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Refining Two Indicators for the Calculation of the User Cost of Housing Indicator (UCOH)

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1.   Background

This note documents the **revision of input data for the User Cost of Housing Indicator (UCOH)** for the Housing Taxation Database v5.0 release in 2024, performed by the JRC.B2 Housing Taxation team. Several changes have been introduced in the variables used to calculate the UCOH:

- The **use of a house price indicator** instead of the consumer price indicator (CPI) to reflect developments in the housing market.
- The **correction of outliers in the time series of the interest rate on government bonds**, which were leading to extreme results in some countries (especially in the period of the financial crisis).

The reference paper for the database remains Barrios et al. (2019), which is complemented by the note describing the revision of the UCOH formula in 2022 by Thiemann et al. (2022). The present note is structured as follow: Section 2 introduces the UCOH calculation and the methodology of its main revisions, Sections 3 and 4 describe the impact on the UCOH of the revision of the calculation of the capital gains indicator and the interest rate indicator, Section 5 concludes.

2.   Methodological changes

2.1.   The UCOH formula

The formula of the UCOH is defined in Thiemann et al., (2022) as:

$$UCOH = \left[\left(1 - \{ t_M \varphi \lambda + t_y (1 - \lambda) \} \right) i \ - \ t_M \varphi \lambda (j - i) + t_p + \beta \left(1 - t_y \right) + m + \delta - \pi \left(1 - t_{capgain} \right) \right] \left(1 + t_{trans} \right) \ + \ t_{ir}$$

Where:

- i is the interest rate for foregone revenue on equity investment
- j represents the interest rate paid on the mortgage
- φ is the fraction of debt benefitting from mortgage interest tax relief
- t_M is the rate at which the tax relief on mortgage is granted
- λ denotes the maximum LTV ratio to reflect the requirement for a down payment
- t_p is the recurrent property tax rate
- β is the pre-tax risk premium term to reflect the different risk for housing relative to other (risk-free) assets

- t_y is the tax rate on interest income, i.e. the tax on risk-free saving investments
- m is the estimated annual maintenance cost
- δ is the economic depreciation rate
- $\pi(1 - t_{capgain})$ is the after-tax revaluation term, with the tax rate $t_{capgain}$ on the capital gains π
- The fraction of the house purchase that is equity financed is $(1 - \lambda)$ and foregoes earned interest at the unit yield of i, which is taxed at a rate t_y
- t_{trans} is the minimum statutory transfer tax rate
- t_{tir} is the tax on imputed rent

The revision does not affect the UCOH formula itself, but rather the derivation of two variables used in the formula. The first variable that will be changed is the term π, which stands for capital gains. The second variable is the term i, i.e., the interest rate for foregone revenue on equity investment. The following sections outline the new methodology for the calculation of these two variables and the impact of this change on the UCOH indicator.

2.2. Changing the proxy for capital gains

The UCOH formula includes a term for capital gains π, which expresses the expected gain when selling the house for a price higher than the purchase one. This term has a negative marginal impact on the UCOH because a capital gain, i.e. an increase in value of the purchased house, reduces the cost of house ownership by realizing potential profits from selling the real estate. Expected capital gains are unobservable at the time of the house purchase and therefore a proxy variable needs to be used instead. Up to version 4.1 of the Housing Taxation Database (HTD), the UCOH used CPI as a proxy for this potential capital gain. Given that CPI and house prices evolved in different directions after 2021, we decided to stop using the CPI as proxy for expected house prices and instead use the House Price Index (HPI) from the ECFIN B1 House Price Database.[1] In particular, we will use the following formula, introduced by Barrios et al. (2016), which reflects individuals' expectation regarding the evolution of house prices:

$$\{E(\pi)\}_t = a * \pi_{ST} + (1 - a) * \pi_{LT}$$

where π_{ST} refers to the short-term change in house prices, defined as the change in house prices between $t - 1$ and $t - 2$, and π_{LT} refers to the long-term change in house prices, defined as the geometric mean change in house prices of the previous ten years ($t - 11$ to $t - 1$).[2] The weight that households give to short-term versus long-term price change is defined by the parameter a. We set the parameter a to the value of 0.1.[3] This reflects the expectation of house price

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[1] See https://s-ecfin-web.net1.cec.eu.int/directorates/db/u1/data/housing/hp.html.

[2] Barrios et al. (2016) calculated long-term price changes using the average of the entire HPI time series. In contrast, we have chosen to calculate the long-term average based on a ten-year period. The length of the HPI time series varies between countries, and averages of the whole available HPI time series would consider different time periods across countries. By considering a ten-year average, the indicator is built for each country with HPI data from a comparable time period, smoothing out potential cycles in house prices (see also Fatica and Prammer, 2018, who use an average of ten years as a minimum time span). In the few cases where there is insufficient HPI data to calculate a ten-year average, we impute the missing HPI data points using the average of the entire time series and then apply the ten-year average to the completed time series.

[3] Barrios et al. (2016) assumed three different values of a: 0.1, 0.5, and 0.9. We used the lowest value of a in order to limit fluctuations in the UCOH due to single-year house price developments.

development that is formed by the experience of the previous longer-term price development, with an emphasis on the most recent price change.

2.3. Outlier correction of long-term interest rate

A second term of the UCOH formula that undergoes a revision in the 2024 release is the long-term interest rate. Long-term interest rates reflect the opportunity costs of housing investment as opposed to an alternative risk-free investment through public bonds. For each country, the UCOH uses national 10-year government bonds to proxy alternative safe investments.

Figure 1. Ten-year government bond yield of Greece over time (2001-2022)
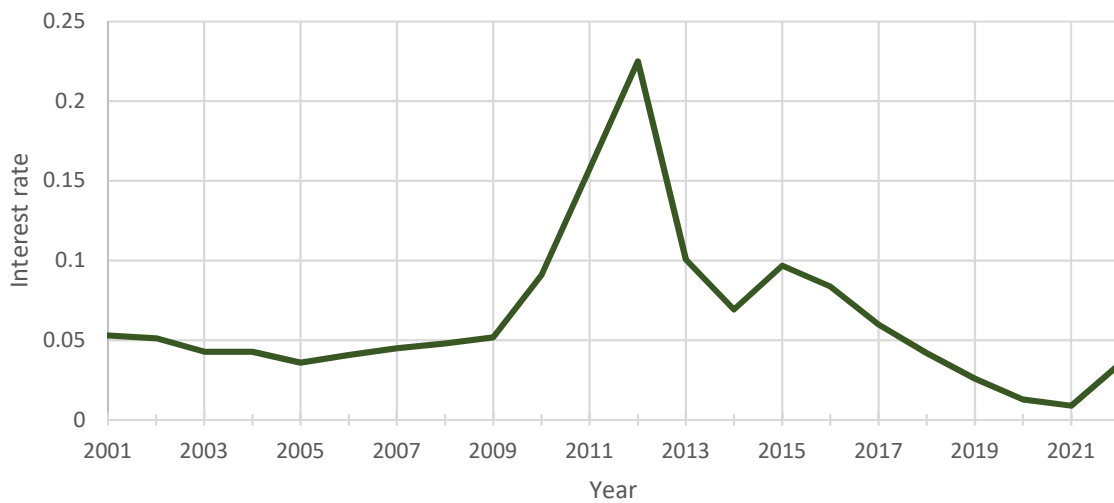
*Source: Eurostat. EMU convergence criterion bond yields*

During the financial crisis, interest rates of government bonds of some countries experienced extreme variation and could not be considered as benchmark alternative investments, at least in some countries and years. For instance, Figure 1 shows the evolution of the ten-year Greek government bond yield that peaked to over 20% in 2012. Incorporating this type of variation in the UCOH formula would include noisy information with little correspondence with the role traditionally played by government 10-years bond as safe asset. To prevent this noisy information from influencing the value of the UCOH indicator, we applied an outlier detection of exceptionally high interest rates, and set a ceiling to this outlier threshold. After analysing the series year by year, we have opted to consider as outliers the values exceeding 1.5 times the interquartile range above quartile 3. Values exceeding the established limit of 1.5 times the interquartile range, and thus, considered as outliers, have been replaced by that boundary value. This technique is commonly used in statistics and data analysis to address the presence of outliers in a dataset.

3.   Impact on the UCOH of the revision of the capital gain indicator

3.1.   Comparison of CPI and HPI

Figure 2 shows the different trends of CPI and weighted average HPI change, expressed as an EU country average between 2005 and 2022[4]. In most years, house price growth has outpaced the CPI. This is because there were two periods of housing booms: before the financial crisis and more recently between 2019 and 2020. However, there were also times when house prices experienced a more stable evolution while consumer prices grew faster than house prices. This happened for example between 2017 and 2019 and again in 2022.

Figure 2. EU-average of consumer price changes and HPI change over time (2005-2022)
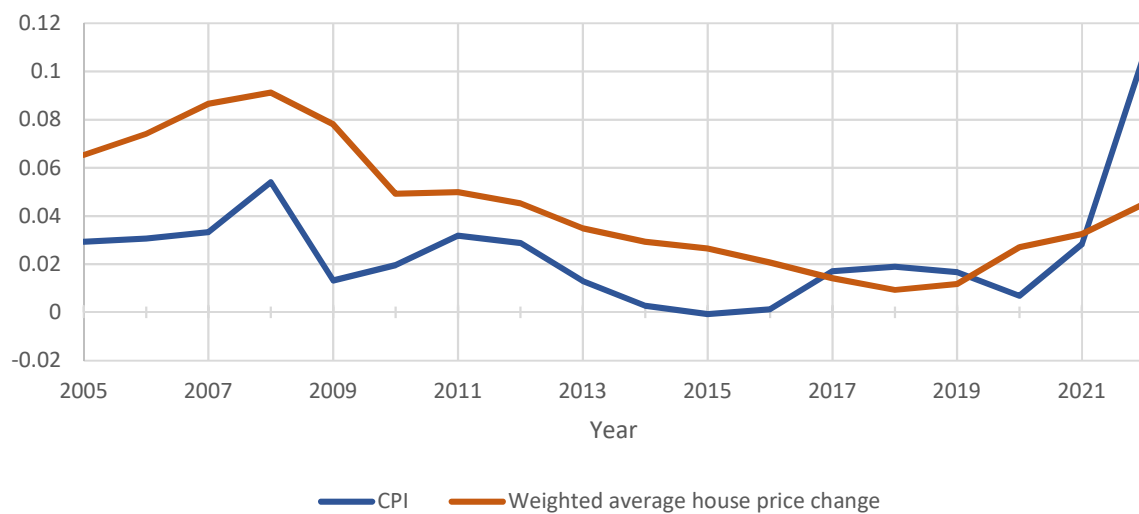
Source: Housing taxation database 1995-2022 v5.0

3.2.   Impact on the UCOH

Figure 3 compares the average UCOH across the EU-27 calculated according to the two methodologies, namely using CPI as previously and weighted average house price change as a proxy for capital gains in the revised version of the UCOH.[5] The UCOH based on the HPI-based proxy for capital gains is higher in the years where the weighted average of HPI is higher than the CPI. Capital gains have a direct effect (net of the amount of capital gains tax) on the UCOH. This explains why the UCOH can take negative values, which happens when costs related to house ownership are lower than the expected capital gain. Using CPI as a proxy for expected house price changes would have strongly overestimated the capital gains in 2022 and, as a consequence, caused a counterintuitive drop in the UCOH. Instead, when using the HPI-based proxy for capital gains, the UCOH moves in the opposite direction in 2022 and slightly increases. Negative UCOH based on HPI changes can be observed prior to the financial crisis,

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[4] Even if the development of countries' house prices and consumer prices are quite heterogeneous within the EU, country average values show the overall trend. The series does not start in 1995, because only with 2005, the HTD includes values for all countries and allow to compare all EU MS.

[5] The UCOH calculations in this section are based on outlier corrected long-term government bond interest rates. The impact of the outlier correction of long-term government bond interest rates on the UCOH is analysed in Section 4.

in years characterised by high house price growth in most EU countries. Finally, a UCOH based on HPI better reflects the house price developments over time.

**Figure 3.** EU-average of UCOH based on consumer price changes and weighted average HPI change
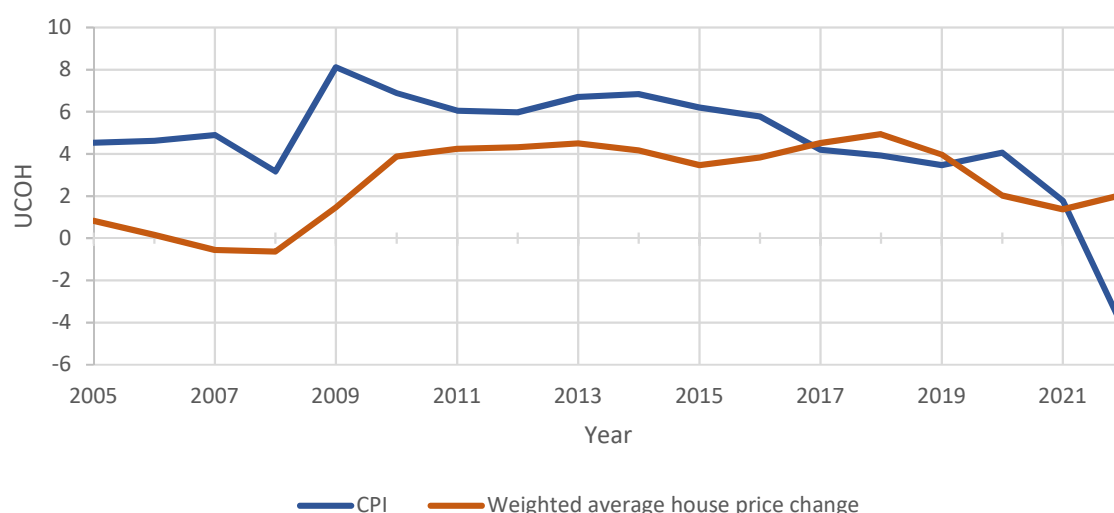
Source: Housing taxation database 1995-2022 v5.0

The trends in the UCOH for each country are presented in Figures 4 and 5, respectively, using the CPI and the weighted average HPI methodologies. The most notable difference is observed in Romania, where the UCOH shifts from being negative to being positive between 2001 and 2005. However, this is not the only instance of sizeable change in the results when comparing the previous methodology with the new one. The opposite happened in Latvia, whose indicator moved from positive values to negative ones between 2008 and 2009. Finally, Slovakia changed its trend in the latest years: from constantly decreasing between 2012 and 2022, to a flatter curve in the same period.

The most striking change for all countries occurred in the last year (2022), when the CPI increased significantly in most EU countries as inflation surged. However, the same cannot be said for house prices, which showed much less variation and even decreased in some cases. In terms of variability of the UCOH over time, the standard deviation is approximately the same in Figures 4 and 5.[6] Finally, the resulting UCOH using weighted average HPI change seems to better represent the actual capital gains a house buyer could expect at that point in time.

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[6] The EU-27 average standard deviation of the UCOH between 2005 and 2022 decreases by just 4% (2.97 vs. 2.84) when using the weighted HPI change instead of the CPI as a proxy for capital gains. In 13 (14) countries out of 27 the standard deviation increased (decreased) when using the weighted HPI change.

Figure 4. Country-specific UCOH based on CPI
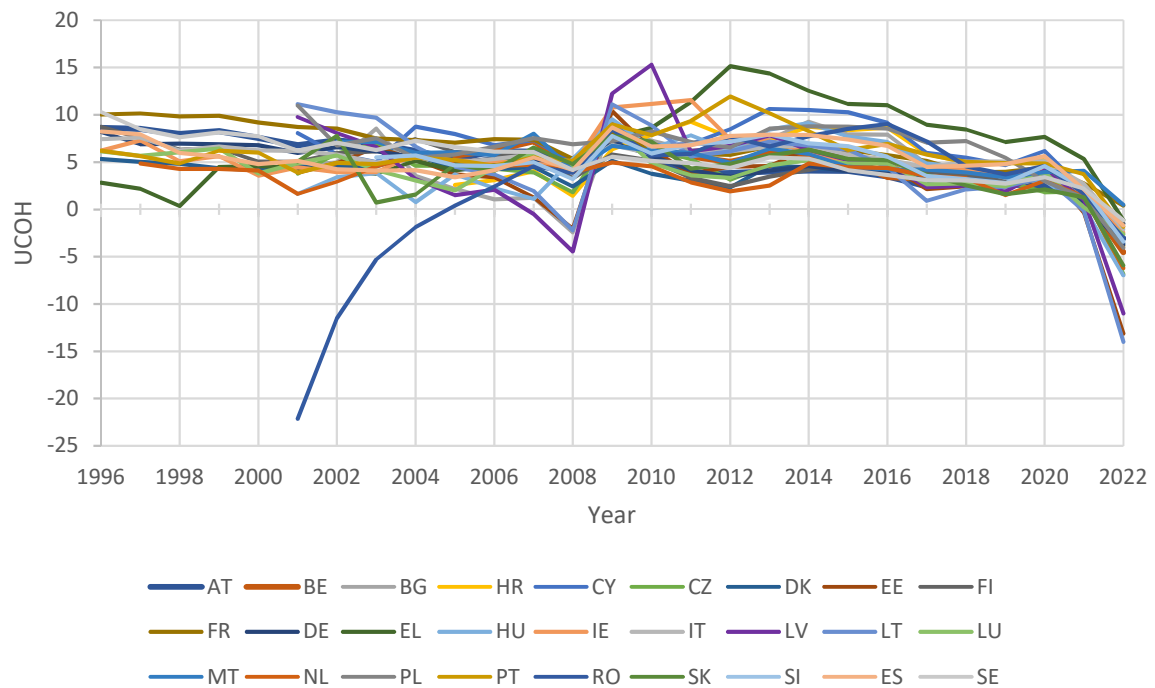
Source: Own calculations

**Figure 5.** Country specific UCOH based on weighted average HPI change
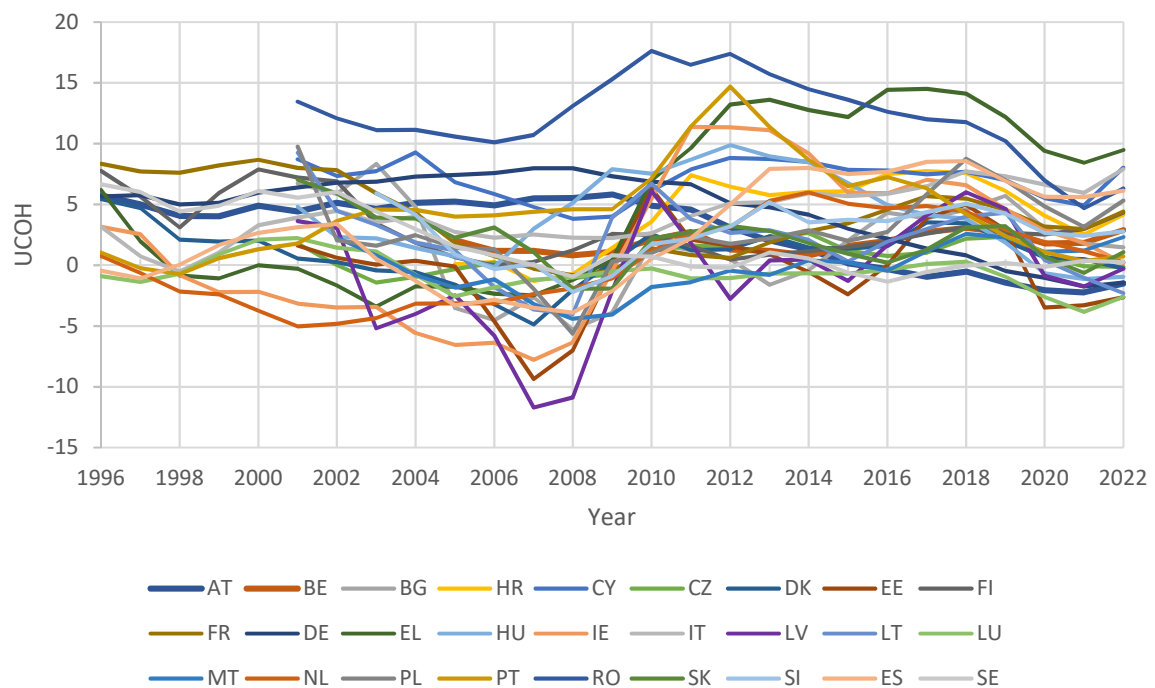
Source: Housing taxation database 1995-2022 v5.0

4.   Impact on the UCOH of the outlier correction of government bonds yields

### 4.1.   Ten-year government bond yields before and after the outlier correction

Figures 6 and 7 show the time series of the ten-year government bond yields (before and after the outlier correction) in countries where an outlier correction took place. The country that has been most impacted by the change in the methodology is Greece, where the indicator corresponding to year 2012 significantly decreased. Other changes can be seen in Hungary, Latvia, Lithuania and Romania.

Figure 6. Long-term interest rates indicator before the outlier correction
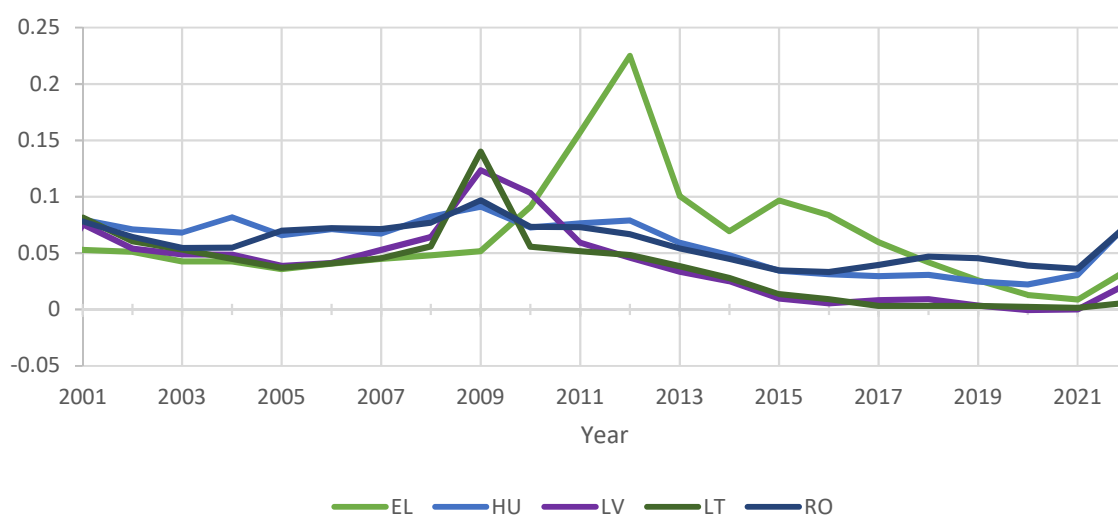
Source: Eurostat - EMU convergence criterion bond yields

**Figure 7.** Long-term interest rates indicator after the outlier correction
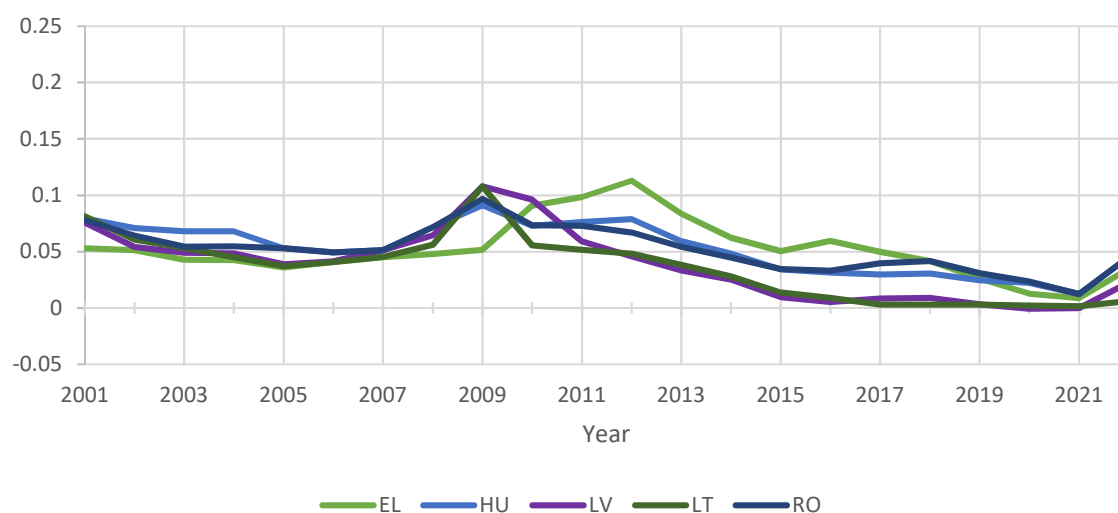
Source: Housing taxation database 1995-2022 v5.0 (outlier corrected values from Eurostat - EMU convergence criterion bond yields)

4.2. Impact of the outlier correction on the UCOH

Figures 8 and 9 shows the UCOH for the countries for which the outlier correction changed the calculation of the long-term interest rate indicator.[7] The outlier correction had a moderate impact on the UCOH for most of the countries. However, one exception is represented by Greece, with the UCOH curve showing a moderate increase between 2012 and 2013 in Figure 9, without the spike depicted in Figure 8.

Figure 8. Country-specific UCOH without outlier correction (using weighted average HPI change) – selected countries
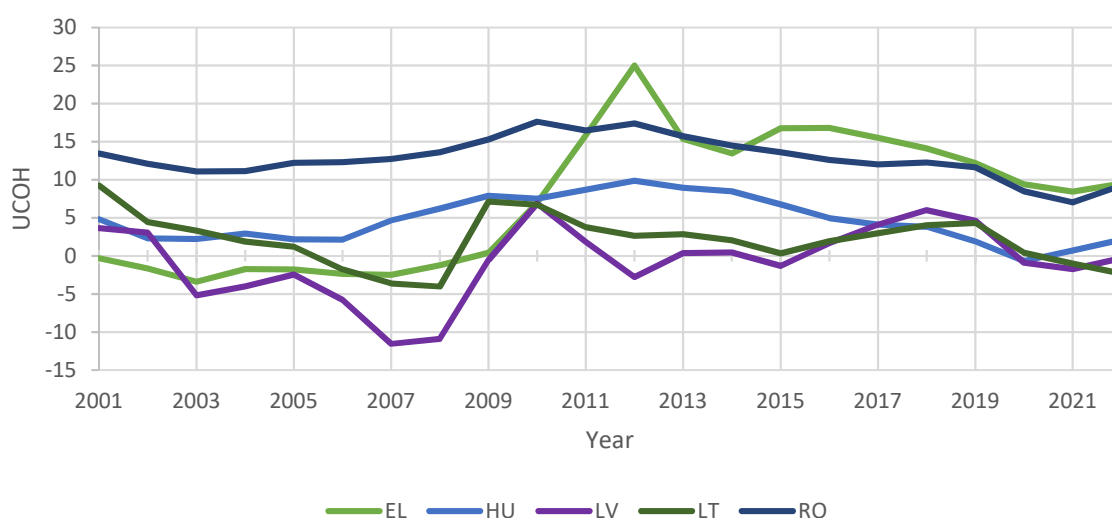
Source: Own calculations

Figure 9. Country-specific UCOH with outlier correction (using weighted average HPI change) – selected countries
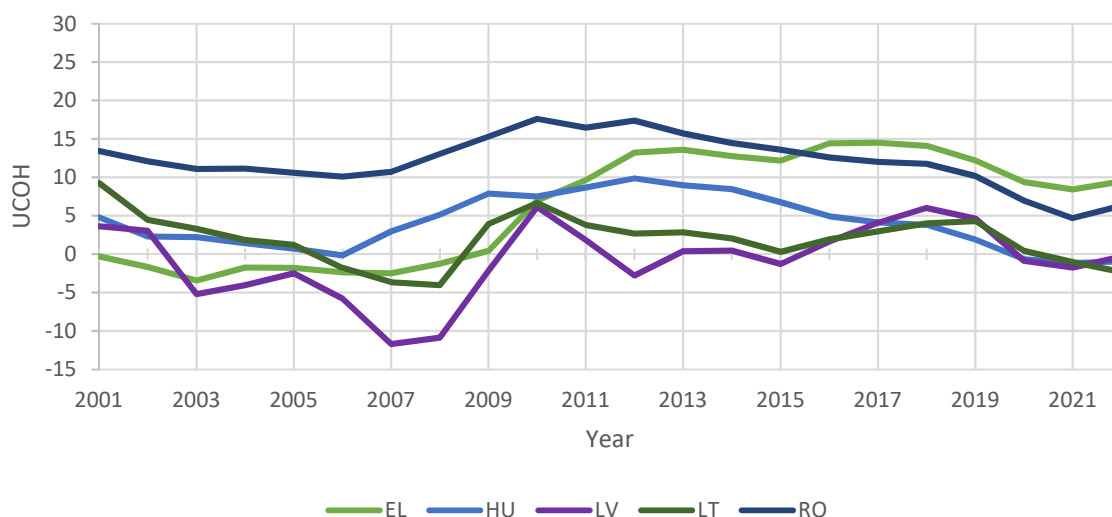
Source: Housing taxation database 1995-2022 v5.0

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[7] All UCOH calculations in this section are based on weighted average HPI change as a proxy for capital gains.

5.   Final remarks

The document described the changes operated in the calculation of the UCOH indicator in preparation of the Housing Taxation Database v5.0 release. It focuses on two key aspects: (i) the use of a house price index instead of the CPI index to proxy housing capital gains and (ii) the correction of a 10-year government bond time series corrected for the presence of outliers. The first change was motivated by the observation that CPI and house prices have evolved differently in the EU, particularly after 2021. By utilizing HPI as the proxy for expected house prices, the UCOH is expected to provide a more accurate representation of the cost of house ownership.

The second correction was implemented in order to avoid the impact of extremely high values observed especially during the financial crisis. The correction involves setting a ceiling for outlier thresholds to prevent these extreme values from influencing the UCOH calculation.

In conclusion, the revisions made to the UCOH input data aim to enhance the accuracy and reliability of the UCOH as an indicator of the cost of house ownership. These changes are crucial for providing policymakers, researchers, and other stakeholders with a more precise understanding of housing costs in EU countries.

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