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Socioeconomic influences on household energy poverty in Greece: Insights from EU-SILC data

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ABSTRACT
Energy deprivation is a complex and multidimensional issue with significant consequences threatening primary human needs and social welfare. This study investigates energy poverty within Greece, aiming to find the factors influencing its occurrence. The empirical analysis uses the 2022 annual Statistics on Income and Living Conditions (EU-SILC) conducted by ELSTAT (Hellenic Statistical Authority), which provides valuable data concerning poverty, social exclusion, income and living conditions, and characteristics of households in Greece. Empirically, this study yields binary logistic regression analysis examining the relationship between the energy poverty phenomenon and various sociodemographic and economic characteristics of the households, such as income level, working status, age, gender, educational level, household size, tenure status, and population density. Results reveal that such factors play a significant role in shaping the indicators reflecting the energy poverty issue, thereby highlighting the need for targeted interventions to address this pressing concern in Greece. The outcomes of this paper provide insights into policy implications aimed at mitigating energy poverty in Greece, stimulating policymakers to adopt effective and substantial measures.

Keywords:
Energy poverty; Sustainability; Vulnerable households

United Kingdom (UK)
European Poverty Advisory Hub (EPAH)
Minimum Income Standard (MIS)
Statistics on Income and Living Conditions (EU-SILC)
Gross domestic product (GDP)
European Union (EU)
MENA (Middle East and North Africa)

1. Introduction

Energy deprivation is a complex and multidimensional issue of global concern. It affects millions of people, threatening social welfare. Energy poverty is perceived as the inability to access sufficient, clean, and affordable household energy. Developing countries struggle to accomplish satisfying access to modern energy, while developed societies cannot mitigate energy costs (Che et al., 2021; Faiella & Lavecchia, 2021). Irrespective of a nation's stage of development, energy remains the primary and crucial objective to meet basic human needs. The EU Energy Poverty Observatory (which evolved into the Energy Poverty Advisory Hub-EPAH) was introduced by the European Commission to help EU members address energy poverty. In Europe, Southern and Eastern European countries face more significant difficulties in addressing energy poverty (Thomson & Snell, 2013).

Literature and governance agencies are often engaged in specific indicators, which are divided mainly into two discrete approaches: the objective and the subjective methods. Objective techniques are either income- and energy-expenditure and/or energy-cost-oriented. Amongst them, the 10% indicator Boardman introduced for the United Kingdom (UK) is considered a fundamental method for measuring and identifying energy poverty. According to this indicator, households are identified as energy-poor if the expenditure for sufficient energy services is more than 10% of their income (Boardman, 1991). Hills introduced the "Low-Income High Costs" indicator (Hills, 2012), according to which households are considered energy poor when the required fuel cost is above a specific threshold and income is below the poverty line after that expenditure. Currently, fuel poverty in the UK is measured using the Low Income-Low Energy Efficiency indicator to identify households that are both low-income (households that fall below the poverty line after the required energy expenditure) and live in homes with poor energy efficiency (UK GOV, 2024).

The European Poverty Advisory Hub (EPAH) suggests two complementary objective indicators: the "High share of energy expenditure in income (2M)" which accounts for the cases in which fuel expenditure is above twice the national median and "Low absolute energy expenditure (M/2)" which accounts for the households whose absolute expenses on fuel are abnormally low (*below half the national median*) (EPAH, 2022). Another objective-based approach is the Minimum Income Standard (MIS) method, introduced by Moore (2012), which classifies households as energy-poor if they cannot meet energy cost requirements after delivering basic needs.

Alongside, some academics have suggested subjective measuring tools to capture energy poverty, involving self-reported 'consensual' indicators that investigate the energy poverty phenomenon, asking households whether:

i) they can keep home adequately warm
ii) they have arrears on utility bills
iii) their homes suffer from leakages, damp, or rot

The most profound advantage of this approach is that collecting consensual data is more uncomplicated than objective-modeled methodologies. Significant information is provided through the Statistics on Income and Living Conditions (EU-SILC) dataset. The survey provides timely and comparable cross-sectional and longitudinal data concerning poverty, social exclusion, income, and living conditions, providing important household demographic, social, and economic characteristics (Eurostat). Furthermore, following a bottom-up process helps researchers capture broader issues associated with energy poverty, such as social exclusion and material deprivation (Thomson et al., 2017).

Although the abovementioned indicators have been widely employed in numerous studies, literature has located significant gaps between them. Identifying households with specific characteristics as energy-poor, according to one indicator, may not coincide with other measuring tools. The comparative analysis of Palma et al. (2024) concerning definitions and measuring tools in the Iberian context underscored that both subjective and objective approaches can benefit from expanding their scope and enhancing inclusiveness.

Energy poverty impacts various aspects of life, leading to major concerns and leaving consumers with a status of vulnerability (Betto et al., 2020). Both the short and long-run economic progress is threatened (Tundys et al., 2021). Another significant fact is that when income inequality is high, energy poverty increases too (Nguyen & Nasir, 2021), hindering energy poverty alleviation (Acharya & Sadath, 2019). Energy poverty is associated with devastating results in access to education, communication, and information, which results in social exclusion, negatively affecting individual development and leaving vulnerable people with no choices (González-Eguino, 2015). Furthermore, energy deprivation and limited or no access to modern energy are strongly and negatively associated with health status (Nawaz, 2021; Oliveras et al., 2021).

Greece faces significant energy poverty issues. The impact of the recent economic crisis led to severe income shrinkage. Furthermore, affordability was deteriorated due to taxes on energy services after 2010. These reasons alongside the old building stock in the country have shaped a worrisome condition in energy poverty (Atsalis et al., 2016). This study aims to shed light on the synergies of energy poverty in Greece, revealing the main socioeconomic and demographic factors that are related.

2. Literature Review

Income and income inequality are directly correlated with energy poverty.
Aiming to examine the impact of inequality on energy poverty, the study of Ben Cheikh et al. (2023) concerning 25 European nations for the period 2006-2019, attempts to capture the patterns of energy poverty drivers utilizing subjective indicators, with nonlinear panel threshold models. As demonstrated, economic growth (GDP per capita) aggravates energy poverty when income is not equally distributed, presenting the opposite effect in cases with lower income inequality. Furthermore, income inequality harms energy prices, making households even more vulnerable when income distribution is unequal.

In the same vein, El-Katiri (2014) elaborates on energy poverty in MENA (Middle East and North Africa), where diverse economic conditions are observed and some countries are major energy suppliers. In higher-income cases, infrastructure and energy supply have led to growth. On the other hand, in cases like Yemen, energy poverty is a significant and persistent phenomenon, indicating that energy sources and the wealth deriving from them cannot guarantee universal country benefits. Similarly, Igawa & Managi (2022) argue that the national economic growth level and income inequality are related to energy poverty. Using data from 37 countries with different economic growth worldwide, they found that energy poverty is differently expressed under the estimations of accessibility, reliability, and affordability. Accessibility and reliability worsen energy poverty in low-income nations, while affordability deteriorates the phenomenon in the middle level of economic growth and greater income inequality.

According to the European Commission, in 2021, 6.9% of Europeans could not keep their homes adequately warm, while in 2023, the proportion rose to 10.6% (European Commission-Energy poverty, 2024). The study of Halkos & Gkampoura (2021) indicated that Scandinavian countries face the lowest energy poverty issues, while Southern and Eastern European nations have significantly more difficulties in addressing energy poverty. Balkans were observed to struggle greatly. Bulgaria, Poland, and Latvia managed to decrease energy poverty over the years. On the contrary, among all European countries, Greece had the greatest increase from 2011 to 2016.

In Greece, energy poverty began to be thoroughly investigated primarily during the 2010 economic crisis, when a surge in the phenomenon was observed (Dubois & Meier, 2016; Halkos & Gkampoura, 2021; Kalfountzou et al., 2022). The national income dropped significantly, and after 2010, taxes were imposed on energy services. Income is considered a significant driver of energy poverty in Greece (Halkos & Kostakis, 2023; Lyra et al., 2022; Papada et al., 2019; Papada & Kaliampakos, 2018).

Another significant driver of energy poverty is the low energy efficiency of buildings (Papada & Kaliampakos, 2018); unfortunately, most vulnerable households dwell low energy efficient homes (Lyra et al., 2022). Taking into account that low-income households and older people do not invest in energy efficiency, probably because they cannot afford such interventions (Damigos et al., 2021), and the fact that being energy-poor in one period endangers suffering in the future too (Halkos & Kostakis, 2023), the risk of being trapped in an energy poverty vicious circle is accentuated. It is therefore assumed that low income restricts households from energy performance interventions, which would be beneficial for their energy poverty status. For these reasons, income impact should be involved in this work.

Furthermore, economically inactive, i.e., unemployed or older people, are considered more vulnerable to energy poverty (Halkos & Kostakis, 2023; Kalfountzou et al., 2022). Energy poverty is considered a crucial dimension of well-being among older people, which can lead to severe health issues or worsen them even more. As older individuals experience a decline in perceived health status, they are more likely to face challenges in paying their utility bills (Sardianou, 2024). Alongside, energy poverty is associated with severe health impacts (Atsalis et al., 2016; Nawaz, 2021; Oliveras et al., 2021; Papada & Kaliampakos, 2016). Consequently, as health status deteriorates within the older population, energy poverty risk increases, ultimately worsening health conditions. Therefore, the way employment status and age shape energy poverty occurrence should be investigated.

Since energy poverty is a condition that affects all aspects of life, various determinants, social and economic factors and households' condition should be examined. Gender is a significant demographic characteristic that needs to be further explored and future research should consider the enhancement of women's overall well-being due to better access to energy (Shahzad et al., 2022). Koengkan & Fuinhas (2021) argue that the gender pay gap negatively affects environmentally friendly consumption and investment behaviors, deteriorating energy poverty issues. Another critical determinant of energy poverty is the educational level attained. According to previous studies, low educational levels are associated with higher energy poverty risk (Halkos & Kostakis, 2023; Lyra et al., 2022). The study of Sardianou (2024) that focused on the factors that impact energy poverty among elderly people in Greece validates that a higher educational level significantly increases the possibility of elderly people affording energy requirements. Furthermore, previous literature examines the role of urbanization level or conducts regional analysis, aiming to provide considerations concerning the role of the residence's location (Halkos & Kostakis, 2023; Kalfountzou et al., 2022; Lyra et al., 2022). Additionally, several demographic characteristics are explored, investigating the significance of households' tenure status (Kalfountzou et al., 2024; Lyra et al., 2022) and household size (Kalfountzou et al., 2022).

3. Data and Methodology

The analysis of this work is based on the large-scale annual data of 9,910 observations of the EU-SILC survey for 2022, which is available through the Hellenic Statistical Authority. This study attempts to capture energy poverty considering the consensual indicator "*Ability to keep home adequately warm*", which refers to the population's enforced ability to keep their home adequately warm. The independent variables consist of income, working status, demographic characteristics, age and gender, the educational level attained, household size, tenure status, and urbanization level.

Table 1.
Variables description

Variable name	Description
Ability to keep home adequately warm	Whether the household can have the required energy to keep home adequately warm
Income	Total disposable income
Not Working	Whether the person is working or not
Age	Age of the person
Gender	Male or female
Education	Whether the person has attained tertiary education or not
Household size	Number of persons in the household
Tenure status	Whether the household owns the residence or not
Urbanization	Urbanization level of an area

The logistic regression model is specified as follows:

Logit (inability to keep home adequately warm) = $\beta_0 + \beta_1$ ln(income) + β_2 not working + β_3 age + β_4 gender + β_5 education + β_6 household size + β_7 tenure status + β_8 urbanization

The logistic regression model is estimated using the maximum likelihood estimation method. At the same time, the marginal effects are computed at the means of the independent variables to interpret the average change in the probability of the event occurring for a unit change in each predictor.

4. Findings and Discussion

Figure 1 presents the indicator of energy poverty (ability to keep home adequately warm) in total and by region in Greece. The figure demonstrates that approximately 20% of the population cannot afford to keep their homes adequately warm. Furthermore, regional disparities are observed, since the minimum proportion of people who cannot satisfy their energy needs is below 13%, while energy poverty reaches almost 30% in Western Macedonia.

Figure 1: Ability to keep home adequately warm by region, 2022

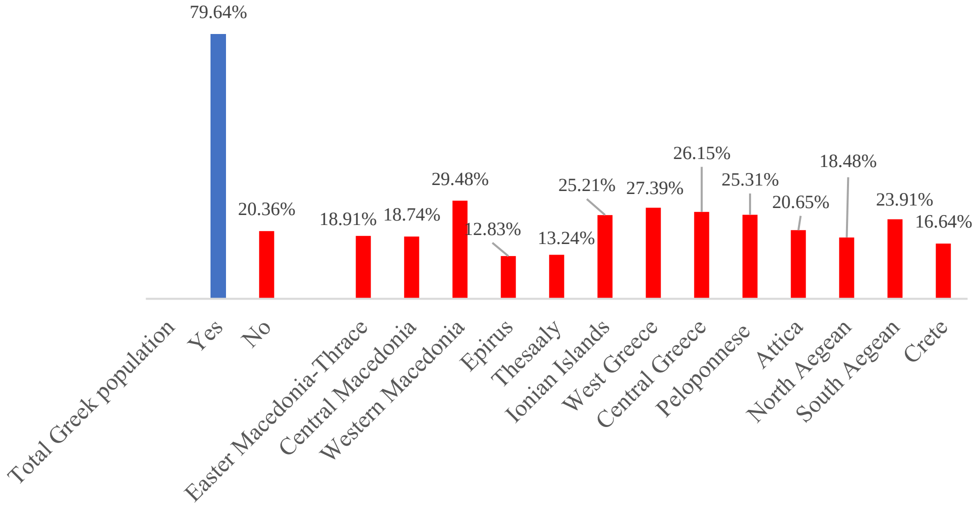

Table 2 presents the main descriptive characteristics of the sample, including the independent variables of the model, as well as other factors. The average annual disposable income is 16,500 €. The total housing cost per year reaches approximately 400 €, which refers to the costs related to energy and water. Water costs in Greece are considered low and slightly influence the total housing costs, therefore, this factor mainly illustrates the total energy expenses. The average annual households' debts are 6,600 €. Concerning the demographic characteristics of the reference person, it is demonstrated that the average age is 60 years, almost 60% are not working (pensioners are included), approximately 60% are males, 17% have attained tertiary education, 36% of households are consisted of 2 members, 70% own their residence and almost 35% live in densely populated areas.

Table 2.
Descriptive statistics

Variable	**Max.**	**Min.**	**Mean**	**Stand. Dev.**
Total disposable household income (€)	408,500	-15,140	16,536	13,844
Total housing cost (including electricity, water, gas and heating) (€)	6,812.16	165.12	397.6	166.3
Household debts (total debts including consumer debts and mortgage loans, excluding mortgages on the purchase of the main residence) (€)	334,155.24	0	6642	9130.5
Age (years)	84	17	59.6	15.2
Number of adults	5	0	1.8	0.7
Number of dependent children	3	0	0.4	0.8
Number of rooms	6	1	3.2	0.9
Household size	5	1	2.18	1.13
Tabulation				
Not working			59.81%	
Gender (males)			69.15%	
Education (tertiary)			27.07%	
1 member			32.64%	
2 members			36.34%	

3 members	14.94%
4 members	11.95%
5 members	4.14%
Tenure status (homeowner)	70.25%
Urbanization	34.87%

Notes: Authors' calculations.

Table 3 presents a logistic regression analysis of the factors influencing the inability to keep home adequately warm. The table displays both coefficient estimates and marginal effects, providing insights into the magnitude and direction of the relationships between each independent variable and the likelihood of being unable to keep one's home warm.

Table 3.
Logistic regression outputs

Variables	Ability to keep home adequately warm	
	Coefficients	Marginal effects
ln (income)	-1.119 ***	-0.162***
	(0.048)	(0.006)
Not Working	-0.165 **	-0.024 **
	(0.074)	(0.010)
Age	0.007 ***	0.001 ***
	(0.002)	(0.000)
Gender (male)	0.250 ***	0.036 ***
	(0.059)	(0.008)
Education	-0.814 ***	-0.118 ***
	(0.274)	(0.039)
Household size	0.201 ***	0.029 ***
	(0.029)	(0.004)
Tenure status	0.403 ***	0.058 ***
	(0.062)	(0.009)
Urbanization	-0.110 *	-0.016 *
	(0.058)	(0.008)

Notes: ***, ** and * denote 1%, 5%, and 10% significance level. Parentheses present the standard errors.

The model predicts the probability of households' inability to keep their home adequately warm. Overall, the coefficients and their significance demonstrate that this consensual indicator of energy poverty is associated with all independent variables. Therefore, all variables included are significant predictors of energy poverty. First, concerning income, the profound outcome that higher income decreases the probability of being unable to keep required indoor temperatures is found, confirming previous literature (Halkos & Kostakis, 2023; Lyra et al., 2022; Papada et al., 2019; Papada & Kaliampakos, 2018). As far as the employment status is concerned, as expected, it is found that being employed decreases the probability of being unable to keep adequately warm. Apart from the obvious interpretation that unemployed people do not have the means to afford sufficient energy services, a significant proportion of people who do not work in this analysis are retired. This excerpt shows that the available income deriving from pensions cannot satisfy sufficient energy access, which worsens if one considers that elderly people are required to keep their homes at acceptable temperatures to a higher degree than the younger population. This finding might confirm the following one, which refers to age, predicting that higher age positively correlates to energy poverty. Outcomes concerning unemployment and older people align with previous works (Halkos & Kostakis, 2023; Kalfountzou et al., 2022). Furthermore, it is noticed that energy poverty depicts another social topic, namely gender inequality. Model results demonstrate that women are more likely to experience energy poverty than men, confirming that pay gap issues affect efficient treatments, deteriorating energy poverty status (Koengkan & Fuinhas, 2021).

Another significant determinant of energy poverty is the educational level. According to the findings, people who have completed tertiary or higher education are less prone to energy poverty, as similarly demonstrated by previous literature (Halkos & Kostakis, 2023; Lyra et al., 2022; Sardianou, 2024). Increased education decreases the probability of being unable to keep home warm. This finding can be attributed to many reasons. First, people with higher education may be better updated concerning energy efficiency. Consequently, they might have a more integrated approach to energy performance aspects and thus use more efficient appliances or invest in buildings' energy efficiency. However, it should be noted that a higher educational level is usually associated with better job opportunities, which help households satisfy required energy needs.

Furthermore, supporting the outcomes of Kalfountzou et al. (2022), larger households suffer more from keeping their residence warm, since each additional person in the household increases the probability of being unable to keep the home adequately warm. This finding is also reasonable, as households with more persons require more sources to satisfy their needs in energy and other essential goods or services. Especially in cases where larger households have more economically inactive members than smaller-sized households, the ability to keep the home adequately warm and the overall affordability to satisfy basic needs drops significantly. According to the findings, being a homeowner seems beneficial since households that do not own the residence have an increased probability of being unable to keep adequately warm, as also noticed in previous studies (Kalfountzou et al., 2024; Lyra et al., 2022). This outcome can be explained by considering that homeowners do not bear the financial burden of rent and consequently, besides being more willing to invest in their permanent residence, they also have better affordability to upgrade the building's energy efficiency. Finally, the analysis concentrates on the urbanization level, demonstrating that living in a densely populated area (urban areas/cities) decreases the probability of experiencing energy poverty compared to living in a less densely populated area (towns/rural areas). This finding confirms the work of El-Katiri (2014) and could be attributed to the fact that densely populated areas mainly consist of blocks of apartments rather than detached houses, which helps them benefit from economies of scale.

5. Conclusions and policy implications

The outcomes from this study reveal that energy poverty is a severe problem with socioeconomic drivers, which policymakers should target to enhance the living conditions of vulnerable households. The main finding of this work confirms that income is the primary factor that shapes the energy poverty status of households, reflecting their ability to sustain the required energy according to their specific needs. Therefore, policy implication should concentrate on this determinant to provide substantial interventions that tackle the problem fundamentally. Authorities should consider that income influences energy poverty and all aspects of well-being, personal development, and social prosperity, which provide better socioeconomic and individual growth.

The second significant determinant is education; higher educational levels decrease the possibility of experiencing energy poverty. Furthermore, being a homeowner, male, employed , and having smaller household sizes decreases the probability of suffering from energy poverty. Job creation that ensures minimum income according to actual expenditure needs, long-term working conditions, and enhanced job opportunities can improve household resilience against economic shocks and financial stability. Additionally, authorities should provide the necessary support to future generations to have equal access to tertiary education to enhance human capital, which will also develop more efficient buildings and technologies. Additionally, governments should aim for policies that ensure that no household is below a minimum disposable income and that people can afford essential goods and services. Households at lower income deciles that are undoubtedly left with fewer opportunities to develop (lower education, unemployment, vulnerable population, larger families) should be specifically treated.

Societies like Greece that suffer deeply from energy poverty should investigate the reasons that Scandinavian countries have the lowest energy poverty rates in Europe. Development and overall prosperity in these countries is illustrated in high-performance macro socioeconomic indicators, like GDP, human capital, R&D, labor sector, sustainability etc. Consequently, policy implications should involve long-term plans, aiming for improvement and prosperity in all aspects of life, in a holistic approach, rather than providing short-term strategies that do not safeguard the most vulnerable people, leaving them exposed to poverty and energy poverty.

For these reasons, future research should explore additional factors such as health status, access to social services, and environmental sustainability to provide a more comprehensive understanding of energy poverty. Furthermore, employing alternative methods, like mixed-effects models, machine learning techniques, and 2SLS models to address endogeneity could strengthen the analysis. Future research could explore these techniques to further refine predictive power and address potential complexities within the data. Additionally, since this study involves data for the year 2022, time series analysis would provide useful insights concerning the energy poverty evolution in the country, involving further analysis during the economic crisis, before, during and after COVID-19.

6. About the Authors

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