

CHANGING PROFILES OF HOUSING DEPRIVATION IN EUROPEAN UNION COUNTRIES

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ARTICLE INFO	ABSTRACT
Keywords: housing deprivation, housing problems, European Union	Housing deprivation is often analyzed as the proportion of population affected by housing problems related to a variety of issues. As a result, even if the level of housing deprivation is similar across countries, they may face different housing-related problems. In the presented research, an attempt was made to identify countries similar in terms of the area of housing problems. The specified dimensions were: (1) housing quality, (2) way of using the dwelling, and (3) neighborhood-related issues. The analysis indicated that in the EU, there are countries that do not show an intensification of housing deprivation in any of the areas. In 2020, these were Czechia, Austria, Estonia, and Finland. Countries with a deprivation profile related to housing quality were Romania, Lithuania, Latvia, and Cyprus; and to a lesser extent, also Hungary, Ireland, Slovenia and Belgium. Housing deprivation was mainly related to the way of using the dwelling in Greece, Bulgaria, and - to a lesser extent - also in Denmark, Poland, Croatia and Slovakia. The deprivation profile related to the neighborhood was identified in Malta, the Netherlands, France, and - to a lesser extent - also Spain, Portugal, Italy, Luxembourg, Sweden, and Germany. Housing deprivation profiles in the EU undergo changes in the 2010-2020 decade.
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1. Introduction

On the basis of the literature, the claim that housing needs are the basic ones may sound trivial. Nevertheless, the importance of housing conditions and their impact on various dimensions of individuals' lives, as confirmed by many studies (Kennedy & Winston 2019; Filandri & Olagnero 2014; Sengoege et al., 2014; Carmona-Derqui et al., 2023), justifies the need for a thorough analysis of housing deprivation. As a consequence, it can be seen that concerns about the quality of housing are still visible in academic and policy discussion on housing (Hick et al., 2022).

The concept of housing poverty refers to the inability to meet housing needs at an appropriate level (Kozera et al., 2017; Ulman & Ćwiek, 2021). This phenomenon depends on personal preferences and limiting factors. Preferences are driven by the needs of household members, lifestyle, and social class. The psychological and social characteristics of residents strongly determine housing needs (Stachura & Jagiełło-Kowalczyk, 2023). Constraints are mainly

related to the financial situation or the availability of housing (Jansen et al., 2011; Ulman & Ćwiek, 2021). In literature, the failure of housing to meet the basic needs of residents is referred to as housing deprivation. At the statistical level, this phenomenon is analyzed as one of the components of material deprivation and overall poverty (Eurostat).

In the literature, a number of concepts for measuring housing deprivation have been proposed. Most commonly analyzed is the percentage of households affected by deprivation or the accumulation of deprivation indicators. Deprivation indicators encompass various aspects of housing, such as a leaking roof, no bath/shower, no indoor toilet, dwelling being considered too dark, no hot running water, no central heating, damp walls, housing cost problems, inability to keep a dwelling warm enough, perceived lack of space, crime, violence or vandalism in the area, noise from neighbors or the street, pollution, grime, or other environmental problems. This reflects a multidimensional analysis of the

phenomenon, where individual manifestations of housing deprivation are treated equally.

When analyzing various methodologies for studying housing deprivation (Table 1), it can be observed that its manifestations pertain to three key dimensions: the technical condition of housing, the way it is used, and neighborhood characteristics. Distinguishing these dimensions may be significant from the perspective of shaping housing policy instruments in different countries. In some of them, investments in the state of housing resources are more desirable, while in others, interventions aimed at shaping the level of public safety are preferred. As a result, the next stage of analyzing the phenomenon - after examining the level of housing deprivation, which is a well-recognized topic in the literature - should be checking in which areas housing problems accumulate within individual countries. This accumulation of housing deprivation in different dimensions was defined as housing deprivation profiles.

The aim of the study is to distinguish the profiles of housing deprivation among European Union countries and to determine relative changes of those profiles in the past decade. To achieve this, three key dimensions of housing deprivation were proposed, and then,

using the method of linear ordering, indicators were constructed to assess its level in each dimension. Based on this, using non-linear ordering (hierarchical cluster analysis), groups of countries with similar housing deprivation profiles were identified. The analysis was conducted for the years 2010 and 2020 to indicate whether housing deprivation profiles are evolving.

2. Literature review

Despite an abundant number of studies concerning housing deprivation, it seems that a consensus has not been reached in terms of a proper method for measuring this phenomenon. To some extent, this is because basic housing conditions describing housing deprivation could include a variety of rather different circumstances (e.g. Murie, 1983; Nolan & Winston, 2011). For example, according to some interpretations, it includes both, the problems of individuals who do not have access to housing at all, as well as those who suffer from some crucial housing problems (Navarro & Ayala, 2008), while other researchers calculate it as an accumulation of housing deficiencies (e.g. Borg, 2015).

The comparison of the methodologies applied in literature to assess housing deprivation was presented in Tab. 1.

Table 1

The comparison of methodologies applied in literature to assess housing deprivation	
Authors, year (method)	Housing deprivation indicators under consideration
Eurostat (co-occurrence of variable)	<i>housing deprivation</i> : leaking roof, no bath/shower and no indoor toilet, or a dwelling considered too dark; <i>severe housing deprivation</i> : whether a dwelling is considered as overcrowded, while also exhibiting at least one of the housing deprivation measures;
Navarro and Ayala (2008) (latent variable model)	no kitchen, no bath, no toilet, no hot running water, no garden, noise in the dwelling, not having enough light, leaky roof, damp, rot in window frames or floor, overcrowdedness, pollution or crime and vandalism nearby;
Nolan and Winston (2011) (% of households reporting problems)	four areas: (1) housing-related problems (no bath/shower, no central heating, no hot water, no running water, no toilet, a leaking roof, damp walls etc.); (2) lack of household durables due to financial reasons (such as: refrigerator, washing machine, microwave); (3) housing costs problems (whether the household has been in arrears for rent or mortgage payments in the last 12 months; and whether the person in the household responsible for meeting the housing costs considers them a heavy burden); (4) neighborhood problems (crime, violence or vandalism in the area; noise from neighbors or the street; pollution, grime or other environmental problems in the area);
Mandic and Cirman (2012) (% of households reporting problems)	perceived lack of space, rot in windows, doors and floors, damp and leaks, no indoor flushing toilet, noise in the dwelling, lack of safety, lack of open areas in the neighborhood;
Amore (2013) (dedicated algorithm)	severe housing deprivation: living without accommodation, living in a non-private dwelling (for example night shelter), living as a temporary resident in a private dwelling, living in housing that lacks one or more basic amenities;
Filandri and Olagnero (2014) (binary variable*)	housing well-being: less than a minimum of one room per person in the dwelling, neighborhood quality (noise, crime and pollution), housing adequacy (house too dark), no bath, shower or indoor flushing toilet, damp walls and floors, leaking roof, rot in doors and windows;
Fusco (2015) (a frequency-based weighted score)	overcrowded household, dark accommodation, leaky roof, rot in window frames or floors, damp walls, floors or foundations, non-hermetic windows, no space to sit outside, lack of double glazed windows;
Palvarini and Pavolini (2010) (% of households reporting	the ratio between housing expenditure and the household's total income, living in an overcrowded dwelling, physical quality of the dwelling (no bath or shower; no indoor flushing toilet; no hot running

problems)	water; no place to sit outside; insufficient light; lack of adequate heating facilities; leaky roof; damp walls, floors or foundations; rot in window frames or floors), the quality of neighborhood (noisy neighbors; noise from outside the home; environmental problems, pollution or dirt; and the presence of crime or vandalism in the area);
Wan and Su (2016) (principal component analysis)	internal facilities (no toilets, no bathing facilities, no tap water pipe, no clean energy), living space (number of buildings per community, number of households per community), physical form and structure (no steel and reinforced concrete structure in a building), attached facilities (percentage of medical, educational, transportation land use per community), natural amenities (percentage of green space, blue space per community), affordability (low rent housing, lack of house properties, the ratio between housing price and income).
Kozera et al. (2017) (TOPSIS method)	housing poverty: no toilet for sole use, no bath or shower, no flushing toilet, leaking roof, damp walls or floors, subjective rating of housing conditions as bad, overcrowding, lack of a color TV / washing machine for financial reasons
Ulman and Ćwiek (2021) (the IFR approach**)	building standard (building type, subjective evaluation of building standards, and building security), housing conditions (whether the household members share the dwelling with others, square footage per person, number of rooms per person, and whether the dwelling is too small/large for the household's needs); objective dwelling standard (whether the toilet is a separate room and whether there is a kitchen, water supply system, bathroom, flushable toilet, hot running water, central heating system, and a balcony, terrace, or garden); subjective dwelling standard (whether each of the water supply and plumbing systems meets the household needs, whether the roof leaks or the walls are damp, whether the apartment is too dark, whether it is warm enough in the winter, and/or cool enough in the summer) and the surroundings (environment noise, burdensome pollution, crime risk, and poor infrastructure)
Wojewódzka-Wiewiórska and Dudek (2023) (binary variable*)	having a leaking roof, damp walls/floors/foundation, or rot in window frames/floor; having neither a bath nor a shower in their dwelling; not having an indoor flushing toilet in their household.
Ayala et al. (2022) (the IFR approach**)	five areas: standard housing deprivation (having a leaking roof, lack of bathtub or a shower or indoor flushing toilet for sole use of the household, a dwelling considered too dark), living space (overcrowded house, degree of urbanization, dwelling type), technology (computer, internet connection for personal use), environment and neighborhood (noise, pollution, crime), economic stress (housing cost ratio, arrears on mortgage or rental costs, arrears on utility bills)
Galeota Lanza and De Martino (2022) (The weighted average of normalized relative value of indicators)	relative indicator used to compare regions in a city: worse housing availability; worse housing condition; worse economic situation; worse social situation.
Matel (2023) (TOPSIS method)	leaking roof, damp walls or floors, no bath or toilet for sole use; dwelling too dark, housing cost overburden rate; overcrowding rate; dwelling too cold; noise from outside, pollution, crime risk

* 1 – if a household suffers from at least one of problem listed

** the the IFR approach is a fuzzy measure proposed by Betti et al. (2006) basing on the cumulative distribution function.

Source: own study.

According to Table 1, there is a variety of indicators of housing deprivation in the literature. There seem to be several reasons behind this. Firstly, their use often depends on the availability of data (Palvarini & Pavolini, 2010). This explains why indicators based on EU-SILC (such as Ayala et al., 2022; Kozera et al., 2017; Fusco, 2015; Nolan & Winston, 2011; Matel, 2023) are quite similar to each other. In contrast, those based on other data sources (e.g. Amore, 2013; Wan & Su, 2013; Galeota Lanza & De Martino, 2022) use a different range of housing deprivation indicators. Additionally, the different methodological approaches may result from different cultural and institutional contexts (Matel & Marcinkiewicz, 2020), which can be seen, among others, in concept of Fusco (2015), who included having double glazed windows. Additionally, the concept may vary across economies, because according to the housing adjustment theory (Morris et al., 1975) households judge their housing conditions

by housing norms that are agreed upon and culturally derived. Another problem is that, in most cases (apart from Amore, 2013), the metrics ignore the issue of homelessness, which is undoubtedly a weakness of most analyses. The reason is that homeless people do not participate in international surveys (such as EU-SILC), which the measurement of deprivation is based on.

The concept of dividing the deprivation symptoms into dimensions has been present in research from the very beginning. One of the oldest concepts for measuring housing deprivation, presented by Townsend (1979), distinguished three dimensions: inadequate construction, inadequate amenities, and insufficient space in relation to the number of users. Norris and Shiels (2007) also focused on three aspects: housing quality, accessibility, and affordability. Additionally, there are concepts that focus on

indicators mostly concerned with the physical attributes of dwellings (Mandic & Cirman, 2012).

In the study conducted - based on an analysis of the relationship between the dwelling and the household occupying it - a division was made into:

1. deprivation indicators resulting from the quality of the dwelling (HDD),
2. deprivation indicators resulting from the way of using the dwelling (HDU),
3. deprivation indicators resulting from the neighborhood which the dwelling is located in (HDN).

The first group of indicators is connected with the quality of housing stock. Most of the methodological approaches to measuring housing deprivation presented in the literature focus specifically on this dimension, including facilities like running water, kitchen, bath or toilet (Amore, 2013; Borg, 2015; Eurostat; Filandri & Olagnero, 2014; Fusco, 2015; Mandic & Cirman, 2012; Navarro & Ayala, 2008; Nolan & Winston, 2011; Norris & Shiels, 2007; Wan & Su, 2016; Kozera et al, 2017; Ulman & Ćwiek, 2021; Wojewódzka-Wiewiórska & Dudek, 2023; Ayala et al., 2022; Matel, 2023). Palvarini and Pavolini (2010) also took into consideration a lack of adequate heating facilities, while Nolan and Winston (2011) assess it by using the variable "lack of central heating". Most of the analyzed approaches include problems that can be named structural, like: a leaky roof, damp and rot in floors and window frames (e.a. Mandic & Cirman, 2012; Navarro & Ayala, 2008; Nolan & Winston, 2011). Fusco (2015) additionally analyzed such indicators as: having non-hermetic windows and the lack of double-glazed windows. Wan and Su (2016) also considered the lack of access to clean energy.

In terms of comparative analyses, it may be indicated that this scope of housing deprivation reflects the quality of the standard of housing stock in a specific country. It relates to the physical attributes of apartments and is independent of who occupies the flat. Improving them requires an impact on the technical condition of the housing stock.

Some of the analyzed methodologies of the housing deprivation measurement took into account indicators resulting from the way of using the dwelling. They are not related to the technical condition of the housing stock. They depend on the characteristics of the household that inhabits it. As residents or their wealth status change, these problems may disappear. As a result, preventing them requires market-related interference, like dealing with

unemployment problems or implementing housing policy tools.

Problems associated with the use of housing include overcrowding (Eurostat; Mandic & Cirman, 2012; Navarro & Ayala, 2008; Palvarini & Pavolini, 2010; Wan & Su, 2016; Kozera et al, 2017; Ulman & Ćwiek, 2021; Wojewódzka-Wiewiórska & Dudek, 2023; Ayala et al., 2022; Matel, 2023). The methods of measuring it differs. Mandic and Cirman (2012) used a subjective measure, i.e. the perceived lack of space. Filandri and Olagnero (2014) and Palvarini and Pavolini (2010) analyzed if there is a minimum of one room per person in the dwelling. A universal measure is the overcrowding rate developed by Eurostat. According to this approach, a person is considered as living in an overcrowded dwelling if the household does not have a minimum number of rooms at its disposal equal to: one room for the family, one room per a couple in the household, one room for each single person aged 18 or more, one room per pair of single people of the same gender between 12 and 17 years of age, one room for each single person between 12 and 17 years of age and not included in the previous category, and one room per pair of children under 12 (Eurostat).

Another indicator of housing deprivation related to the way of using the dwelling is the housing costs burden (Nolan & Winston, 2011). The need to consider this aspect of accommodation was indicated by L. McDowell (1982), whose research seems to pioneer the subject in question. She claimed that "an ideal measure should be multi-dimensional, including not only physical conditions but also measures of the cost of housing in relation to income" (McDowell, 1982, p. 145). Wan and Su (2016), when comparing regions in terms of this aspect, took into consideration affordability and used the following indicators: the existence of low rent housing, percentage of households without house properties, the ratio between housing price and income. Then, Nolan and Winston (2011) measured whether the household has been in arrears for rent or mortgage payments in the last 12 months and whether the person in the household responsible for meeting the housing costs considers them a heavy burden. Palvarini and Pavolini (2010) took into consideration the ratio between housing expenditure and the household's total income. Such an approach is implemented by Eurostat. According to the methodology of the EU-SILC panel data housing cost overburden indicator means the percentage of the population living in a

household where total housing costs (net of housing allowances) represent more than 40% of the total disposable household income (net of housing allowances) (Eurostat). Using a subjective opinion about housing costs seems to be justified. This is because spending part of the income on housing costs in itself, if not burdensome, is not a measure of housing deprivation, as it may as well be the result of preferring to live in particularly luxurious conditions. On the other hand, when using only a subjective measure, the influence of personal characteristics of household members on deprivation index cannot be controlled.

Both overcrowding and burdensome housing costs refers to the way of using the dwelling. This also refers to the indicator analyzed by the Eurostat - the ability to keep the dwelling adequately warm. On the other hand, these indicators also contribute to the problems which households need to face in terms of housing conditions (Navarro and Ayala, 2008).

Some of the proposed measures (Tab. 1) include also neighborhood problems (Mandic & Cirman, 2012; Navarro & Ayala, 2008; Nolan & Winston, 2011; Palvarini & Pavolini, 2010; Wan & Su, 2016; Ulman & Ćwiek, 2021; Ayala et al., 2022; Matel, 2023). Indicators analyzed in this area are problems associated with noise, crime and pollution. Navarro and Ayala (2008) studied if there is pollution or crime and vandalism nearby. Mandic and Cirman (2012) claimed that the households live in a deprived vicinity when they complain about noise, safety and lack of open areas in their neighborhood. Nolan and Winston (2011) took account of a wide range of neighborhood problems, including grime or other environmental issues (similar: Ayala et al., 2022; Matel, 2023). Wan and Su (2016) additionally explored access to medical, educational, and transportation facilities. Those indicators do not refer to the physical characteristics of the dwellings or the characteristics of their occupants. They derive from what happens around the dwelling. They are related to public safety and order and require other impact tools.

Within the literature, differences in housing deprivation between EU countries are explained in different ways. Usually, institutional factors are highlighted. Mandic and Cirman (2012) analyzed the role of economic development. Norris and Shiels (2007) examined the role of the rental sector. The difference in housing conditions between new and older EU member states are often explained by the experience of the Eastern European housing model (see also Hegedüs et al., 1996). Also, development of

rental housing system and competition between private and public landlords can lead to better housing quality (Kemeny et al., 2005; Borg 2015). These different factors have the potential to affect housing deprivation in quite different dimensions.

As a result, it can be expected that the phenomenon of housing deprivation varies from country to country. Some have greater problems with the quality of the housing stock, others with the ability of households to use it adequately, and still others - with environmental problems. These variations, especially within countries with overall similar levels of housing deprivation, have been referred to as housing deprivation profiles.

2. Material and methods

The structure of a multidimensional indicator of housing deprivation (Fig. 1) is based on a 3-level hierarchy accounting for how housing deprivation indicators are linked to the housing stock. The indicators discern: (1) indicators resulting from the quality of the dwelling (HDD), (2) indicators resulting from how the dwelling is used (HDU), (3) indicators resulting from the neighborhood of the dwelling (HDN). Three variables were selected for each of the analyzed dimensions of housing deprivation. The choice generally depends on its reference to prior literature (Tab 1) and the availability of comparable data in particular countries.

It can be seen that most of the selected indicators are subjective (HDD3, HDU3, HDN1, HDN2, HDN3). Such an approach is the widely accepted approximation of an objective measure of housing characteristics (Mandic & Cirman, 2012). This study uses publicly available data provided by the Eurostat, collected within the EU-SILC survey. It is an up-to-date and the most comprehensive source of information on housing in Europe. The study was based on data for 2022 as this was the most recent year when the data presented by the Eurostat was complete. The results were compared with those for 2010 and 2020.

A synthetic measure of housing deprivation and the ranking of countries were designed using a multidimensional comparative analysis - the Technique for Order Preference by Similarity to Ideal Solution method, known as TOPSIS method (Hwang and Yoon, 1981), with a common pattern and anti-pattern of housing deprivation in the EU. This method is used to conduct multi-dimensional decision analysis and to analyze the spatial diversity of socio-economic phenomena as well (Roszkowska & Filipowicz-

Chomko, 2020; Godlewska & Sidorczuk-Pietraszko, 2019). In the TOPSIS method, the examined objects are characterized by a set of variables. The best alternative is calculated as the shortest geometric distance from the positive ideal solution (named pattern) and the longest geometric distance from the

negative ideal solution (named anti-pattern) which makes it possible to make a final ranking of the objects (Hwang & Yoon, 1981).

At a country level, the indicators presented in Tab. 2 were used.

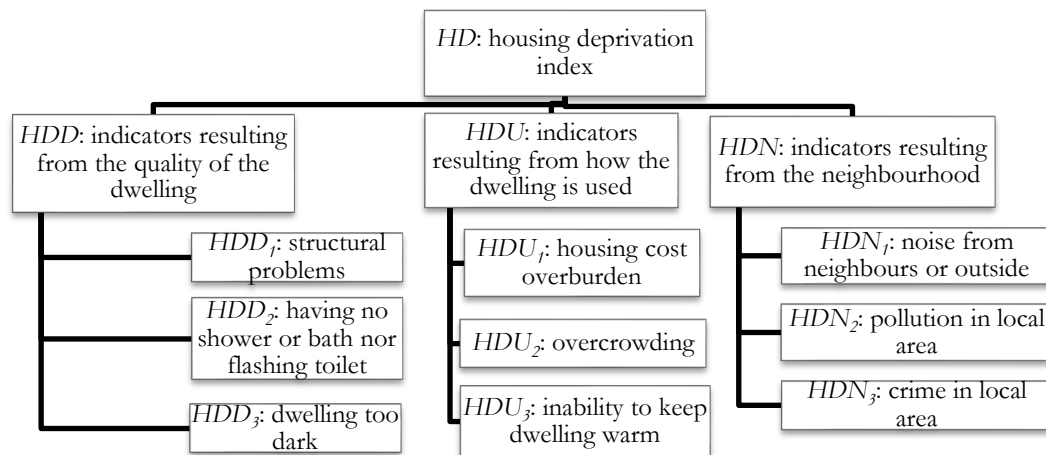


Fig. 1. Indicators of housing deprivation in three dimensions. Source: own study.

Table 2

Indicators of housing deprivation in three dimensions	
Symbol of indicator	Description of indicator
Indicators resulting from the quality of the dwelling (HDD)	
HDD₁	the percentage of households with any of the following problems with a dwelling/accommodation: leaking roof, damp walls/floors/foundation, or rot in window frames or floor
HDD₂	the percentage of households having no shower unit or bathtub nor flushing toilet in a dwelling for sole use of the household
HDD₃	the percentage of households living a dwelling which is too dark, meaning there is not enough daylight coming through the windows
Indicators resulting from how the dwelling is used (HDU)	
HDU₁	the percentage of the population living in a household where total housing costs (net of housing allowances) represent more than 40% of the total disposable household income (net of housing allowances)
HDU₂	the percentage of the population living in an overcrowded household (according to EU-SILC panel data methodology described in the literature review section)
HDU₃	the percentage of population who are unable to keep the home adequately warm
Indicators resulting from the neighborhood (HDN)	
HDN₁	the percentage of total population who face the problem of too much noise in their dwelling from neighbors or from the outside (traffic, business, factory, etc.)
HDN₂	the percentage of the total population who face the problem of pollution, grime or other environmental problems in the local area, such as: smoke, dust, unpleasant smells or polluted water
HDN₃	the percentage of total population who face the problem of crime, violence or vandalism in the local area

Source: own study.

In the presented research, some modifications were made to the method (similarly: Godlewska & Sidorczuk-Pietraszko, 2019; Roszkowska & Filipowicz-Chomko, 2016). A common pattern (ideal and anti-ideal solution) was used for the entire period under study (2010 & 2020). For each variable, its maximum and minimum values for the whole period were used. This not only allowed to create a ranking of countries in a particular year, but also to assess progress in overcoming housing deprivation problems in the

period considered. Such a modification according to Godlewska and Sidorczuk-Pietraszko (2019) allows to overcome certain weakness of this method, namely the fact that it allows for the ranking of objects without taking into account the temporal dimension.

The stages of this procedure are as follows:

1st step. Selection of indicators based on substantive and statistical criteria

In the TOPSIS method, it is recommended to eliminate

variables with a low coefficient of variation (less than 10%) and highly correlated variables (0.7 and more). For example, both the percentage of households without an indoor flushing toilet in the dwelling and percentage of households without a shower unit or a bathtub could be used to measure the first dimension of housing deprivation (HDD). However, they were highly correlated, so a variable with a higher coefficient of variation was selected.

2nd step Construction of a data matrix:

The data matrix has a form:

$$X_t = [x_{ikt}] \quad (1)$$

where: x_{ikt} - the value of the k -th indicator ($k=1, 2, 3... m$) for the i -th country ($i=1, 2, ..., 28$), in the t -th year ($t = 2008, 2018, 2022$).

3rd step. Normalization of the diagnostic variables

The diagnostic variables were normalized according to the min-max normalization formula to bring all values into the range $[0, 1]$.

For stimulants:

$$z_{ikt} = \frac{x_{ikt} - \min(x_{ik})}{\max(x_{ik}) - \min(x_{ik})} \quad (2)$$

For destimulants:

$$z_{ikt} = \frac{\max(x_{ik}) - x_{ikt}}{\max(x_{ik}) - \min(x_{ik})} \quad (3)$$

where: z_{ikt} - normalized value of the k -th indicator ($k=1, 2, 3... m$) for the i -th country ($i=1, 2, ..., 27$), in the t -th year ($t = 2010, 2020$); $\min(x_{ik}) / \max(x_{ik})$ - maximum / minimum value of the k -th indicator ($k=1, 2, 3... m$) for the i -th country ($i=1, 2, ..., 27$), in the years under study (whole period, both 2010 and 2020);

4th step. Choosing weighting method

In the TOPSIS method, weights could be either equal or calculated based on the coefficients of variation or on the correlation coefficients (a.o. Roszkowska and Filipowicz-Chomko, 2016), as well as using the entropy weight method (a.o. Godlewska and Sidorczuk-Pietraszko, 2019). In order to construct a synthetic measure of housing deprivation, equal weights were adopted according to the recommendation by Gan *et al.* (2017), who suggested equal weights as the most universal weighting method in terms of the spatial and temporal scale and possible comparisons:

$$\sum_{k=1}^m w_k = 1 \quad (4)$$

where: w_k - weight of the k -th indicator ($k = 1, 2, ..., m$).

5th step. Calculation of the Euclidean distance

Then the Euclidean distance to the pattern and anti-pattern (the same for 2010 and 2020) was calculated according to the formulas:

$$d_{it}^+ = \sqrt{\sum_{k=1}^m (w_k z_{ikt} - w_k z_{kt}^+)^2} \quad (5)$$

$$d_{it}^- = \sqrt{\sum_{k=1}^m (w_k z_{ikt} - w_k z_{kt}^-)^2} \quad (6)$$

where: $z_{kt}^+ = (1, 1, ..., 1)$ - housing deprivation pattern, $z_{kt}^- = (0, 0, ..., 0)$ - housing deprivation anti-pattern.

5th step. Calculating the synthetic measure for the i -th country and t -th year according to the formula:

$$HD_{it} = q_{it} = \frac{d_{it}^-}{d_{it}^- + d_{it}^+} \quad (7)$$

where: q_{it} - the synthetic measure for i -th country and t -th year, whereby:

$$0 \leq q_{it} \leq 1 \quad (8)$$

High values of the indicator mean that there is a high intensity of housing deprivation in a given country. Correspondingly, if the indicator shows higher values in 2020 compared to 2010, it means that the level of housing deprivation increased.

When applying cluster analysis, measures of similarity or dissimilarity are based on the distance between the units $d(O_i, O_j)$. The greater this distance is, the more dissimilar they are judged to be. Thus, the objects in a cluster are those that are close to each other, but at the same time far from others belonging to a different cluster (Murtagh and Legendre, 2004). Ward's method is a hierarchical clustering procedure which applies minimum variance criterion to minimize the total within-cluster variance. At each step, the pair of clusters that leads to minimum increase in total within-cluster variance after merging is found. Squared Euclidean distance was applied as a measure of distance between individual objects:

$$d(x, y) = \sqrt{\sum_{i=1}^n (x_i - y_i)^2} \quad (9)$$

where: n - number of variables.

Based on the results, a squared distance matrix is created in the next step. The Ward's method was used to separate clusters of EU countries due to the similarity of the level of housing deprivation in each dimension. The Ward's method appears to be one of the most commonly used in cluster analysis. Analysis of variance is used in this method to estimate the distance between clusters. The method aims to minimize the sum of squares of deviations within clusters (Roman *et al.*, 2022, p. 8-9).

Predictive Solutions software by IBM was used.

3. Results

3.1. Changes in levels of housing deprivation

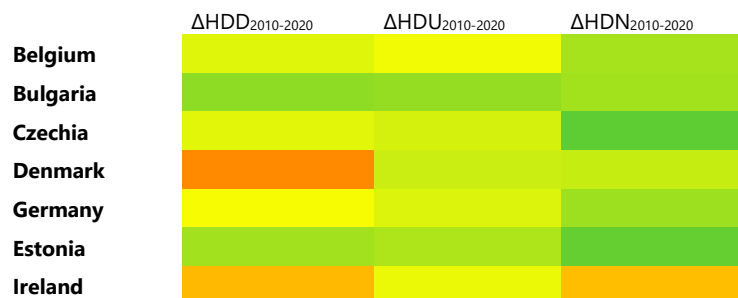
The study analyzed the level and the progress of the EU-27 member states in overcoming housing deprivation in its particular dimensions (Tab. 3). In each of the analyzed dimensions, the majority of countries demonstrated a decrease in housing deprivation. The greatest progress in the reduction of housing deprivation resulting from the quality of the housing stock was observed in the Baltic States (Estonia, Lithuania, Latvia), as well as Romania and

Bulgaria. In this respect, the lowest level of housing deprivation in 2020 was observed in Finland, Slovakia and Czechia, whereas the quality of the housing stock in Romania differed significantly from the EU27 countries, despite the observed progress.

In the dimension of housing neighborhood, high deterioration was observed in many countries like Czechia, Estonia, Cyprus, Latvia, Romania or Slovakia. Within this area, some countries demonstrated a slight decrease in the housing deprivation level (Spain, France, Lithuania, Luxembourg and Sweden).

Table 3

The level of housing deprivation in three dimensions: dwelling quality (HDD), use of dwelling (H DU), neighbourhood deprivation (H DN)						
Country	HDD dwelling quality		H DU way of using the dwelling		H DN neighbourhood	
	HDD ₂₀₁₀	HDD ₂₀₂₀	H DU ₂₀₁₀	H DU ₂₀₂₀	H DN ₂₀₁₀	H DN ₂₀₂₀
Belgium	0.193	0.138	0.133	0.111	0.414	0.259
Bulgaria	0.385	0.188	0.631	0.444	0.534	0.373
Czechia	0.076	0.027	0.190	0.115	0.424	0.142
Denmark	0.054	0.125	0.296	0.203	0.313	0.213
Germany	0.094	0.080	0.213	0.152	0.467	0.297
Estonia	0.256	0.092	0.227	0.084	0.361	0.092
Ireland	0.079	0.132	0.090	0.056	0.176	0.215
Greece	0.160	0.109	0.350	0.504	0.605	0.508
Spain	0.170	0.223	0.156	0.166	0.312	0.364
France	0.156	0.203	0.094	0.108	0.375	0.485
Croatia	0.180	0.064	0.321	0.212	0.113	0.006
Italy	0.172	0.162	0.215	0.196	0.404	0.265
Cyprus	0.233	0.274	0.286	0.220	0.476	0.222
Latvia	0.450	0.220	0.389	0.244	0.669	0.222
Lithuania	0.395	0.194	0.409	0.275	0.178	0.240
Luxembourg	0.126	0.124	0.060	0.124	0.267	0.331
Hungary	0.251	0.193	0.323	0.126	0.251	0.144
Malta	0.137	0.160	0.159	0.079	0.650	0.606
Netherlands	0.105	0.100	0.193	0.111	0.434	0.436
Austria	0.143	0.094	0.121	0.107	0.326	0.167
Poland	0.188	0.049	0.331	0.210	0.181	0.185
Portugal	0.198	0.206	0.332	0.200	0.380	0.310
Romania	0.806	0.492	0.430	0.283	0.532	0.244
Slovenia	0.283	0.153	0.203	0.076	0.335	0.256
Slovakia	0.015	0.017	0.242	0.179	0.383	0.104
Finland	0.044	0.027	0.049	0.054	0.181	0.167
Sweden	0.105	0.103	0.123	0.139	0.209	0.285



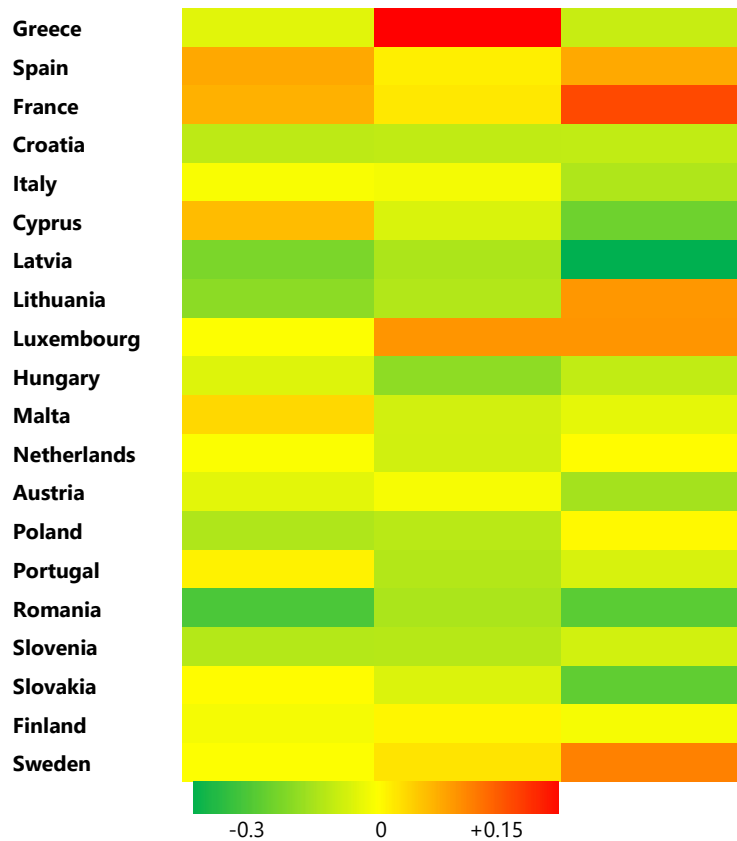


Fig. 2. Heat map presenting changes in HD level in EU countries. Source: own elaboration.

A higher dynamic was observed in the HDU indicator. HDU may be affected by short-time changes, is less stable, and is closely related to the financial situation of households. When the financial situation of a household worsens, almost immediately the indicator of the housing costs burden on the household budget increases, as does the ability to keep the dwelling adequately warm. Changes in the quality of housing stock occurred in the longer period of time than those connected with the way of using the dwelling (decrease of household income would likely result in decreased spending on housing stock renovation investment, leading to a decreased quality of housing stock in the long term). These changes are not visible from year to year. Deterioration in the dimension of dwelling use in the analyzed period was observed in two countries, with significant changes taking place in Greece and slight changes in

Luxembourg. The biggest progress in combating deprivation related to housing use was observed in Bulgaria and Hungary.

5.2. The profiles of housing deprivation in European Union

Housing deprivation has a different character among different countries. Some countries experience housing issues related to the low quality of housing stock, while in others, problems with the way in which the dwelling is used occurred. That is why the study attempted to identify groups of countries similar in terms of the intensity of housing issues within the distinguished dimensions of housing deprivations. The objective was to determine housing deprivation profiles in the EU. Cluster analysis was applied to discern groups of countries in terms of the intensity of housing problems (the appendix).

Table 4

The profiles of housing deprivation in UE-28 countries in 2010					
Group	Country	The level of housing deprivation in three dimensions:			The profile of housing deprivation
		HDD	HDU	HDN	
1	Ireland, Sweden, Finland	low	low	low	leading countries
2	France, Belgium, Spain, Austria, Luxembourg	average	low	average	catching-up countries

3	Czechia, the Netherlands, Germany, Italy, Denmark, Slovakia	low	average	average	catching-up countries countries
4	Estonia, Slovenia, Cyprus, Portugal	average	average	average	moderate HD
5	Greece, Malta	average	average	high	deprived neighborhood
6	Lithuania, Hungary, Poland, Croatia	average	high	low	deprived way of using the dwelling
7	Romania, Bulgaria, Latvia	high	high	high	high HD in all areas

Source: own elaboration.

Table 5

The profiles of housing deprivation in UE-28 countries in 2020					
Group	Country	The level of housing deprivation in dimension:			The profile of housing deprivation
		HDD	HDU	HDN	
1	Czechia, Austria, Estonia, Finland	low	low	low	leading countries
2	Denmark, Poland, Croatia, Slovakia	low	average	low	catching-up countries with deprived way of using the dwelling
3	Hungary, Ireland, Slovenia, Belgium	average	low	low	catching-up countries with deprived housing quality
4	Spain, Portugal, Italy, Luxembourg, Sweden, Germany	average/low	average/low	average	catching-up countries with deprived neighborhood
5	Malta, the Netherlands, France	average	low	high	deprived neighbourhood
6	Greece, Bulgaria	average	average	high	deprived way of using the dwelling
7	Romania, Lithuania, Latvia, Cyprus	high	high/average	average	deprived housing quality

Source: own elaboration.

The first of the discerned groups comprises of countries with a low level of housing deprivation in all dimensions. These included, in 2010, three countries (Ireland, Sweden, Finland). This profile was described as "leading countries". In 2020, the leaders included Czechia, Austria and Estonia, so two countries from the EU enlargement that took place in 2004. Ireland and Sweden are no longer leaders. In Ireland, a declining quality of the housing stock has been noted over the last decade. The percentage of households with a leaking roof has increased from 12.6% to 16.6%, while most EU countries have seen an improvement in housing quality. In the case of Sweden, the negative changes were neighborhood-related. The percentage of households who face the problem of too much noise in their dwelling from neighbors increased from 13.1 to 17.3%, while those who face the problem of crime, violence or vandalism in the local area increased from 10.4 to 13.8%.

Next group was described as "catching-up countries". This one comprises countries where the level of housing deprivation in one dimension was low, but average in other dimensions in comparison with the other EU28 member states. None of these countries demonstrated a high level of housing issues in the analyzed dimensions. In 2010, this group included France, Belgium, Spain, Austria, Luxembourg, Czechia, the Netherlands, Germany, Italy, Denmark and Slovakia. In 2020, three groups of catching-up countries were distinguished, with the first group (Denmark, Poland, Croatia and Slovakia) experiencing a greater prevalence of problems related to the usage of dwellings, the second group (Hungary, Ireland, Slovenia and Belgium) facing a higher incidence of issues concerning the quality of housing resources, and the last group (Spain, Portugal, Italy, Luxembourg, Sweden and Germany) encountering challenges related to the neighborhood. However, all these

countries exhibited a moderate or low level of intensity of housing deprivation manifestations.

Countries with a high level of deprivation in the neighborhood area with low or medium levels of deprivation in the other dimensions were identified as "countries with deprived neighborhoods". In 2010, Greece and Malta were included in this group. A decade later, Malta exhibited the same profile of deprivation, while in Greece, it was more associated with the way dwellings were used, likely as a result of the economic crisis in the country. On the other hand, in 2020, the Netherlands and France experienced a higher prevalence of problems related to the neighborhood.

In 2010, countries with a high level of deprivation in the area of dwelling usage included Lithuania, Hungary, Poland, and Croatia. Most of them advanced to catching up countries over the decade under study. However, the deprivation profile changed in Lithuania. Currently, the country faces a greater issue with the quality of housing resources.

In 2010, three countries (Bulgaria, Romania, and Latvia) were identified where a high level of deprivation occurred in all dimensions. In 2020, there was no longer such a country, although in Romania, Lithuania, Latvia, and Cyprus, the highest intensity of housing deprivation manifestations was observed, especially in the area of housing quality, hence they were classified as countries with deprived housing stocks.

4. Discussion

In the current study, the traditionally analyzed indicators of housing deprivation were grouped into three areas. They are divided into those that are directly related to the quality of housing and those that are a manifestation of technical and structural problems. This area of deprivation is taken into account in all concepts of measuring the phenomenon, proposed in the literature (e.g. Eurostat & Amore, 2013; Borg, 2015; Eurostat; Filandri & Olagnero, 2014; Fusco, 2015; Mandic & Cirman, 2012; Navarro & Ayala, 2008; Nolan & Winston, 2011; Norris & Shiels, 2023; Matel, 2023). According to the analysis, Romania, despite significant progress in the last decade, is still one of the countries characterized by the highest level of housing deprivation in this dimension. It can be seen that, in most countries, the technical condition of the housing stock is improving (especially in the Baltic countries, such as Lithuania, Latvia and Estonia), however, in others, negative

changes have been noticed (Denmark, Ireland and Spain). Positive changes in the 2004 enlargement countries and negative changes in the group of long-standing countries result in the equalization of housing conditions in the EU in this area.

Most of the analyzed literature concepts also take into account the manifestations of housing deprivation, which are related to the way the apartment is used (Eurostat; Mandic & Cirman, 2012; Navarro & Ayala, 2008; Palvarini & Pavolini, 2010; Wan & Su, 2016; Kozera et al, 2017; Ćwiek & Ulman, 2021; Wojewódzka-Wiewiórska & Dudek, 2023). They have a completely different specificity. They are not related to the condition of the buildings, but to who lives in them. Such manifestations include the burden of housing costs or the overcrowding of the apartment. The intensification of symptoms in this area requires a different impact from public policy instruments. According to research, the highest problems in this area occur in Greece and Bulgaria, with quite high severity also observed in Romania, Lithuania and Latvia. Problems in this area are decreasing in most EU countries (except in Greece and, to a lesser extent, Luxembourg).

The last dimension highlighted in the proposed concept is that related to the apartment's surroundings. It is widely accepted (including Mandic & Cirman, 2012; Navarro & Ayala, 2008; Nolan & Winston, 2011; Palvarini & Pavolini, 2010; Wan & Su, 2016; Ćwiek & Ulman, 2021; Ayala et al., 2022; Matel, 2023). That deprivation is also manifested by inconvenience related to what is happening „outside the walls” of a given house, including the level of crime, pollution and noise. The study indicates that this is the dimension of deprivation in which the greatest changes are taking place, most of them being positive (except for: Spain, France, Lithuania and Luxembourg), and the greatest problems occur in Malta, Greece, France, the Netherlands, Bulgaria, Spain and Luxembourg.

In some countries, the intensification of housing problems can be observed in one of the dimensions, while in others - in all of them. There are also countries that can be considered leaders in the EU in overcoming housing problems. In 2010, this group included Ireland, Sweden and Finland, but only Finland maintained this status until 2020. The leading countries were joined by Czechia, Austria and Estonia. In 2010, there were few countries that were defined as catching up countries, i.e. those in which there was no high level of deprivation in any of the areas (France,

Belgium, Spain, Austria and Luxembourg). As a result of the falling level of deprivation in general, in 2020 there were many more such countries, and some of them were characterized by intensified problems in the area of mixed use (Denmark, Poland, Croatia and Slovakia), the quality of the housing stock (Hungary, Ireland, Slovenia and Belgium) or problems in the neighborhood (Spain, Portugal, Italy, Luxembourg, Sweden and Germany). In Romania, Bulgaria and Latvia in 2010, on the other hand, a high level of deprivation was observed in all analyzed areas; in 2020, Romania and Latvia mainly faced problems with the quality of the housing resources, and Bulgaria showed a high level of problems in the area of the way of using the housing.

5. Conclusions

The phenomenon of housing deprivation in EU countries is not uniform, as indicated by almost every concept of measuring this phenomenon proposed in the literature on the subject. Deprivation indicators take into account various factors related to the quality of the housing stock, the household's ability to maintain it, the overcrowding of apartments and discomfort associated with living in a specific area. These indicators form three different groups: the quality of the apartment, the way the apartment is used and the neighborhood. Based on this division, an attempt was made to examine the profiles of housing deprivation in EU countries. The study indicated that there are countries where housing deprivation is not severe in any of the areas (leading countries), but only Finland maintained such a status during the 2010-2020 decade. We can also point to countries with a particular intensity of problems related to the quality of housing resources (Romania, Lithuania, Latvia, and Cyprus; and, to a lesser extent, also: Hungary, Ireland, Slovenia and Belgium), the way of using housing (Greece, Bulgaria, and, to a lesser extent, also: Denmark, Poland, Croatia and Slovakia) and the neighborhood (Malta, the Netherlands, France, and to a lesser extent, also Spain, Portugal, Italy, Luxembourg, Sweden and Germany).

An interesting direction for further research is the analysis of the relationship between housing deprivation profiles and housing market models in EU countries. As was proved in the study of H. Dudek & A. Wojewódzka-Wiewiórska (2024) in Poland, the problem of housing deprivation affects tenants more than homeowners. The authors also noted differences depending on the type of tenancy. In the case of

market rent, the probability of being not housing deprived was lower than in the case of tenants paying a reduced price. There are many classifications of housing models in the literature. Comparing the results obtained with one of them - proposed by J. Barlow and S. Duncan - the Scandinavian countries presenting a social democratic model - where the state is involved in setting housing prices and rents - are the leaders in terms of overcoming problems of housing deprivation. Paradoxically, the scale of housing problems is also lower in countries with a liberal model, such as Ireland, where the state intervenes in the housing market in a negligible way. A greater severity of problems is seen among representatives of the rudimentary model (e.g. Greece, Spain, Portugal) with a high rate of owner-occupied housing and a low level of rental market development. Countries with a corporate model - including Germany, Italy or Belgium - can be categorized as having a medium severity of housing problems (Kucharska-Stasiak et al., 2020, pp. 45-46). On the basis of the research carried out, it can be seen that these divisions are more pronounced for the 2010 data than for the 2020 et. On the one hand, this is due to the evolution of housing patterns in Europe and, on the other, to the blurring of differences related to post-transformation changes, despite similar economic conditions and the political situation in the past (see: Rącka, Pawlicki & Kosov, 2015). Hence, the topic appears to be cognitively important and requires in-depth analysis.

The occurrence of different profiles of housing deprivation can provide a basis for making some recommendations for public policy. It provides information on what aspects of housing policy should be focused on in individual EU regions, as well as the scale of existing inequalities. Nevertheless, it can be seen that most EU countries are gradually overcoming the problem of housing deprivation, and the leading countries are no longer only long-standing EU countries - as was the case in 2010. This group is joined by countries from the 2004 enlargement, such as the Czechia and Estonia. Moreover, among the catching up countries in 2020, there are many countries from the 2004 enlargement (including Poland, Slovakia, Hungary and Slovenia), as well as Croatia, which joined the EU in 2010. Therefore, there is a gradual equalization of housing conditions. Moreover, it occurs in all analyzed dimensions. This, in turn, can be interpreted as the effectiveness of the implemented cohesion policy at the European level.

On the other hand, it can be noted that some of the post-transformation countries are struggling to equalize the level of meeting their citizens' housing needs. These include, above all, Romania, Bulgaria and Latvia. These countries experience particular problems related to the quality of the housing stock. In order to fully meet the demands of the convergence of the European Union markets, it seems necessary to develop methods to support them.

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Appendix

