Enhancing the SHIW weighting methodology with external data sources

by

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1 Introduction[2]

The Survey on Household Income and Wealth (SHIW) was launched in the 1960s. The survey is used to collect granular information on many aspects ranging from the socio-demographic characteristics of the household and of its members, to the different sources of income, to the household's assets and liabilities to the consumption and saving behaviour. Historically, the finals sample size has been of about 8,000 households.

Traditionally, reflecting external data limitations, the sample was drawn in two stages: first, a stratified sample of municipalities was selected, followed by a simple random sample of households from the population registers.

Starting with the 2019 wave, the target size of the final sample has been raised to 10.000 households, and the sampling design has been modified to enhance the survey's ability to describe each segment of the income distribution, particularly the very affluent households that are typically difficult to enroll, and to increase the precision of the estimators. In collaboration with the National Statistical Office, the sample of households to be interviewed is now selected on the basis of administrative data on households' taxable income (see Barcaroli et al. 2019). In the 2019 wave, the survey also included an independent one-off independent sample of 2.000 indebted households drawn from the Central credit registry (CR) whose planned use was to improve the analysis of household indebtness and financial vulnerability.

Unfortunately, the introduction of these changes coincided with the outbreak of the COVID-19 pandemic. The 2019 wave, whose fieldwork began in early 2020, had to be interrupted and was eventually conducted in 2021, with 2020 as reference year and a different collection mode (shifting from Computer Assisted Personal Interview - CAPI - to a mixed approach that included telephone interviews). Despite the postponement, there was a significant drop in household willingness to participate, due to ongoing restrictions and fear of contagion. The final number of interviews from the main sample (approximately 5,300 households) did not meet the historical standard of the SHIW, which typically consists of around 8,000 households. Hence, the additional sample of indebted households was added to the main one to achieve an acceptable minimum sample size. As a result, the total achieved sample was about 6,200 households (out of a target of 10,000 for the main sample and 2,000 for the one-off sample of indebted households).

The traditional weighting scheme[3] was modified to incorporate the new selection probabilities of the updated sampling design and to mitigate potential biases in the results caused by the pandemic (see

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[3] The weighting scheme is a crucial process designed to produce survey weights, which are adjustment factors that account for different probabilities of selection and compensate for issues such as non-response from certain population subgroups. The main purpose of these weights is to ensure that the survey findings are as accurate and representative as possible.

Section 2). Moreover, an additional set of weights was created to enable comparisons with the previous waves by approximating the composition of the sample that would have been obtained without the methodological changes made to the sampling design.

Survey data were planned to be subsequently linked with external data to enhance their use in the weighting process. Unfortunately, these auxiliary data did not become available until after the release date of the 2020 wave results.

The 2022 wave, begun in early 2023, is the second one conducted with the new sampling design. The availability of administrative data, along with the taxable income totals to be used as benchmarks, has made it possible to refine the weighting methodology for 2022 and to conduct a critical review of the methodology and results obtained for 2020.

2 The weighting process

2.1 The traditional weighting process (until 2016)

Traditionally, the weighting process involves the following steps.

In step 1, an initial weight is computed as the inverse of selection probability (design weight $w_{hi}^{(0)}$) which is the same for all households residing in municipality *i:*

$$w_{hi}^{(0)} = \left(\frac{1}{m_h}\frac{P_h}{P_{hi}}\right)\frac{N_{hi}}{n'_{hi}} \qquad h = 1, \dots, H;\ \ i = 1, \dots, M$$

where *h* denotes the stratum in which municipalities are grouped[4], P_h and m_h represent respectively the number of resident population and the number of sample municipalities in the stratum *h*, P_{hi}, N_{hi} and n'_{hi} are respectively the resident population, the resident households and the sampled households in municipality i. The product $\left(\frac{1}{m_h}\frac{P_h}{P_{hi}}\right)$ represents the reciprocal of the inclusion probability of municipality *i.* The ratio $\frac{N_{hi}}{n'_{hi}}$ represents the inverse of the inclusion probability for a single household residing in municipality i, conditional on the fact that municipality i is included in the sample.

In step 2, the weight is then multiplied by the inverse of the response rate estimated at the municipality level to adjust for unit non-response[5]:

$$w_{hi}^{(1)} = w_{hi}^{(0)}\frac{n'_{hi}}{n_{hi}}$$

where n_{hi} is the number of respondents in municipality *i.*

[4] Before the municipalities are selected, they are stratified by region and population size (up to 20,000 inhabitants, 20,000-40,000, and over 40,000).

[5] This method also adjusts for non-participation due to other causes than refusals, such as wrong address, death, or change of address.

In step 3, the weight $w_{hi}^{(1)}$ is further adjusted for panel attrition (i.e. non-response from household units who participated in previous surveys) and to replicate the panel's optimal share, estimated at approximately 50 per cent of the sample, resulting in the weight $w_{hic}^{(2)}$

$$w_{hic}^{(2)} = w_{hi}^{(1)} \cdot \alpha_c$$

where α_c is the adjustment factor for households belonging to cell *c* (*c* = 1,..12). The cells are formed by the intersection of income class (4 categories) and work status of the head of household (3 classes), as collected in the previous wave. The adjustment aims to align the distributions of these variables in the panel component with those observed in the previous wave for the entire population.

In step 4, $w_{hic}^{(2)}$ is finally adjusted using an iterative weight rebalancing technique (raking) to match the share of people with given characteristics estimated by SHIW with the actual shares available in external sources, obtaining the final weight $w_{jhic}^{(3)}$.

$$w_{jhic}^{(3)} = w_{hic}^{(2)} \cdot \gamma_j$$

where γ_j is the adjustment factor for household j. In the traditionally approach, external benchmarks consider socio-demographic characteristics such as gender, age groups (<26, 26-45, 46-65, >65), geographical regions (North, Centre, South, and Islands), and the population size of the municipality of residence (<20,000; 20,000-40,000; 40,000-500,000; >500,000).

2.2 The new weighting process (from 2022 onwards)

Whereas external information on household finances was not utilized in any of the steps of the traditional weighting process, the new weighting process intensively uses administrative benchmarks by leveraging on the linkage between survey and register data.

In step 1, the new design weight for households residing in municipality *i* and having taxable income stratum *k* is given by:

$$w_{hik}^{(0)} = \left(\frac{1}{m_h}\frac{P_h}{P_{hi}}\right)\frac{N_{hik}}{n\prime_{hik}} \qquad h = 1, \dots, H;\ ;\ i = 1, \dots, M;\ k = 1, \dots, K$$

where *h* is the usual stratum for muncipalities and k is the new taxable income stratum. The ratio $\frac{N_{hik}}{n\prime_{hik}}$ represents the reciprocal of the inclusion probability of households residing in municipality i and belonging to taxable income stratum *k* (conditional on the fact that municipality i is included in the sample).

In step 2, the design weight is then multiplied by the reciprocal of the response rate, estimated for each taxable income stratum k, to adjust for unit non-response:

$$w_{hik}^{(1)} = w_{hik}^{(0)} \frac{n'_k}{n_k}$$

where n'_k and n_k are the number of selected households (theoretical sample) and respondent households (actual sample) in the stratum *k* of taxable income.

In step 3, the weight $w_{hik}^{(1)}$ is then adjusted for panel attrition in the same way described in Section 2.1, resulting in the weight $w_{hikc}^{(2)}$.

In step 4, we now use a two-step approach. In the first step, in addition to calibrating for socio-demographic variables, we now also calibrate on taxable income classes, debt classes, and the shares of individuals with taxable income from employment, entrepreneurial activity, and self-employment:

$$w_{jhik}^{(3,1)} = w_{hik}^{(2)} \cdot \gamma_j$$

where γ_j is the adjustment factor for household j.

In the second step we calibrate the administrative information linked to the survey to the total amount of taxable income, categorized by geographical area and type of income (pension income, employment income, self-employment income, income attributable to the entrepreneur in simplified accounting, income from participation in partnerships and similar entities).
We follow the methodology proposed in Deville et al (1993) and more recently used in di Salvatore and Moscatelli (2024). Let $x = \{x_1, \dots x_j, .. x_n\}$ be the value taken by each household *j* for a vector of m auxiliary variables $x_j = [x_j^1, \dots, x_j^m]$ for which the population total $t_x = \sum_{j=1}^{N} x_j$ is assumed to be known. The calibrated weight is obtained as

$$w_{jhikc}^{(3c)} = w_{jhikc}^{(3,1)} \cdot g_j$$

where g_j is the adjustment factor that satisfies the following constraint:

$$\sum_{j=1}^{n} w_{jhikc}^{(3,1)} x_j g_j = \sum_{j=1}^{N} x_j = t_x$$

while minimizing the distance[6] beween initial and final weight ($w_{jhikc}^{(3,1)}$ and $w_{jhikc}^{(3c)}$). This methodology requires that administrative information is known for all units in the sample[7].

[6] As distance function we choose the logit(0.1,10) method (see Tillé et al, 2016), which has the advantage, with respect to other methodologies, of not generating negative calibration coefficients and of not giving excessively high coefficients to a small number of households.

[7] In 2022, administrative information was missing for about 4% of individuals for whom personal ID was missing. This information was imputed using data from similar households based on their reported income, geographical location, gender, and type of occupation. The imputation method used was nearest neighbor matching.

Since the taxable income is significantly associated with the income declared by households, the inclusion of two additional calibrations in the construction of survey weights offers the benefits of increased precision, bias reduction and consistency with external data.

Additionally, it is important to highlight that the information we use at micro-level for calibration is entirely consistent in terms of concepts and definitions with the overall external benchmarks. This consistency would not have been achievable if we had relied on data reported by respondents during interviews, which is often affected by quality issues such as rounding or under-reporting.

3 The revision of the 2020 weights

The availability of administrative data allows for a reconsideration of the 2020 weights, whose construction had to contend with data limitations (administrative data on taxable income were not available), the need to combine two samples initially intended to be separate, and dramatic changes in participation and response patterns due to the COVID-19 pandemic.

To account for the inclusion in the main sample of the additional sample of indebted households (originally intended as a separate sample for studying financial vulnerability) and for the potential biases introduced by the pandemic, the construction of the original weights for the 2020 wave departed from the process described in subsection 2.1, as follows.

Step 1 in the traditional process was modified by first estimating the joint distribution of households by taxable income *k* and debt stratum *d* for the whole population, $\widehat{N}_{kd}$. Due to the absence of external data on income or debt distribution, the estimation relied on partial data, mainly from units within the theoretical sample with known taxable income and debt strata. Recent data indicated this estimation was skewed towards the higher end of the distribution.

Then, the weights based on the inclusion probabilities were aligned to match the estimated totals $\widehat{N}_{kd}$ of the joint distribution obtaining a the design weight $w_{hikd}^{(0)}$.

Step 2, which relates the correction for unit non-response, was modified to take into account the response probabilities in the two samples (main sample and indebted households sample):

$$w_{hikd}^{(1)} = w_{hikd}^{(0)} \frac{n'_{kd}}{n_{kd}}$$

Finally, the traditional benchmarks used in the calibration foreseen in step 4 in the scheme were modified because the sample, likely due to pandemic-induced biases, was not adequately aligned to all available external information. Specifically, we added two new benchmarks relating to the level of

education and household composition, and the benchmark on geographical areas was made more granular.[8]

This strategy to construct 2020 weights appeared to be the most appropriate given the data available at the time and the plausibility of the majority of the results.

Following the publication of the 2020 data, the increased availability of external information enabled additional in-depth analyses to further assess the reliability of the survey results. These studies utilized a larger set of benchmarks from administratative records for the years 2020 and 2022 (the last being the reference year of the new SHIW wave) and the data linkage between survey and register data. Specifically, survey data were linked at the individual level with taxable income records and debt from the Italian Credit Register (CR) making it possibile to assess the representativeness of the sample along these dimensions.

Overall, the estimated total amount of taxable income in 2020 based on the original 2020 weights was nearly 40 per cent higher than the actual amount in the tax registers; similarly, the survey estimate of debt was more than twice the amount recorded in the CR register (Table 1). In particular, the upper tails of both the distributions of taxable income and CR debt were overestimated in the survey data[9] (Figures 1 and 2).

Table 1

Comparison between micro and macro totals

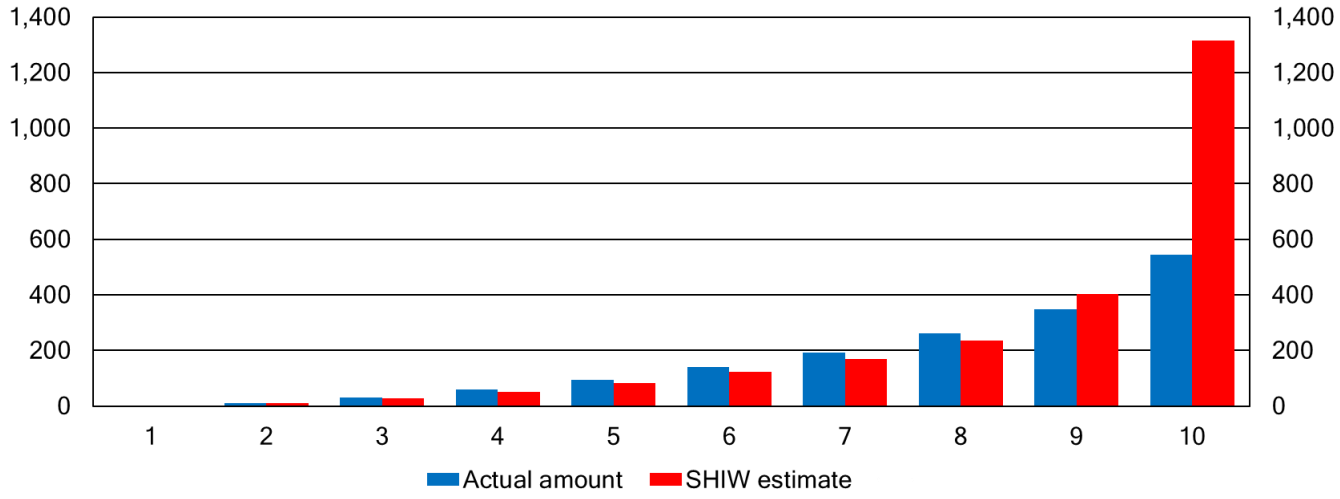
	2014	2016	2020 old	2022
	Ratio between micro and macro totals			
Taxable income	0.94	0.94	1.37	1.00*
Outstanding debt from CR	0.85	0.95	2.41	1.07

Note: In 2022, the weighting system ensures that the total taxable income in the sample matches the total taxable income from tax records (see Section 3).

[8] For a thorough description of the SHIW weighting procedure, see the methodological note available at https://www.bancaditalia.it/statistiche/tematiche/indagini-famiglie-imprese/bilanci-famiglie/metodologia-ibf/index.html?com.dotmarketing.htmlpage.language=1

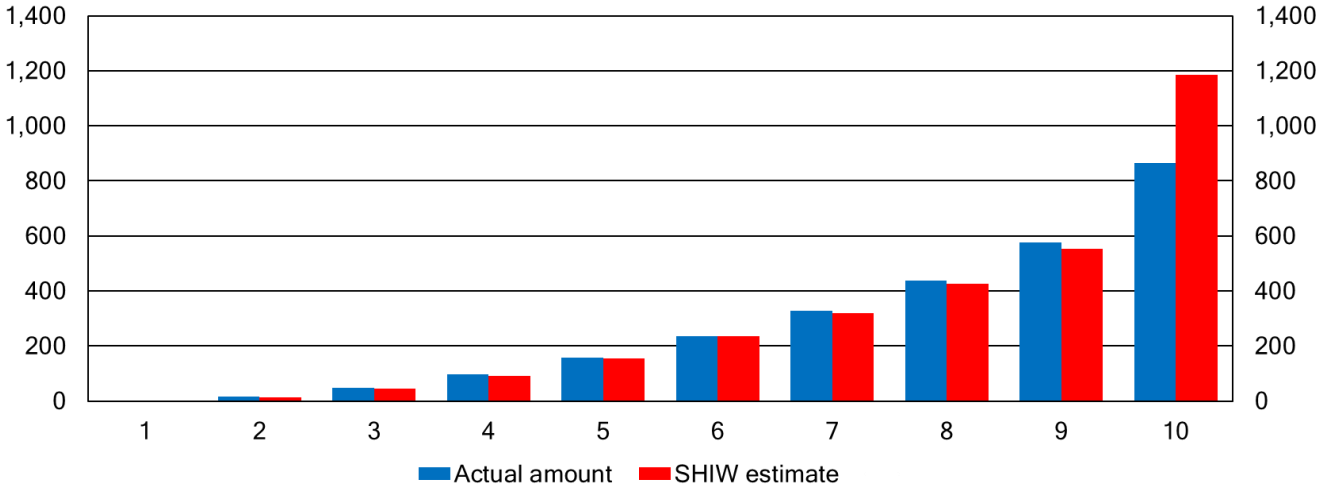
[9] The comparison is made only for taxable income and CR debt because there is no distributional data available on housing stock.

Figure 1. Comparison of 2020 SHIW estimate and actual amount of CR debt
(by cumulated tenths; billions of euro)



Note: The figure compares the total amount of outstanding debt recorded in the credit register with the total estimated using the 2020 SHIW sample linked to the CR. The deciles are defined based on CR data.

Figure 2. Comparison of 2020 SHIW estimate and actual amount of taxable income
(by cumulated tenths; millions of euro)



Note: The figure compares the total personal taxable income derived from aggregated statistics publicy available in the Ministry of Economy and Finance (MEF) website with the total estimated using the 2020 SHIW sample. Income deciles are defined based on the thresholds published by the MEF.

In light of this evidence, the 2020 weights were revised. However, the methodology introduced in section 2.2 could not be straighforwardly applied because, as explained above, the final 2020 sample is

composed of two samples selected independently with different criteria reflecting their planned use. The approach devised for the 2020 wave is thus different, and based on the following steps.

In step 1, the design weights take into account that the observations from two independent samples were combined into a single dataset. For a generic households the probability of selection π is :

$$\pi = \pi_1 + \pi_2 - \pi_1\pi_2$$

where π_1 is the selection probability for the main sample (MS), drawn from the population register of households stratified by taxable income, and π_2 indicates the selection probability from the second sample (IS), drawn from the population of indebted households stratified by outstanding CR debt amount.[10] The weights are adjusted to account for the probability of multiple inclusion which is given by the product of the two selection probabilities $\pi_{1j}\pi_{2j}$.

In our case, the probability of selection of a household residing in municipality *i* in the main sample MS is computed as:

$$\pi_1 = \left[\frac{N_{hik}}{n'_{hik}}\right]^{-1}, \qquad h = 1, \dots, H; \;\; k = 1, \dots, K,$$

where N_{hik} and n'_{hik} are respectively the number of resident households and the number of selected households (theoretical sample) in municipality i of stratum h belonging to income stratum k. In the same way, the probability of selection of a household residing in municipality *i* in the indebted sample IS is computed as:

$$\pi_2 = \left[\frac{N_{hid}}{n'_{hid}}\right]^{-1}, \qquad h = 1, \dots, H; \;\; d = 1, \dots, D,$$

where the stratum *d* is defined according to the oustanding amount of debt in CR of the household.

The design weights for households are obtained, as usual, as:

$$w_{hikd}^{(0)} = \left(\frac{1}{m_h}\frac{P_h}{P_{hi}}\right) \cdot [\pi]^{-1}$$

with $\left(\frac{1}{m_h}\frac{P_h}{P_{hi}}\right)$ being defined in Section 2.1.

The design weights are then calibrated to ensure that both taxable incomes and outstanding CR debt linked to the survey match the external distributions at population level of individuals by taxable income and CR debt[11]:

$$w_{hikd}^{(0,c)} = w_{jhikd}^{(0)} \cdot \gamma^{(0)}$$

[10] The method follows the methodology of Bankier (1986), adopted also by O'Muircheartaigh and Pedlow (2002), Kaminska and Lynn (2012) and Watson (2014).

[11] The distribution of individuals by taxable income are produced by the Ministery of Economy and Finance and available at https://www1.finanze.gov.it/finanze/pagina_dichiarazioni/public/dichiarazioni.php. The distribution of debt is based on the CR data.

where $\gamma^{(0)}$ is the adjustment factor that guarantees the alignment to the external data.

The adjustment for non response is modified to take into account also the response rate of indebted households. Specifically, the design weight $w_{hikd}^{(0,c)}$ is multiplyed by the reciprocal of the response rate of the cell (k, d) to which each household belongs:

$$w_{hikd}^{(1)} = w_{hikd}^{(0,c)} \frac{n'_{kd}}{n_{kd}}$$

where n'_{kd} and n_{kd} are the number of selected households (theoretical sample) and respondent households (actual sample) in the cell given by the joint strata of taxable income k and of CR debt d.

Finally, the alignment to external benchmarks was changed to the two step process that incorporates administrative information described in subsection 2.2.

4 Main effects of revising the weighting methodology on 2020 data

Table 3 compares the distributions of old and revised weights for the 2020 SHIW, showing smaller lower percentiles in the revised weights. This is due to the fact the revised weights penalize high-income and wealthy households, who had a higher selection probability in 2020 (and thus have a lower weight). Figure 3 confirms that households at the top of the income and wealth distributions were given too high a weight under the old methodology. For these households, there is a significant percentage reduction in the weights, with a redistribution to other deciles.This effect is partially driven by a decrease in the overall weight of the sample of indebted households, which drops from 12.8 to 8.5 per cent of total weight (see also Figure 4, which shows the percentage variation by income and wealth deciles divided by main sample and sample of indebted households).

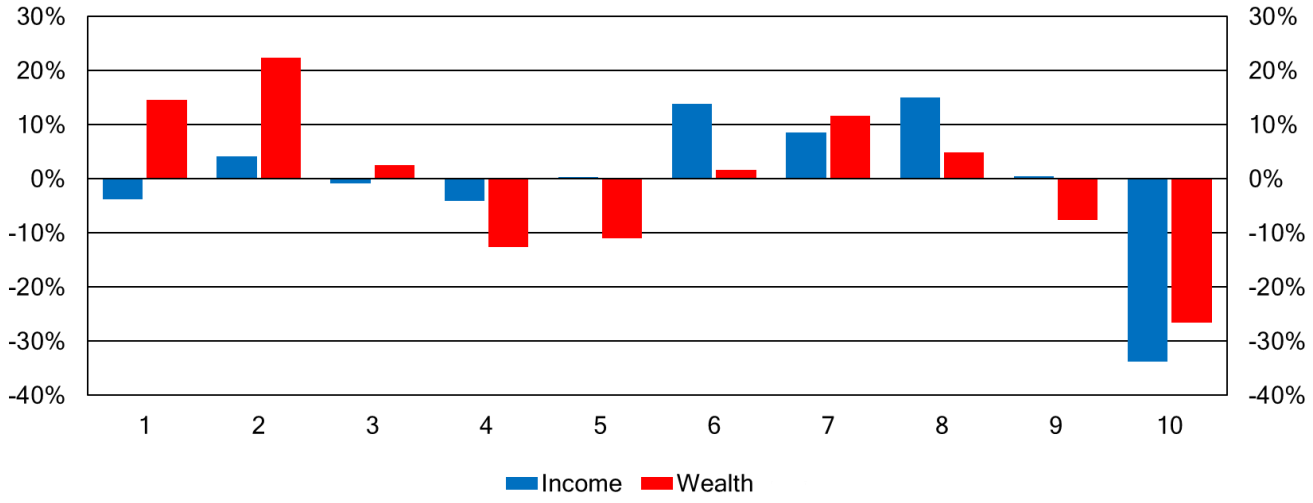
Table 3

Distributions of revised and old weights for the 2020 wave

	P5	P10	P25	P50	P75	P90	P95
Old weights	0,11	0,15	0,27	0,55	1,14	2,49	3,68
Revised weights	0,01	0,03	0,13	0,40	1,10	2,54	4,07

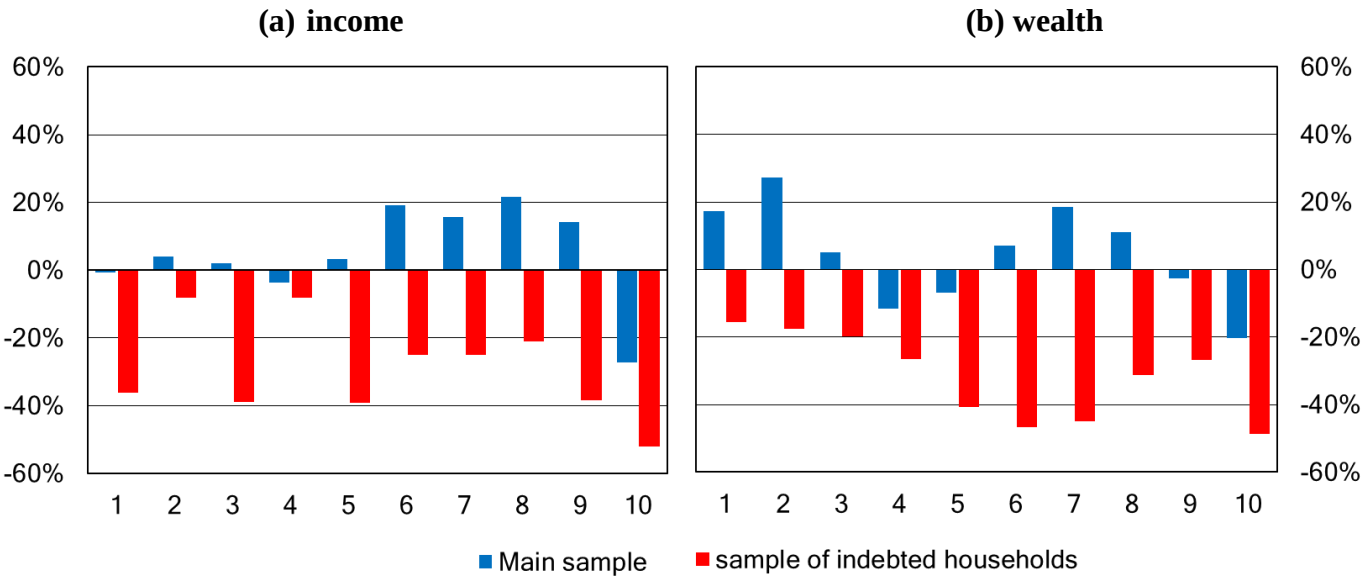
Note: the table shows the main percentiles of the two distributions of weights.

Figure 3. Percentage variation between revised and old weight by income and wealth deciles



Note: The figure shows the percentage variation between revised and old weights across income and wealth deciles, defined using the old weights thus maintaining the same households in the deciles.

Figure 4. Percentage variation between new and old weights by income / wealth deciles and type of sample



Note: The figure shows the percentage variation between revised and old weights across income (left panel) and wealth (right panel) deciles computed using old weights and by type of sample (main sample and indebted household sample).

Figures 5 and 6 show that the new methodology allows to align the sample to the external benchmarks of taxable income and CR debt.

Figure 5. Ratio between SHIW estimates of total taxable income actual values by deciles of the taxable income distribution

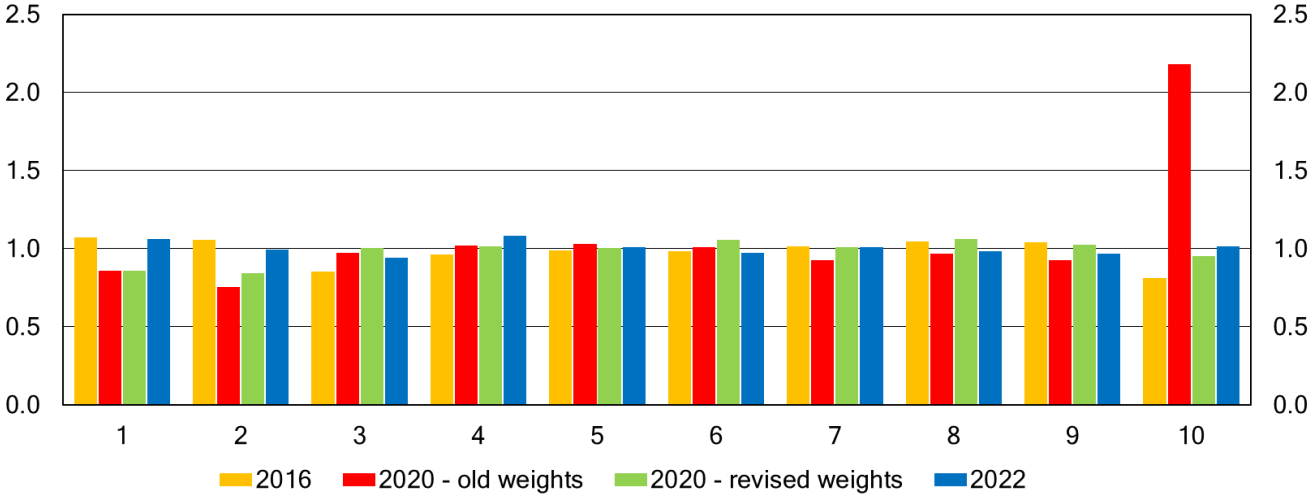
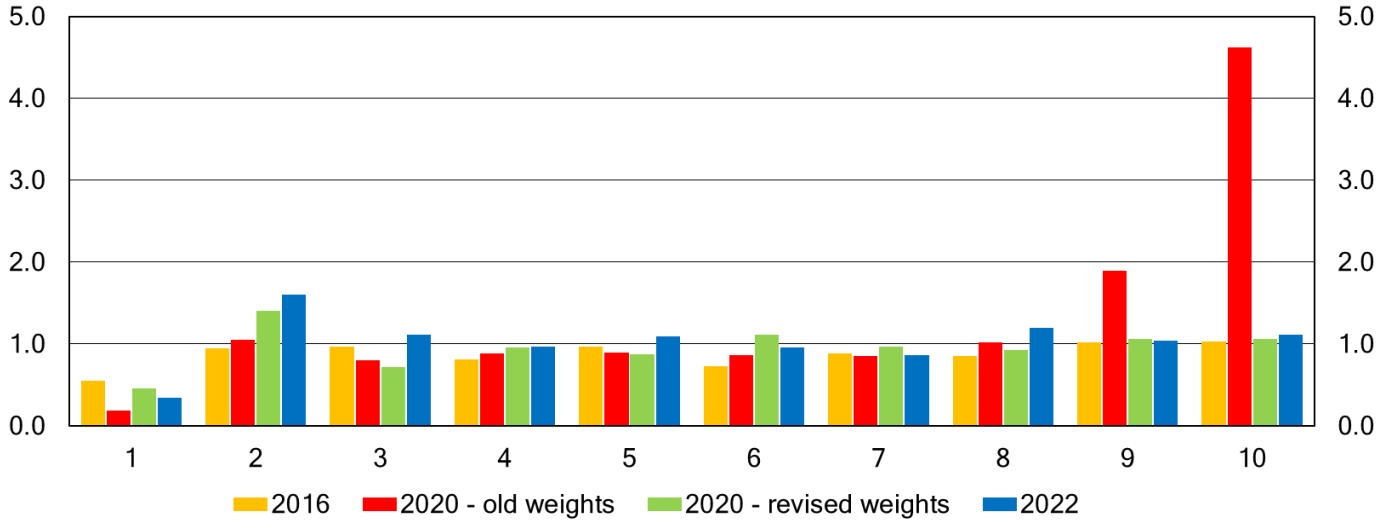


Figure 6. Ratio between IBF estimate of CR debt and actual values, by deciles of the debt distribution



The revision of 2020 weights results in a reduction in the average values of income and wealth in 2020 as well as in the related inequality measures obtained with the initial weighting scheme (table 4, columns A and B). Yet, values obtained with the old and the revised weights for historical comparison[12] are broadly in line, suggesting that previous studies analysing economic trends between 2016 and 2020 are not substantially affected by the change in the weighting metodology (table 4, columns C and D).

[12] See section 5.

Table 4

The effect of the revised survey weights on income, net wealth, indebtedness and inequality measures in 2020

(euros; per cent)

	(A)	(B)	(C)	(D)
	New design weights with old metodology (1)	Revised new design weights (2)	Weights for historical comparison with old metodology (2)	Revised weights for historical comparison
Household mean disposable income	39,274	34,107	32,384	32,701
Household median disposable income	28,009	28,064	26,030	26,821
Household mean net wealth	335,342	265,774	215,370	244,868
Household median net wealth	148,440	141,895	115,550	129,600
Household mean indebtedness to financial intermediaries	80,820	49,665	59,831	48,327
Gini index (3)				
Household mean income	42.8	35.5	35.8	35.5
Equivalized income	39.6	32.8	33.0	32.8
Household net wealth	68.1	65.2	64.7	64.7
Low-income individuals (4)	21.5	20.8	21.4	21.8
Indebted households (5)				
Share of total households	21.4	19.6	18.9	17.4
Share of financially vulnerable households (6)	1.8	1.6	1.2	1.3

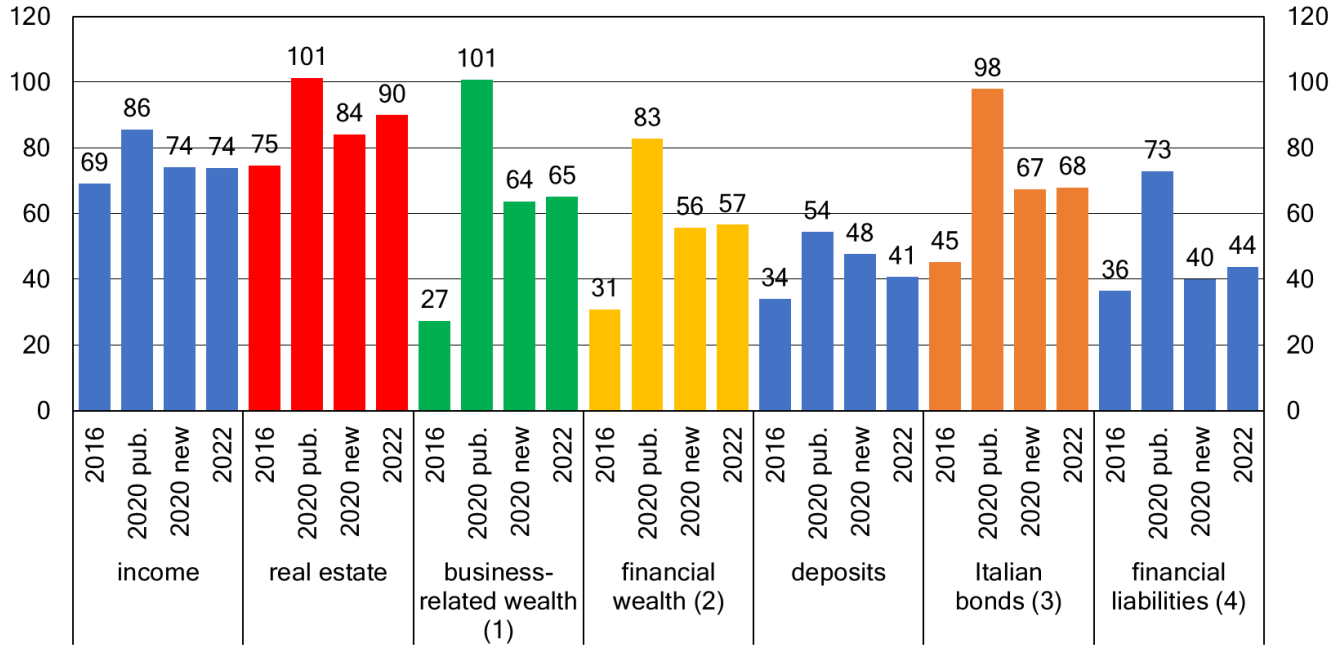
Sources: Based on annual data from the Survey on Household Income and Wealth 2020, and the historical database of the Survey on Household Income and Wealth, version 11.1. (1) Values obtained using the new design weights before (column A) and after (column B) the revision. – (2) Values obtained using weights for historical comparison before (column C) and after (column D) the revision. – (3) The Gini concentration index, expressed in percentage values, ranges from 0 (perfect equality) to 100 (maximum inequality). – (4) Low-income individuals are defined as those with an equivalized income below the 60% of median equivalized income using OECD-modified scale. – (5) Only includes debt for property purchases or renovations and for purchases of consumer goods. – (6) Share of indebted households over total households with an equivalized income below the median and annual debt service payments equal to more than 30 per cent of their income.

The decline in the average values of key household balance sheet items results in lower coverage compared to the figures obtained with the old 2020 weights. (Figure 7). [13] Nonetheless, the coverage is

[13] It is important to note that this comparison is between respondents' interview reports and national accounts estimates. Therefore, part of the discrepancy is due to non-sampling errors, particularly to underreporting. Households often underreport their income and wealth for various reasons, including social desirability, a desire to shorten the interview, and difficulty retrieving accurate information due to poor memory or lack of knowledge (D'Alessio and Faiella, 2002; Biancotti et al., 2008; Neri and Ranalli, 2012).

still larger than that of the 2016 wave, thus highlighting the importance of using the stratified sampling scheme to improve estimates of the totals. The revised weights also bring the 2020 coverage much closer to that of 2022, which follow a similar sampling scheme.

Figure 7. Degree of coverage of the main macroeconomic aggregates



Notes: (1) Nonresidential buildings and land, equity and other participating interests. (2) The data do not include pension funds, insurance reserves and trade credits. (3) Italian government and private bonds. (4) It includes only loans from banks and other financial institutions.

5 Weights for historical comparison

The adoption of a more detailed sampling design, facilitated by the availability of administrative records, introduces a significant methodological break that prevents the comparability of results over time. To mitigate this drawback, "historical" weights are constructed for the surveys from 2020 onwards that aim at preserving comparability with past editions.

The formal methodology remains broadly the one presented in Gambacorta and Porreca (2024), where survey weights are adjusted so that the distribution of the 2020 sample with respect to the new design variables (taxable income and CR debt) conforms to the distribution observed in the 2016 sample, net of changes in the population distribution. Here we briefly recall the main steps.

Initally, we estimate the distribution of households by their outstanding debt (from credit register) and their taxable income (from tax records) in the previous wave with the old samping design. For the 2016

it was done using the standard survey weights, while, for the 2020 wave, the weights for historical comparison (i.e. distributions obtained in 2020 net of the design revision).

In the second step we use an iterative weight rebalancing technique (raking) to match the distributions estimated using the final cross-sectional weight $w_{jhik}^{(3,c)}$ with the distributions estimated in the previous step:

$$w_{jhik}^{(3,h)} = w_{jhik}^{(3,c)} \cdot h_j$$

where h_j is the adjustment factor for household j.

Finally, we use the calibration to force the coverage ratio of taxable income for the 2022 wave (i.e the ratio between the survey-based estimate of total from external benchmark) to be equal to the one that would be observed with the old sampling design. This benchmark is estimated using the 2016 wave and it is equal to 0.94 per cent (table 1).

6 Conclusions

The paper discusses the new SHIW weighting methodology based on the use of administrative data. The innovative aspect of this approach is the final-stage calibration of administrative data linked to the survey with external benchmarks, represented by the distributions of individuals by taxable income and CR debt.

Typically, in surveys similar to the SHIW, the final calibration primarily uses demographic variables such as age, gender, and household size due to data limitations. When the data linkage with administrative data is not available, the only viable option to include external aggregate benchmarks on income is to use the information collected in the survey (i.e, the income reported by respondents). The main challenge with this approach is that the survey may use different concepts and definitions from those used for population totals. Furthermore, even with the same concepts and definitions, self-reported values are notoriously subject to under-reporting, which may cause an unjustified inflation of the weights of the highest-income and wealthiest households. In our case, the definitions used in the sources are consistent, as the administrative microdata — used to compute population totals — are record-linked with each individual in the sample.

By incorporating the information coming from register data not only in the sampling design but also in the survey weights, the new methodology addresses previous limitations and enhances the survey's ability to describe income distribution, particularly among affluent households. The application of this novel approach to the 2020 case demonstrates its ability to protect against unforeseen events that may challenge the accuracy and reliability of the survey's results. Moving forward, the continued integration of administrative data and the refinement of weighting techniques will be essential in maintaining the high standards of the SHIW and ensuring its relevance in an ever-evolving economic landscape.

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