Fourth Workshop on Methodologies for Official Statistics
Rome, 2nd December 2025

Innovations in the Quality of EU-SILC Survey Estimates

Diego Chianella, Michele D'Alò, Claudia De Vitiis, Stefano Gerosa, Marco Dionisio Terribili

ISTAT

OUTLINE

1. A methodological review of the EU-SILC survey
2. Precision requirements and survey estimates
3. The revision of IT-SILC weighting procedure
4. The impact of the revision of the EU-SILC weighting procedure
5. Open questions and future work

A methodological review of the EU-SILC survey

The EU-SILC survey is undergoing **a comprehensive methodological review process** that covers multiple aspects. Main drivers:

- availability of **new data sources** integrated in the System of Statistical Registers
- new and demanding **precision requirements** for key EU-SILC indicators

Three different areas are involved

1. A revision of the **weighting procedure,** using data from BDR fiscal archive

2. A revision of **EU-SILC sampling strategy**, using data from the income register for the stratification of households

3. The development of **small-area estimation (SAE) methods and models** for EU-SILC indicators

Regulation 2019/1700: new precision requirements for EU-SILC

Regulation 2019/1700 establishes a common framework for European social statistics (ESS) and sets new precision requirements for EU-SILC:

- while former requirements were based on **minimum effective sample size**, the new ones are based on **precision thresholds (i.e. standard errors)** on key indicators.

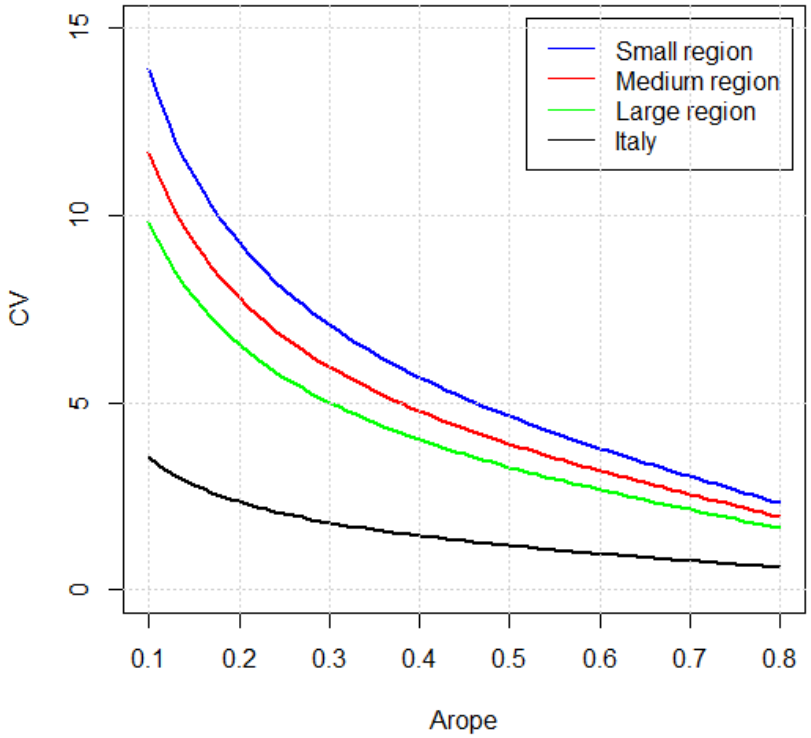
- requirements for the leading AROPE (at risk of poverty or social exclusion) indicator, **are also introduced at regional (NUTS2) level**

In particular, the estimated standard error of a particular estimate $\hat{p}$ shall not be bigger than

$$\sqrt{\frac{\hat{p}(1-\hat{p})}{f(N)}}$$

where $f(N) = a\sqrt{N} + b$, N is a measure of population size and (a,b) are parameters.

Regulation 2019/1700: new precision requirements for EU-SILC



New precision requirements are **demanding**:

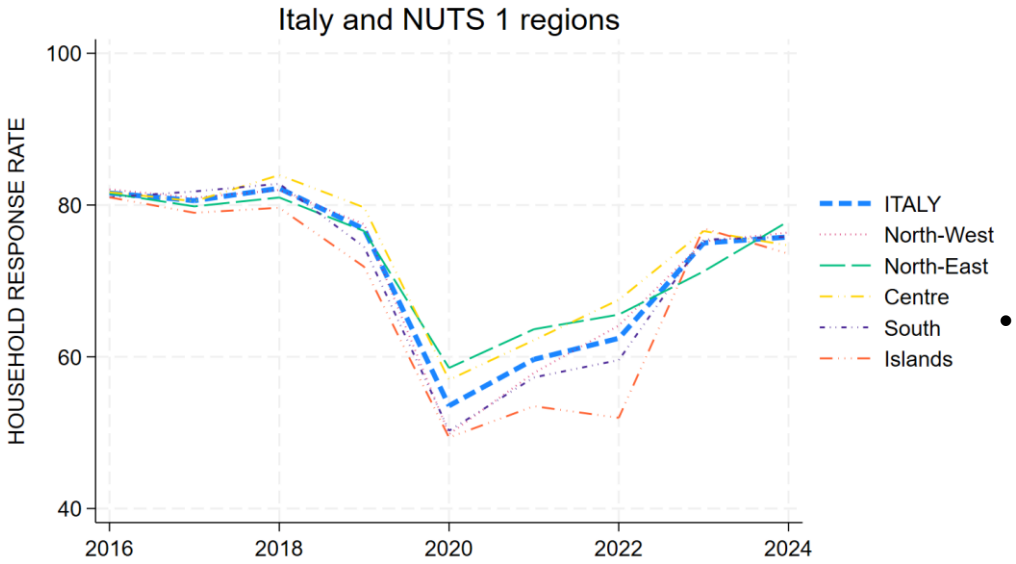
- for an AROPE value around 25% the **requested CV is around 2% at the national level** and between 5% and 7% for NUTS 2 region.
- for regions that have both **large populations and a high value of AROPE**, such as Campania and Sicilia, the requested CV is **under 4%**.

Compliance with AROPE NUTS 2 requirements for EU-SILC. Years 2016-2024 (unweighted means NUTS 2 regions)

	AROPE	CV_AROPE	RESPONSE RATE	NON-COMPLIANT REGIONS	PRECISION GAP
2016	29.0	7.5	81.7	9	-1.0
2017	28.0	7.2	80.5	6	-7.1
2018	25.9	8.3	82.3	7	7.8
2019	23.9	8.6	76.4	8	2.0
2020	24.8	10.8	54.3	19	27.2
2021	24.3	10.3	60.9	17	23.1
2022	25.1	11.7	63.5	20	40.6
2023	22.8	10.4	75.0	13	17.1
2024	22.2	9.6	76.0	6	4.4

- the **average CV of AROPE** estimates rose from an 7.5% to a maximum of 11.7% in 2022
- the **number of non-compliant regions** went from 6 to a maximum of 20
- the **average precision gap** went from -1%, with the average regional SE under the required threshold, to more than 40% in the worst year.

Household response rate at national and NUTS 1 levels. EU-SILC 2016-2024.



- **Lower response rates affects estimates precision directly**, by reducing sample size, and **indirectly**, through the increase in the variability of sampling weights associated with non-response adjustment.
- Because of the **longitudinal structure of EU-SILC and of its sampling design**, the impact of the sharp decline in response rate will be felt for the years to come, and only slowly decaying.

IT-SILC Sampling Design

- **Rotational sample design** - independent rotational groups (waves) each of them similar in size and design and representative of the whole population. From one year to the next, a part of the sample is rotated **(a sub-sample exits and a new sub-sample enters)** and the other part remains unchanged.

- Until 2019, the Italian sample consisted of 4 rotational groups, each of which remained in the sample for four consecutive years. From 2021, **6 rotational groups** were adopted each remaining six consecutive years.

- Since 2015, **a mixed CAPI-CATI technique** is used for collecting interviews, through household and personal questionnaires.

IT-SILC Sampling Design

Two stage sampling design:

- ✓ First stage: the Primary sampling units (PSU) are the municipalities
- ✓ Second stage: the Secondary sampling units (SSU) are the households

- PSU are stratified according to their demographic size (i.e. # residents)
- Stratification is carried out inside each administrative region
- PSU are selected in each stratum with probability proportional to their size

- Secondary sampling units (i.e. households) are not stratified
- Households are selected with equal probability by systematic sampling in each selected municipality from population register lists (LAC)
- No substitution of unit non-response has been applied

Current EU-SILC Weighting Procedure – Non Response Adjustment

- Each household in the sample is initially assigned a **design weight** given by the inverse of its inclusion probability:

$$d_k = \frac{1}{\pi_k}$$

- The base weights are then **adjusted for unit non-response at the household level** :

$$w_k = \varphi_k^{-1} d_k$$

where the **response probability φ_k** is estimated by a **logistic regression model,** separately defined and estimated for the 1st and subsequent waves**.**

Current EU-SILC Weighting Procedure - Calibration

- A **first calibration step** is then applied to assure the same population structure of LFS with respect to **education level and professional position** (since non-response is highly correlated with both variables). Resulting weights $\widetilde{w_k}$ are then trimmed to reduce dispersion.

- Final weights are then obtained applying a **calibration of household weights to population registers**, so that calibrated weights $\widehat{w_k}$ are able to exactly reproduce a **set of demographic known totals** (distribution of the population by sex and 14 age-groups at the NUTS-1 level; distribution of the population by demographic size of the municipality at Nuts 1 level; distribution of non-national population at NUTS-1 level by sex and 2 age-groups; number of households at NUTS-2 level).

- The procedure also ensures that **each member of the same household has the same weight**.

New EU-SILC Weighting Procedure - Non-response adjustment

1. **Logistic Model with Quartile-Based Grouping**

- Separate estimation of logistic regression models for:
  - ✓ First wave vs. subsequent waves
  - ✓ CATI (Computer-Assisted Telephone Interview) vs. CAPI (Computer-Assisted Personal Interview) modes

- Selection of explanatory variables through stepwise procedure

Main innovation: instead of assigning individual correction factors, units are grouped according to their estimated response propensity.

New EU-SILC Weighting Procedure - Non-response adjustment

Grouping strategies:

- ✓ Tertiles
- ✓ **Quartiles ✓ (adopted solution)**
- ✓ Quintiles
- ✓ Deciles

Evaluation metrics:

- **Concordance Index (CI):** measures how well the logistic model can distinguish between units that responded and units that did not respond to the survey
  Higher values = better separation between respondents and non-respondents

- **Kish Index (1+CV):** quantifies the effect of weight variability
  Lower values = less weight dispersion and greater efficiency

New EU-SILC Weighting Procedure - Non-response adjustment

2. **CART Model (Classification And Regression Trees)**

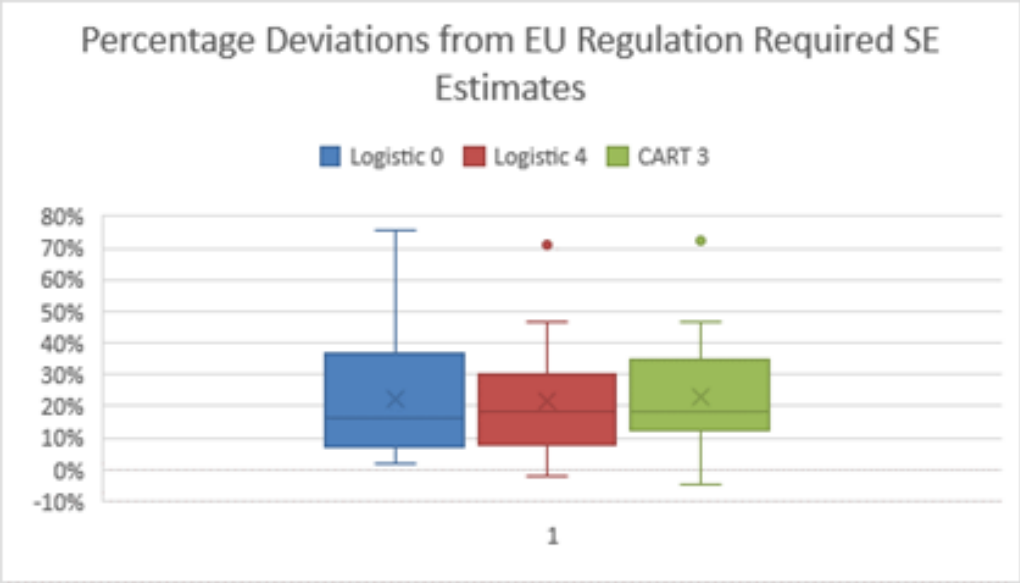
- ✓ Non-parametric method that recursively identifies optimal variables and thresholds to create homogeneous groups
- ✓ Implementation in R using ctree function from the party package
- ✓ Control parameter: maxdepth=3 (maximum 3 sequential splits)

Comparison Results

The analysis compared **percentage deviations from the required SE at the regional level**, focusing on positive deviations (where the observed standard error exceeds the regulatory threshold).

Analysis of the EU-SILC non-response adjustment

- **CART model appears to yield inferior results compared to logistic approaches**. This is observed through a larger median and/or a wider IQR, suggesting less precise targeting of the nonresponse adjustment when using this specific tree structure.
- **Quartile-based grouping strategy** for the logistic model contributes effectively to enhancing the stability of the correction factor.



New EU-SILC Weighting Procedure – Fiscal data

Introduction of fiscal data from the BDR (Banca Dati Reddituale) archive: there is evidence of **a nonignorable nonresponse bias varying along the fiscal income distribution,** potentially affecting multiple income-based indicators. We introduce constraints for

- the **number of taxpayers**
- **fiscal income aggregates**

by fiscal income decile, with a decomposition of the last decile (90-95, 95-99 and the highest 1%), to capture the details of the upper tail of the fiscal income distribution.

New EU-SILC Weighting Procedure - From Two-Step to One-Step Calibration

The Simplified One-Step Approach:

- **Strategic Rationalization** → from 209 to 175 Constraints

- **Three-Phase Strategy**:
  1. Essential Constraints First: Focus on EU regulatory requirements
  2. Classification & Documentation
     - ✓ Inventory of current constraints
     - ✓ Justification for each constraint
     - ✓ Identification of redundancies
  3. Empirical Validation
     - ✓ Test additional constraints: Evaluate contribution to precision (CV reduction)

1 - The impact of the new weighting procedure – Non-response bias

	TAX-FILERS (2023)			FISCAL INCOME (2023)				
	BDR	SILC	Delta	BDR	EU-SILC	Delta	EU-SILC (W1)	Delta
Percentile								
10	4.09	3.66	-10.3%	3.9	3.3	-14.1%	3.7	-4.9%
20	4.09	3.37	-17.6%	22.0	18.3	-17.0%	22.1	0.3%
30	4.09	3.89	-4.8%	38.3	36.3	-5.0%	38.2	-0.3%
40	4.09	3.76	-8.1%	54.5	50.2	-7.9%	54.5	0.1%
50	4.09	3.87	-5.3%	70.3	66.7	-5.1%	70.4	0.2%
60	4.09	3.72	-9.1%	85.0	77.2	-9.2%	84.9	-0.1%
70	4.09	3.94	-3.5%	99.1	95.6	-3.5%	99.2	0.1%
80	4.09	4.02	-1.6%	116.9	115.3	-1.4%	117.2	0.2%
90	4.09	4.19	2.5%	144.3	147.5	2.2%	144.0	-0.2%
90-95	2.04	2.09	2.4%	96.3	98.8	2.6%	95.1	-1.3%
95-99	1.64	1.66	1.2%	126.4	128.0	1.2%	122.8	-2.9%
99-100	0.41	0.41	0.6%	93.3	91.0	-2.6%	91.8	-1.6%
Total	**40.88**	**38.59**	**-5.6%**	**950.4**	**928.2**	**-2.3%**	**943.9**	**-0.7%**

The impact of the new weighting procedure

- In 2023 and 2024, the **number of tax filers is underestimated by a fraction between 6% and 7%,** but the underestimation is **concentrated in the lower tail**, with the two lowest deciles underestimated by a fraction between 10% and 20%.

- The same holds true for tax income, but **also total income of the last percentile, the richest 1%,** is underestimated by a significant fraction.

- **Calibrating only with respect to the number of tax filers** by income decile is not sufficient to eliminate the under-estimation of income aggregates in the bottom and upper deciles.

2 - The impact of the new weighting procedure – Eu-SILC Indicators

	2023	2023 new	Δ	2024	2024 new	Δ
INCOME						
Household net income	35,995	36,413	1.2%	37,511	38,323	2.2%
Employee income	16,130	15,774	-2.2%	16,982	16,318	-3.9%
Self-employment income	5,791	6,001	3.6%	5,868	6,529	11.3%
Pension income	10,330	10,824	4.8%	10,848	11,601	6.9%
AROPE INDICATORS						
AROPE	22.8	22.8	0.0	23.1	22.4	-0.6
Risk of poverty	18.9	19.0	0.0	18.9	18.5	-0.4
Severe material and social deprivation	5.6	5.4	-0.2	5.6	5.0	-0.5
Low work intensity	8.9	8.8	-0.1	9.2	8.7	-0.5
INEQUALITY						
Gini index	31.5	31.3	-0.3	32.2	31.8	-0.5
S80/S20 ratio	5.3	5.2	-0.1	5.5	5.3	-0.2

- **Household net income increases** between 1% and 2%, with large increases in self-employment and pension incomes and a contraction in employee income.
- **AROPE indicators show slight reductions**, more pronounced in 2024, and **inequality decreases**.

3 - The impact of the new weighting procedure – Efficiency

	OLD WEIGHTS			NEW WEIGHTS			
	SE	SE_req	GAP	SE	SE_req	GAP	DELTA
Piemonte	1.02	1.18	-13%	0.86	1.15	-26%	-12%
Valle d'Aosta	1.36	2.56	-47%	0.89	2.57	-65%	-18%
Lombardia	1.47	0.98	51%	1.13	0.98	14%	-36%
Bolzano	1.81	1.46	24%	1.41	1.25	12%	-12%
Trento	1.44	1.82	-21%	1.17	1.65	-29%	-8%
Veneto	1.34	1.12	20%	1.64	1.10	50%	30%
Friuli-Venezia Giulia	1.29	1.56	-18%	1.13	1.44	-22%	-4%
Liguria	1.50	1.51	-1%	1.13	1.48	-24%	-23%
Emilia-Romagna	1.15	1.04	11%	0.93	0.96	-4%	-15%
Toscana	1.38	1.27	8%	1.34	1.26	6%	-2%
Umbria	1.13	1.80	-37%	1.06	1.72	-38%	-1%
Marche	1.12	1.44	-22%	1.28	1.44	-11%	11%
Lazio	1.34	1.41	-5%	1.64	1.41	17%	22%
Abruzzo	3.59	2.05	75%	3.03	2.07	47%	-28%
Molise	3.57	3.05	17%	2.85	2.99	-5%	-21%
Campania	1.61	1.66	-3%	1.58	1.65	-5%	-1%
Puglia	1.92	1.75	10%	1.98	1.70	16%	6%
Basilicata	2.78	2.55	9%	2.74	2.63	4%	-5%
Calabria	3.14	2.15	46%	2.27	2.14	6%	-40%
Sicilia	2.08	1.67	24%	2.18	1.69	29%	5%
Sardegna	2.45	2.01	22%	2.42	2.00	21%	-1%
ITALIA	**0.45**	**0.50**	**-9%**	**0.43**	**0.49**	**-13%**	**-4%**

- **Precision gap** (the percentage distance between the estimated and the requested standard error for the AROPE indicator) as the relevant metric.
- Across regions, we **obtain a 10% reduction in the precision gap in 2023 and a 7% reduction in 2024,** while the number of non-compliant regions decreases from 13 to 8 in 2023 and from 6 to 4 in 2024.
- Thanks to a large reduction in the precision gap of the most populous Italian region (Lombardy), **in 2024 Italy would have been compliant with Eurostat requirements** with the new weighting procedure.

Ongoing work – The revision of EU-SILC sampling design

- **Tax income as a stratification variable** for the second-stage of EU-SILC sample extraction: beginning with EU-SILC 2026 , the households of the oncoming wave will be **stratified into seven classes defined by quantiles of equivalized family income** (the first two and last two deciles, and the second, third, and fourth quintiles).

- For the sample allocation among the seven classes**, a multivariate optimal allocation has been developed**, which is still under study. For now, it has been decided to use a proportional distribution of families within the regional strata.

- The study has shown **a significant efficiency gain due to stratification itself**, for the estimation of the target parameters (AROPE, APROP).