HOUSEHOLD ENERGY POVERTY IN SLOVAKIA: EVIDENCE FROM EU-SILC DATA

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Abstract

The paper examines determinants of energy poverty among Slovak households using microdata from the 2020 EU Statistics on Income and Living Conditions (EU-SILC) and a binary logistic regression model based on households' subjective inability to keep their homes adequately warm. The findings show that higher equivalised disposable income is the strongest factor reducing energy poverty. In addition, housing quality, specifically the absence of dampness, leaking roofs, or inadequate natural light, significantly lowers risk, whereas higher housing costs elevate it. Substantial regional disparities also emerge, with households in the Banská Bystrica, Prešov, and Košice regions facing significantly higher odds of thermal deprivation. Ultimately, the paper provides pioneering empirical evidence for Slovakia, highlighting that effective policy responses must integrate income support with energy-efficiency investments and targeted regional measures.

Key words: energy poverty; EU-SILC; logistic regression; household vulnerability; housing conditions; Slovakia

JEL Code: I32, Q48, R20

Introduction

Energy poverty has become an important socio-economic and policy issue in Europe. It refers to a situation in which households are unable to secure adequate levels of essential energy services in their homes, including heating, cooling, lighting and the use of household appliances (Thomson et al., 2017). The phenomenon is closely related to the interaction of several factors, particularly household income, energy prices, the energy efficiency of dwellings and household-specific energy needs. Consequently, energy poverty should not be understood solely as a problem of low income, but rather as the outcome of the interaction between economic resources, housing characteristics and household circumstances (Bouzarovski, 2014; Thomson et al., 2017).

The relevance of energy poverty extends beyond households' financial situation. Inadequate access to essential energy services can affect living conditions, health and subjective well-being. Previous research has documented associations between energy poverty, cold housing and adverse health and well-being outcomes, indicating that the inability to maintain adequate indoor temperatures may represent an important dimension of material deprivation (Thomson et al., 2017; Thomson et al., 2017b).

Measuring energy poverty, however, remains challenging. There is no single indicator that fully captures all dimensions of the phenomenon (European commission, 2020&2023). Researchers have therefore employed a range of objective and subjective indicators, including expenditure-based measures, income-based thresholds, arrears on utility bills and households' reported inability to keep their homes adequately warm (Thomson et al., 2017). These indicators may identify partly different groups of households because they capture different aspects of energy deprivation. This issue is particularly important when analysing household-level determinants, as economic resources, household composition and housing characteristics may influence different dimensions of energy poverty in different ways.

In Slovakia, energy poverty remains an important socio-economic challenge. This study examines households' inability to keep their homes adequately warm as a direct indicator of access to an essential energy service. Using EU-SILC 2020 microdata, a binary logistic regression model is applied to assess the role of economic conditions, household composition, housing characteristics and regional factors. By analysing these dimensions simultaneously, the study provides household-level evidence on the main factors associated with energy vulnerability in Slovakia.

1 Literature Review

The recent energy crisis has highlighted energy poverty as a major socio-economic challenge, raising concerns about households' ability to afford essential energy services and maintain adequate living conditions. Although widely recognised as a major social challenge, there is still no universally accepted definition. Most studies define energy poverty as the inability of households to secure an adequate level of essential energy services, including heating, cooling, lighting and the use of household appliances, at an affordable cost (Bouzarovski, 2014; Pye et al., 2015). Energy poverty is also associated with adverse health and well-being outcomes, which further reinforces its broader social significance (Thomson, Snell, et al., 2017).

Early approaches relied mainly on expenditure-based indicators. The best-known measure is the 10% indicator, introduced in the United Kingdom, which classifies households as energy poor if they spend more than 10% of their income on domestic energy (Boardman, 1991). However, this measure has been criticised for ignoring differences in household needs, housing quality and climatic conditions (Hills, 2012). Consequently, recent research increasingly adopts a multidimensional perspective, combining expenditure-based measures with subjective indicators such as the inability to keep the home adequately warm and arrears on utility bills (Sareen et al., 2020; Thomson, Bouzarovski, et al., 2017). This approach reflects the interaction between low income, poor housing conditions, high energy prices and household-specific energy needs.

Previous research consistently identifies household income as one of the strongest determinants of energy poverty. Low-income households devote a larger share of their disposable income to housing and energy expenditures and are therefore more vulnerable to increases in energy prices (Bouzarovski, 2014; Pye et al., 2015). Nevertheless, income alone does not fully explain differences in household vulnerability.

Housing conditions represent another important determinant. Poor thermal insulation, inefficient heating systems and older buildings increase the amount of energy required to achieve adequate indoor comfort, making households more exposed to energy poverty regardless of income (Thomson, Bouzarovski, et al., 2017). In addition, demographic characteristics such as age, household composition and the presence of dependent children influence energy demand and financial resilience. Regional disparities may further reflect differences in income levels, housing quality and local socio-economic conditions (Bouzarovski, 2014).

Recent empirical studies demonstrate that energy poverty has intensified following the COVID-19 pandemic and the 2022–2023 energy crisis. Rising energy prices disproportionately affected low-income and socially vulnerable households, although the magnitude of these effects differed across European countries depending on housing quality, energy efficiency and national policy responses. Substantial cross-country differences in energy poverty have also been documented by Rodríguez-Álvarez et al. (2021).

Using EU-SILC data for 32 European countries, Makridou et al. (2024) found that low household income, poor housing conditions and overcrowding significantly increase the likelihood of energy poverty. Their results suggest that improving housing quality and energy efficiency may be more effective in reducing energy poverty than policies relying solely on income support.

Recent studies have also highlighted limitations of existing measurement approaches. Menyhért (2024) showed that subjective and expenditure-based indicators often identify different groups of households as energy poor, indicating that no single measure captures all dimensions of the phenomenon. Similar concerns regarding the comparability and limitations of European energy poverty metrics are highlighted by Sareen et al. (2020). These findings support the use of subjective indicators, such as the inability to keep the home adequately warm, particularly when analysing household-level vulnerability.

Although the determinants of energy poverty have been widely examined in European countries, empirical evidence for Slovakia remains limited. Existing studies often rely on descriptive analyses or aggregate indicators, whereas household-level econometric analyses are relatively scarce. This study contributes to the literature by examining the socio-economic, housing and regional determinants of households' inability to keep their homes adequately warm using Slovak EU-SILC 2020 microdata and a binary logistic regression model.

2 Data and Methodology

2.1 Data

The empirical analysis is based on household-level microdata from the 2020 European Union Statistics on Income and Living Conditions (EU-SILC) for Slovakia. EU-SILC is a harmonised survey providing comparable information on household income, demographic characteristics, housing conditions and material deprivation across EU Member States. (Eurostat,2021)

The dependent variable is the household's inability to keep the home adequately warm, one of the most widely used subjective indicators of energy poverty in European research and official EU monitoring. The analysis aims to identify the socio-economic, housing and regional determinants of energy poverty among Slovak households.

The study addresses the following research questions:

- **RQ1:** Which socio-economic characteristics significantly affect the probability of experiencing energy poverty?
- **RQ2:** Do housing characteristics significantly influence the risk of energy poverty after controlling for socio-economic factors?
- **RQ3:** Are there significant regional differences in the probability of experiencing energy poverty in Slovakia?

The dependent variable is a binary indicator representing whether the household reported being unable to keep its home adequately warm. The variable takes the value **1** if the household

declared that it could not afford to maintain adequate indoor warmth and **0** otherwise. This indicator has become one of the most applied subjective measures of energy poverty within EU-SILC-based research (Thomson, et al., 2017; European Commission, 2023).

The explanatory variables were selected according to previous empirical studies and include household income, household type, household size, tenure status, housing quality, degree of urbanisation and region of residence. These variables represent the principal economic, demographic and housing-related factors associated with energy poverty in the literature (Bouzarovski, 2014; Pye et al., 2015; Thomson, Bouzarovski, et al., 2017).

Tab. 1: List of variables used in analysis

Variable	Description	Type
Energy poverty	Unable to keep home adequately warm (0/1)	Dependent
Household income	Income quintile	Independent
Household type	Household composition	Independent
Household size	Number of household members	Independent
Housing quality	Housing deprivation indicator	Independent
Tenure status	Owner/Tenant	Independent
Degree of urbanisation	Cities, towns, rural areas	Independent
Region	NUTS3 region	Independent

Source: own based on EU SILC 2020

2.2 Econometric Model

Given the binary nature of the dependent variable, a binary logistic regression model is employed to estimate the probability that a household experiences energy poverty. Logistic regression is widely used in studies analysing household vulnerability because it estimates the probability of a binary outcome while allowing the simultaneous inclusion of multiple explanatory variables.

The estimated model can be expressed as

$$P(Y_i = 1|X_i) = \frac{1}{1+e^{-(\beta_0+\beta_1 X_i)}}, \quad (1)$$

where Yi denotes the probability that household i is unable to keep its home adequately warm, while $X1, \ldots, Xk$ represent the selected explanatory variables.

The estimated coefficients are interpreted using odds ratios, which indicate how a one-unit change in an explanatory variable affects the odds of experiencing energy poverty while

holding all other variables constant. Statistical significance is assessed at the 1%, 5% and 10% significance levels.

Tab. 2: Logistic Regression Model Results

Variable / Category	Estimate	Std. Error	Pr(>|z|)	Odds Ratio
(Intercept)	1,180*	0,460	0,010	3,250
Region				
Trnava Region	0,640*	0,300	0,030	1,900
Trenčín Region	0,510.	0,280	0,070	1,670
Nitra Region	-0,040	0,300	0,910	0,960
Žilina Region	0,230	0,290	0,430	1,260
Banská Bystrica Region	1,010***	0,260	0,000	2,740
Prešov Region	0,920***	0,270	0,000	2,510
Košice Region	0,900***	0,270	0,000	2,460
Equivalised disposable income	-0,140***	0,030	0,000	0,870
Household type				
Household of 2 adults without dependent children (under 65 yrs)	0,030	0,250	0,900	1,030
Household of 2 adults without dependent children (at least 1 aged 65+)	0,050	0,230	0,820	1,050
Other households without dependent children	0,220	0,390	0,570	1,250
Household with 1 parent and 1 or more dependent children	-0,520	0,440	0,230	0,590
Household of 2 adults with 1 dependent child	-0,440	0,390	0,260	0,650
Household of 2 adults with 2 dependent children	-0,670	0,470	0,160	0,510
Household of 2 adults with 3 or more dependent children	-0,890	0,690	0,190	0,410
Other households with dependent children	-0,250	0,610	0,680	0,780
Equivalised household size	0,050	0,280	0,860	1,050
Residence status				
Residence status - temporarily absent household member	0,720	0,870	0,410	2,060
Number of rooms available for the household	0,030	0,050	0,520	1,030
Leaking roof, damp walls/floor/foundation or rotting window frames				
Leaking roof, damp walls,.. 2 - No	-0,830***	0,190	0,000	0,440
Total housing costs	0,000*	0,000	0,020	1,000

Ability to make ends meet				
With difficulty	-1,140***	0,150	0,000	0,320
With some difficulty	-2,130***	0,170	0,000	0,120
Fairly easily	-2,540***	0,250	0,000	0,080
Easily	-3,860***	1,020	0,000	0,020
Very easily	-14,680	321,76	0,960	0,000
Problems with dwelling: too dark, not enough light				
Problems with dwelling: 2 - No	-0,840***	0,260	0,000	0,430
Model Fit Statistics				
AIC	2127,421			
McFadden	0,252			
Cox & Snell	0,118			
Nagelkerke	0,300			
N (Sample Size)	5 525			
*Note: Signif. codes: *** p < 0.001, * p < 0.05, . p < 0.1*				

Source: own calculations based on EU SILC 2020

In this logistic regression model, the dependent variable P ($Y_i = 1$) measures the probability that household *i* is unable to keep its home adequately warm, serving as a primary indicator of energy poverty. The set of explanatory variables X_1, …, X_k accounts for economic situation, demographic composition, regional placement, and physical dwelling quality. The estimated regression coefficients β_i reflect the change in the log-odds of a household experiencing thermal deprivation per unit change in the corresponding predictor, while the exponentiated coefficients Odds Ratios, e^β quantify the relative change in odds.

The logistic regression results reveal significant economic, housing-related and regional determinants of energy poverty. Regional disparities are particularly pronounced. Compared with Bratislava, households in Banská Bystrica (OR = 2.74), Prešov (OR = 2.51), Košice (OR = 2.46) and Trnava (OR = 1.90) have significantly higher odds of being unable to keep their homes adequately warm. The effect for Trenčín is only marginally significant (OR = 1.67, p = 0.070).

Economic conditions also play an important role. Higher equivalised disposable income is associated with lower odds of energy poverty (OR = 0.87, p < 0.001), while greater ease in making ends meet is associated with a substantial decline in vulnerability. Housing quality is

similarly important: households without dampness or structural problems have 56% lower odds of energy poverty (OR = 0.44), while those without insufficient lighting have 57% lower odds (OR = 0.43). Total housing costs are also statistically significant (p = 0.020).

In contrast, household type, household size, number of rooms and residence status are not statistically significant. Overall, the results indicate that economic conditions, housing quality and regional location are the main factors associated with energy poverty in Slovakia, supporting its multidimensional character.

Conclusion

This paper examined the determinants of energy poverty in Slovakia using household-level data from the 2020 EU Statistics on Income and Living Conditions (EU-SILC). A binary logistic regression model was employed to identify the socio-economic and housing-related characteristics associated with households' inability to keep their homes adequately warm.

The results indicate that energy poverty is primarily driven by households' economic situation. Higher equivalised disposable income significantly reduces the probability of experiencing energy poverty, while households reporting greater financial difficulties are considerably more likely to be unable to afford adequate heating. These findings are consistent with previous studies that identify insufficient financial resources as one of the main determinants of energy poverty (Bouzarovski, 2014; Legendre & Ricci, 2015; Thomson et al., 2017).

Housing conditions also play an important role. Households living in dwellings without dampness or leaking roofs, as well as those without problems related to insufficient natural light, were significantly less likely to experience energy poverty. These findings support the multidimensional perspective on energy poverty, which emphasises that housing quality is an important determinant alongside household income (Day et al., 2016; Menyhért, 2024). In addition, higher housing costs were associated with a greater likelihood of energy poverty, highlighting the increasing financial burden of housing-related expenditures.

The analysis further revealed significant regional disparities. Compared with the reference region, households living in the Banská Bystrica, Prešov and Košice regions exhibited substantially higher odds of experiencing energy poverty. These results suggest that regional socio-economic differences remain an important factor influencing household vulnerability in Slovakia and underline the need for region-specific policy measures.

Overall, the estimated model achieved satisfactory explanatory power (Nagelkerke R^2 = 0.300), indicating that the selected variables explain a substantial part of the variation in households' exposure to energy poverty. Nevertheless, the absence of statistically significant effects for several demographic characteristics suggests that economic and housing factors outweigh household composition in explaining energy poverty in Slovakia.

The findings have important policy implications. Measures aimed solely at increasing household income are unlikely to eliminate energy poverty unless they are accompanied by investments in housing quality, energy efficiency improvements and targeted support for vulnerable regions. Future research should examine alternative measures of energy poverty and compare the determinants identified using subjective and expenditure-based indicators to provide a more comprehensive understanding of household energy vulnerability.

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