of 107 presentations organized in 22 solicited sessions and 11 contributed sessions, two plenary talks, and the participation of over 300 authors, made evident a very alive interest in evaluation topics. Previous IES editions include:

- IES2009 was held at the University of Brescia (June 24-26, 2009) with selected papers published in special issues of Electronic Journal of Applied Statistical Analysis (EJASA) and Statistica & Applicazioni;
- IES2011 was held at the University of Florence (May 30 – June 1, 2011) with selected papers published in a special issue of the Journal of Applied Quantitative Methods;
- IES2013 held at the University of Milan "Bicocca" (December 9 – 13, 2013) with selected papers published in the Procedia Economics & Finance (Elsevier Publisher);
- IES2015 was held at the University of Bari "Aldo Moro" (June 8 – 9, 2015) with selected papers published in a special issue of Quality & Quantity;
- IES2017 held at the University of Naples "Federico II" (September 6 – 7, 2017) with selected papers published in special issues of Social Indicator Research, Quality & Quantity, and EJASA;
- IES2019 was held at the European University of Rome (July 4 – 5, 2019) with selected papers published in special issues of Socio-Economic Planning Science and EJASA.

All IES2022 contributions are based on the development of innovative statistical methodologies or interesting applications. The topics covered in the numerous presentations range over the following fields: Sustainability, Health, Wellness, Sport, Tourism, Education, Training and Research, Bank and FinTech, Transportation, Environment, Enterprise, Cultural changes and values, Industry and Finance, E-commerce, Digital Marketing, Labour Market, Public Administration, Advertising, Political preferences, Justice System. Several short papers deal with the shock of the COVID-19 pandemic and its impact in different areas such as poverty and sustainability, education and distance learning, student satisfaction, environment, health services, and social interactions. From a methodological standpoint, many of the short papers deal with challenging structures such as high-dimensional data, complex survey designs, constrained variability, sparsity, multicollinearity, and multidimensional longitudinal series. A wide range of statistical tools and models have been employed, including functional data analysis, various types of regression models (high-dimensional, logit, quantile, OLR, LASSO, etc.), machine learning algorithms for classification, methods for multi-way data and contingency tables,

generalized discriminant analysis, multidimensional Item Response Theory, PLS-SEM, advanced visualization techniques, compositional data analysis, Bayesian methods and so on. Extended versions of selected IES2022 papers will be included in a special issue of the Computational Statistics Journal titled "High-dimensional Data Analysis and Visualisation to Assess Service Quality" and of Annals of Operations Research Journal, titled "Statistical Methods and Data-Driven for Decision Making in Public Sector".

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Contents

Solicited Session SS1 – *Compositional Data Analysis*
Organizer and Chair: Gianna Monti

Compositional Data and graph theory

Dati Compositivi e Teoria dei grafi

Christopher Rieser and Peter Filzmoser

Abstract In this short paper we discuss an extension of compositional data to signals with network domain. We recapture the geometric nature of compositional data and describe its relationship to graphs. The derived methodology is illustrated with a data set originating from the Gemas project. This data set with concentrations of chemical elements in soil samples has been considered multiple times in the literature, and we present new insights by using this connection of compositional data analysis with graph theory.

Key words: Compositional Data, Graph theory

1 Introduction

Compositional data analysis (CoDa) has been a very active field of research since the original work of John Aitchison [1]. Assume that $x = (x_1, \ldots, x_D)'$ is a D-dimensional multivariate strictly positive variable of interest, then the core assumption in CoDa is that the information we are interested in is carried by all pairwise log-ratios $\log(\frac{x_i}{x_j})$, for $i, j = 1, ..., D$. This point of view led to the development of the Aitchison geometry and the adaption of tools from classical multivariate statistics to the compositional framework. Many data sets, such as Microbiome data [4] or chemical compositions, have been recognized to bear a compositional nature and have to be treated accordingly. In reality, however, the assumption that all pairwise log-ratios are equally important and influential in the analysis does not seem to be

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appropriate. In practice it seems more realistic that only specific log-ratios are relevant for the analysis, and some log-ratios shall not even be considered because the corresponding compositional parts might not present any interpretable relationship. This naturally leads to a consideration in form of a graph structure of the relevant connections between compositional parts, and an approach with links graph theory and CoDa has been proposed in [10]. In this paper we use this approach and present an application to a well studied compositional data set from the Gemas project, a European geochemical mapping project, where the chemical element concentrations of more than 2000 soil samples have been analyzed. The data set is freely available in the R package [11].

2 Some important concepts from CoDa

We denote $\mathbb{R}^D_+$ as the space of strictly positive D-dimensional real valued vectors. In classical CoDa one works in the D-part simplex $\mathscr{S}^D$

$$\mathscr{S}^D := \left\{ (x_1,\dots,x_D)' \in \mathbb{R}^D_+ \middle| \sum_{j=1}^{D} x_j = 1 \right\} \subset \mathbb{R}^D_+ ,$$

equipped with the two operations $x \oplus y := (x_1 y_1,\dots,x_D y_D)'$ and $\alpha \odot x := (x_1^\alpha,\dots,x_D^\alpha)'$, for any $x = (x_1,\dots,x_D)'$, $y = (y_1,\dots,y_D)' \in \mathbb{R}^D_+$ and $\alpha \in \mathbb{R}$, and the Aitchison inner product,

$$\langle x,y \rangle_{\mathscr{A}} := \frac{1}{2D} \sum_{i,j=1}^{D} \log\left(\frac{x_i}{x_j}\right) \log\left(\frac{y_i}{y_j}\right) . \tag{1}$$

The inner product (1) being at the core of the Aitchison geometry $(\mathscr{S}^D, \langle\cdot,\cdot\rangle_{\mathscr{A}}, \oplus, \odot)$ has the important property of scale invariance – any rescaling of x or y by a constant will not change the analysis. Further desirable properties are permutation invariance and subcompositional coherence [1]. The space $(\mathscr{S}^D, \langle\cdot,\cdot\rangle_{\mathscr{A}}, \oplus, \odot)$ can be shown to be a Hilbert space as well as one-to-one isometrically to $(\mathbb{R}^{D-1}, \langle\cdot,\cdot\rangle_E, +, \cdot)$, where $\langle\cdot,\cdot\rangle_E$ is the standard Euclidean Inner product. Multiple isometries exist, often considered are so called ilr (isometric logratio)-maps, see [2], which are given after fixing a matrix $\mathbf{V} \in \mathbb{R}^{D\times D-1}$ with orthogonal columns spanning the space $\{z \in \mathbb{R}^D | \langle z,1\rangle_E = 0,\}$, by

$$\mathrm{ilr}_{\mathbf{V}} : \mathscr{S}^D \to \mathbb{R}^{D-1}, \quad \mathrm{ilr}_{\mathbf{V}}(x) := \mathbf{V}' \,\mathrm{clr}(x) , \tag{2}$$

where clr denotes the centered log-ratio map

$$\mathrm{clr} : \mathscr{S}^D \to \mathbb{R}^D, \quad \mathrm{clr}\,(x) := \left(\log\left(\frac{x_1}{\sqrt[D]{\prod_{j=1}^D x_j}}\right), ..., \log\left(\frac{x_D}{\sqrt[D]{\prod_{j=1}^D x_j}}\right)\right)' . \tag{3}$$

where n_i is the sample size in province i, w_{ij} is the survey weight of household j in area i, p_{ij} is the food expenditure of household j in area i and t_{ij} is the total consumption expenditure of household j in area i. The survey weights have been calibrated to sum to the total households at provincial level. Although the λ_i's are estimated at the provincial level – thus possibly unreliable because of small sample size – we judge the direct estimates suitable for our purpose.

Having computed the adjusted nPLs, we then calculated the corresponding direct estimates of the poverty rates. As the variability of the direct estimates was too high (approximately half of the provinces have a CV greater than 30%) we estimated a Fay-Herriot (FH) model with the following auxiliary variables: the ratio between number of taxed persons over the population, and the ratios between the number of persons with *i*. income coming from salary, *ii*. income coming from pensions and *iii*. income lower than 10,000 euros per year, over the number of taxed persons. These data come from the Italian tax agency database 2017. The EBLUPs (Empirical Best Linear Unbiased Predictors) obtained with the FH model showed a gain in efficiency with respect to direct estimates. We obtained a CV smaller than 16% in 37 provinces, while half of the provinces had a CV smaller than 20%. We also computed the EBLUPs without any adjustment of the national poverty line, using the same small area model as for adjusted EBLUPs. Figure 2 reports the comparison of the two set of EBLUPs estimates: as we can see, using the SPI($Q_{0.2}$) to adjust the poverty lines, the HCRs in northern and central provinces slightly decrease.

The results obtained here suggest that the methodology can be extended to include other Spatial Price Indexes, therefore adjusting the national poverty line with other components of households' consumption expenditure. Indeed, our results suggest the products included in the scanner data represent a relevant but still limited share of the total household consumption expenditure, approximately equal to the 20%. Therefore, by including other consumption expenditure components, such as for example the expenditure for the rent, the national poverty line could be adjusted in a more complete manner.

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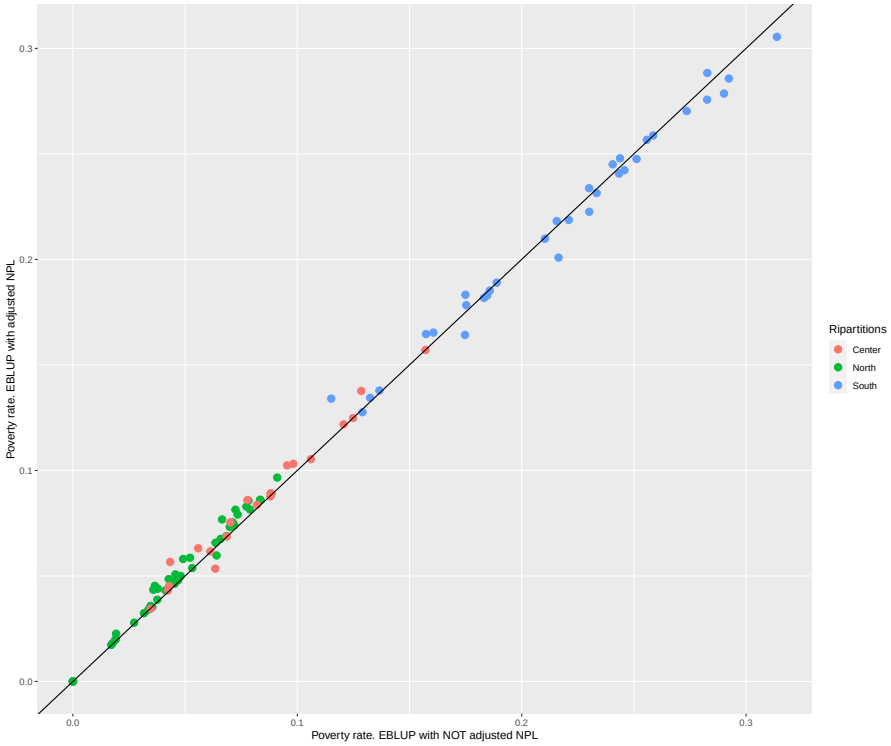

Fig. 2 Poverty rate at provincial level in Italy: provincial EBLUPs estimates using the SPI($Q_{0.2}$) adjusted vs not adjusted national poverty line.

Assessing the targeting of the anti-poverty measure "Reddito di Cittadinanza" using Small Area Estimation methods

Valutazione del targeting del Reddito di Cittadinanza attraverso la stima per piccole aree

Giovanni Tonutti, Gaia Bertarelli, Caterina Giusti and Monica Pratesi

Abstract Sustainable Development Goal 1 calls for the implementation of nationally appropriate social protection systems to contrast poverty. In Italy, a crucial anti-poverty policy is the "Reddito di Cittadinanza" (RdC) introduced in April 2019. In this work we aim at evaluating the targeting of the RdC in 59 local areas represented by the region by degree of urbanisation level in Italy. To measure the local poverty share, we estimate At-Risk-of-Poverty rates and Absolute Poverty rates through the application of Small Area Estimation models. Our results suggest that the RdC shows very heterogeneous targeting performance at the local level, excluding large shares of poor households from the program.

Abstract *L'Obiettivo di Sviluppo Sostenibile 1 richiede l'implementazione di sistemi di protezione sociale adeguati a livello nazionale per contrastare la povertà. In Italia il "Reddito di Cittadinanza" (RdC), introdotto nell'aprile 2019, rappresenta una misura cruciale in tal senso. In questo lavoro valutiamo il targeting del RdC in 59 aree locali rappresentate dai tre gradi di urbanizzazione in ciascuna regione. Per misurare i tassi di povertà, stimiamo il rischio di povertà e la povertà assoluta attraverso l'applicazione di modelli di stima per piccole aree. I nostri risultati suggeriscono che l'RdC mostra un targeting molto eterogeneo a livello locale, escludendo ampie quote di famiglie povere dal programma.*

Key words: Poverty, Targeting Analysis, Small Area Estimation methods

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1 Introduction

In April 2019, the Italian government introduced a national measure of guaranteed minimum income under the name of "Reddito di Cittadinanza" (RdC). RdC represents the largest monetary transfer program to low-income families in the history of the Italian social security system. For the year 2019 alone, total program expenditure was forecasted at €5.6bn, with an estimated cohort of beneficiaries of 1.3m households. Poverty reduction represented the first and key objective of the policy as well as the central theme in the communication campaign leading to the introduction of the measure. Official statistics by the Italian National Statistical Institute (ISTAT) show indeed how the number of households in absolute poverty in Italy had been on the rise over the course of the five years previous to the introduction of the policy. In 2018, the number of families in absolute poverty has reached the figure of 1.8m, with an absolute poverty incidence in the Italian population of 7% (ISTAT 2019), against an estimated total of 1.3m households as potential beneficiaries of the RdC highlighting a gap between the overall cohort of RdC beneficiaries and the total number of families in absolute poverty in Italy (compare INPS 2019). Based on these considerations, this research assesses the extent to which the policy succeeds in targeting support to families in poverty at the local level and which factors related to the local demographic and economic characteristics drive variations in targeting coverage and take-up rates. In addressing these questions, the research will provide the first assessment of the targeting of RdC based on administrative data on its beneficiaries. To capture the geographical heterogeneity in the effects of anti-poverty interventions, we consider as the unit of analysis the degree of urbanization as measured by the DEGURBA classification across the 20 Italian regions. By and large, official poverty indicators are estimated on the basis of surveys collected by national statistical agencies at the national level, and often, due to their limited sample sizes, cannot provide accurate estimates at lower sub-regional units of analysis (Tzavidis et al. 2018). Small Area Estimation (SAE) methods offer the tools to overcome this gap, introducing statistical models that combine the direct estimates obtained from the surveys with error-free administrative covariates to improve the precision of the estimates. While the application of SAE models to study of the geographical distribution of poverty is an established methodology, this work proposes a new application of SAE methods to assess an anti-poverty program. In this paper SAE methods are instrumental to provide the baseline poverty estimates for each of the 59 areas of analysis to successively estimate the targeting performance of the RdC across such areas. The results and conclusions drawn by this research are important for policy makers as they can help them in the design of livelihood policies in the territory where people live. In addition, this paper propose a novel application of SAE methods for assessing local targeting of anti-poverty policies.

2 Data

The analyses presented in this work are based on four main data sources. Estimates for absolute poverty (AP) are based on the HBS data for the year 2017. The survey

provides information on households consumption behaviour. The data-set provides a flag for households living in AP and comprises $\approx$ 17,000 observations. The estimates produced are reliable at regional level but not at the sub-regional due to the limited sample size. Estimates for the at-risk-of-poverty rate (AROP) are based instead on EU-SILC survey collected in 2017. EU-SILC aims at collecting timely and comparable cross-sectional and longitudinal multidimensional microdata on income, poverty, social exclusion and living conditions. The 2017 wave of survey contains information on self-reported income for the year 2016 with a total of 22,200 observations. Finally, information on the number of RdC beneficiaries and the monetary amount of benefit received by municipality was provided by INPS, the Italian Social Security Agency. The data-set identifies the total number of households and individuals in receipt of the scheme as of December 2019.

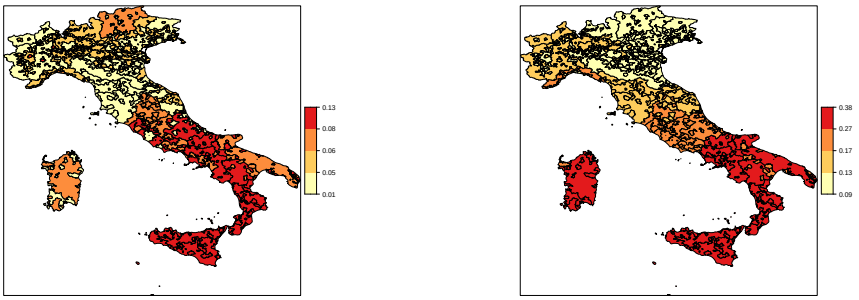
3 Methods

For both AP and AROP estimates, our target indicators are the small area means. The application of SAE models aims at increasing the precision of direct survey estimates through the use of the administrative covariates at DEGURBA $\times$ region level. To this purpose, we apply the Bivariate Fay-Herriot (FH) model (Benevanent and Morales 2016). The FH model and its multivariate transformations are area level models that links direct estimates to area level covariates. In the study of anti-poverty programs, the concept of targeting refers to the attempt by public officials to identify who is poor and then to restrict transfers to those individuals (Hanna and Olken 2018). Data on RdC beneficiaries was made available for this research at the municipality level. This level of aggregation does not allow to identify those recipients of RdC who can be considered as not poor. As such, the most meaningful targeting indicator to be applied in this analysis is the Coverage Rate (CR) metric (Coady et al. 2004) Defining by D_{ij} an indicator variable that takes value 1 if unit j living in area i was beneficiary of the RdC and by c_{ij} and y_{ij} the unit consumption and income measure, and with t_{ij} and t the corresponding poverty lines, two CRs can be defined as following:

$$CR_{iAP} = \frac{\sum_{j=1}^{N_i} D_{ij} \cdot \mathrm{I}(c_{ij} \leq t_{ij})}{\sum_{j=1}^{N_i} \mathrm{I}(c_{ij} \leq t_{ij})} \qquad \text{and} \qquad CR_{iAROP} = \frac{\sum_{j=1}^{N_i} D_{ij} \cdot \mathrm{I}(y_{ij} \leq t)}{\sum_{j=1}^{N_i} \mathrm{I}(y_{ij} \leq t)}.$$

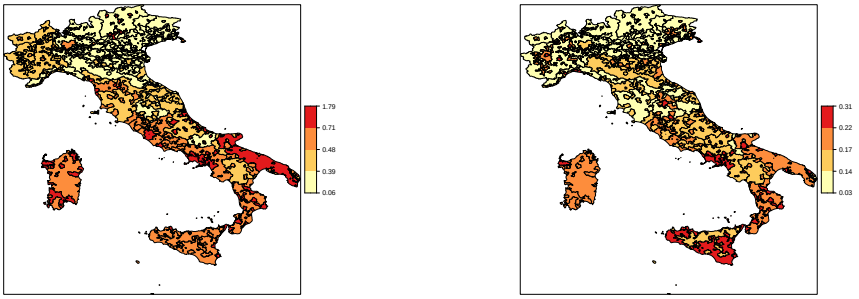
The two measures above correspond to the ratio between the total amounts of households in absolute poverty and at risk of poverty who received the RdC living in area i, over the corresponding total amount of households in absolute and relative poverty in area i.

4 Results and Discussion



(a) (b)

Fig. 1: Estimates of absolute poverty (panel a) and of the AROP (panel b) for the 59 degrees of urbanisation across 20 regions in Italy.



(a) (b)

Fig. 2: Coverage rate of RdC estimated on AP (CR_{AP} - panel a) and on AROP (CR_{AROP} - panel b) for the 59 degrees of urbanisation across Italy 20 regions.

Small area estimations are employed to improve the precision of direct estimates from both HBS and EU-SILC, surveys designed to provide reliable information at higher geographical levels. To assess gains in the accuracy of our estimates we compare the coefficient of variations of bivariate FH model with those of the respective direct estimates. In this analysis, the application of SAE methods brings considerable gains to the precision of estimates as illustrated in Table 1. The bivariate FH model reduces the number of areas with CV estimates above the 33.3% threshold by more than three times, compared to the direct estimates of absolute poverty, leaving

only 7 areas with an uncertainty of estimation too high to be considered as reliable. By contrast, the bivariate FH estimates of AROP show CVs all below the 16.5% threshold. The difference in precision between the two estimates stems from three main reasons.

		<16.5%	16.5-33.3%	>33.3%
AP	Direct	5	32	22
	FH bivariate	11	41	7
AROP	Direct	33	22	2
	FH bivariate	59	0	0

Table 1: Comparison of the coefficients of variation of absolute poverty and AROP estimates.

Figure 1 shows the distribution of poverty for the 59 degree of urbanisation across Italy 20 regions for both AP and AROP indicators. Both maps show a clear distinction in poverty incidence across the country's three main areas of north, centre and south: higher poverty incidence characterise southern areas. The AP index ranges from a maximum of 13.38% for the rural areas of Molise (South), to 1.11% in the sub-urban areas of Trentino-Alto Adige (North). The AROP ranges from 37.62% in sub-urban Sicilian areas (South) to 9.13% in sub-urban Friuli-Venezia Giulia (North). These findings reflect the country long-lasting economic dualism. While following a clear north-south divide, the geographical distribution of absolute poverty incidence shows variation within the three main geographical areas. The second main consideration is related to the within region heterogeneity in the incidence of AP, in contrast with a rather homogeneous within-region distribution of the AROP indicator. When poverty is measured on consumption, there seems to be greater variations within the same region across different degrees of urbanisation. The considerations highlighted so far are the result of differences in the definition of the poverty indicators considered by the analysis. As discussed in Section 2, AP is estimated on the basis of consumption behaviour based on different poverty lines, varying across Italy three macro-areas and across the size and type of municipality of the survey respondent. Unlike single national poverty threshold, such as the AROP indicator present in the EU-SILC data, this approach allows to capture differences in costs of living. Given the limitations of the data on RdC beneficiaries, which are available at aggregate municipalities level, and the difficulty in excluding non-poor recipients from the overall share, the targeting indicators are likely an overestimate of the true parameter. Figure 2 plots the two CR indicators of the RdC for each of the 59 DEGURBA areas across the 20 Italian regions. We observe a rather heterogeneous distribution of the CR indicators across Italy. The main difference in the comparison of the two indicators is in the width of the range of values. The CR_{AP} indicator ranges from 5.6% in the rural areas of Trentino-Alto Adige to 179.31% in the sub-urban areas of Sardinia. Values of the CR_{AROP} indicator, on the contrary, show a significant narrower range, from 3.31% of rural areas in Trentino-

Alto Adige to 31.07% of urban areas in Sicily. The CR_{AROP} indicator highlights how the vast majority of households identified as at risk of poverty are excluded from the support provided by the RdC. The CR_{AP} indicator, on the contrary, describes a policy with large geographical heterogeneity in its targeting performance, excluding large number of absolute poor households in areas with higher costs of living, and including non-poor households in more affordable ones. Overall, the policy seems to consistently show lower targeting performance in the northern areas of the country, especially in the North East. Approximately all among the bottom 10 areas for both CR_{AP} and CR_{AROP} indicators are in the North. Moreover, if we consider both CR_{AP} and CR_{AROP} metrics, rural areas across Italy present lower targeting performance, irrespective of the three macro-areas considered.

5 Conclusion

In this work we presented a first study on the targeting at the local level of the RdC anti-poverty policy in Italy. The study was based on four main data sources and made used of appropriate SAE techniques to obtain reliable poverty estimates for the 59 local areas of interest. It is essential to implement local level targeting of anti-poverty policies to meet the needs and problems of the territory where people live. The results of this study show an heterogeneous targeting performance of the RdC policy, with a general lower targeting affecting norther regions and rural areas.

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Household Consumption and Food Insecurity in Mexico: Covid19 and Sustainable Development

Consumi delle famiglie e insicurezza alimentare in Messico: Covid19 e sviluppo sostenibile

Adrian Vargas-Lopez and Luca Secondi

Abstract Attaining a lower level of food insecurity is crucial for developing countries as its consequences spread wide and deep into specific communities. Covid-19 has magnified the adverse effects of several problems worldwide, including food security. This study investigates the Mexican Households' four food security thresholds using the 2018 and 2020 waves of the National Household Income and Expenditure Survey (ENIGH), which contains the Latin American and Caribbean Food Security Scale (ELCSA). In this research, we assess the differences in the four food security categories with reference to both individual and household variables as well as contextual factors.

Abstract *Raggiungere un livello inferiore di insicurezza alimentare è fondamentale per i paesi in via di sviluppo poiché le conseguenze si estendono in modo ampio e profondo in comunità specifiche. Il Covid-19 ha amplificato gli effetti negativi di diversi problemi in tutto il mondo, inclusa la sicurezza alimentare. Questo studio indaga le quattro soglie di sicurezza alimentare delle famiglie messicane utilizzando i microdati delle indagini 2018 e 2020 del National Household Income and Expenditure Survey (ENIGH), che contiene la scala di sicurezza alimentare dell'America Latina e dei Caraibi (ELCSA). In questa ricerca, valutiamo le differenze nelle quattro categorie di sicurezza alimentare sia con riferimento a variabili individuali e familiari che contestuali.*

Keywords: Food Insecurity, Covid19, Mexico, ELCSA

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1 Introduction

Food security is defined as "*having at all times, physical, social and economic access to sufficient, safe and nutritious food that meets dietary needs and food preferences for an active and healthy life*" (World Food Summit, 1996). On the other end, household food insecurity is a significant threat that targets vulnerable groups (Vilar-Compte et al., 2014). According to figures from FAO, almost 811 million people faced hunger last year.

The physical consequences of all forms of malnutrition intensify problems related to chronic illnesses, obesity and additional forms of maladies (Santana-Cárdenas and López-Uriarte, 2021). People living in food insecurity conditions significantly reduce their quality of life and cut their life expectancy (Hampton, 2007). Thus, reducing the number of people that suffer from food insecurity is morally urgent.

We know global crises intensify problems that individuals face daily (Vilar-Compte et al., 2014; Vilar-Compte et al., 2019). The Covid-19 pandemic is not the exception since several studies suggest that food supply chains were disrupted (Singh et al., 2021). Living in a family heavily hit by the pandemic made things more difficult for each member, where infants suffered the most (Magaña-Lemus et al., 2016).

In this study, we explore the likelihood of being into the four food security thresholds by referring to two different waves of the Mexican Household Income and Expenditure Survey (ENIGH) carried out in 2018 (before) and 2020 (during the Covid-19 pandemic).

The remainder of this paper is organized as follows. In the next section, we briefly describe the food security status in Mexico. Then, in Section 3, we describe the data and briefly mention the type of model we selected. In Section 4, we describe our results, while in Section 5, we draw the main conclusions and further necessary progress of the research.

2 Food insecurity in Mexico

In Mexico, individuals experiencing severe food insecurity are geographically located in some of the poorest regions (Mundo-Rosas et al., 2018). These areas are predominantly rural sites in the southern part of the country. Additionally, of these families, when asked if they speak an indigenous language, most state they do (Mundo-Rosas et al., 2018).

Concerning Mexicans' type of diet, Mundo-Rosas et al., 2019 find that having less healthy diets correlates with harsher food insecurity levels. Moreover, they also find that people with severe food insecurity have remained unchanged from 2012 until 2018, at 43%. Magaña-Lemus et al., 2016 paint a clear picture regarding

the characteristics of the head of the household. Dwellings, where the head of the household is a woman with less education, single or widowed, younger, with a disabled relative, experience higher insecurity levels (Magaña-Lemus et al., 2016). Mora-Rivera and van Gameren, 2021 find that homes with access to remittances improve their food security conditions (Mora-Rivera, J. and van Gameren, E., 2021).

3 Data and Methods

The data we used for the analysis considers two waves retrieved from the National Household Income and Expenditure Survey (ENIGH), a nationally representative survey conducted every two years. Most countries in Latin America measure food insecurity using the Latin American and Caribbean Food Security Scale (ELCSA). These are six questions where families signal if during the past three months they had access to a limited variety of food, whether they skipped a meal, if they had eaten less than they thought they should, if they ran out of food, if they felt hungry but did not eat, and if they had not eaten for a whole day. These questions are asked twice if in the household there are children (i.e., individuals younger than 18). The second time, respondents answer for the infants living in the dwelling (Villagómez-Ornelas, 2014).

The severity of food insecurity is constructed by the number of questions that people answer affirmatively. When households without children answer "Yes" to 5-6 questions, they are *Severely Insecure*. If they answer 3-4 questions affirmatively, they are *Moderately Insecure*; 1-2 questions, *Mildly Insecure*; and, 0 questions, *Secure*. Similarly, each threshold is built for households with and without children. Those homes with children that answer 8-12 questions affirmatively are *Severely Insecure*; 4-7, *Moderately Insecure*; 1-3, *Mildly Insecure*; and 0, *Secure*.

Additionally, the data we include in our model is if people live in an urban or rural condition (1 "Rural" or 0 "Urban"), their level of socioeconomic status (1 "Low", 2 "Medium Low", 3 "Medium High" or 4 "High"), the gender of the head of the household (1 "Male" or 0 "Female"), if they receive government's aid (1 "Yes" or 0 "No"), if the household receives remittances (1 "Yes" or 0 "No"), if they have a form of debt (1 "Yes" or 0 "No"), if they have received donations in the past three months (1 "Yes" or 0 "No"), if they live in a household with children (1 "Yes" or 0 "No"), the type of diet consumed at home to meet basic needs (1 "Poor", 2 "Bordering" or 3 "Acceptable"), and the region they belong (i.e., eight regions in total). Where traditionally, regions 6 and 7 are the ones with higher levels of poverty.

To analyze food insecurity in households, we used a multinomial logistic regression. The preliminary analysis considers the variables described in the data section as the vector of X_j independent variables and the four possible thresholds of food insecurity as the *k* categorical outcomes. Furthermore, we stick to the traditional approach of multinomial logistic regressions shown in Greene, 2012. Since the